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Biotechnology Development and threat of Climate Change in Africa: The Case of Nigeria

VOLUME 2

Edited by

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Kehinde A. Taiwo PhD
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DEDICATION

This book is dedicated to the Alexander von Humboldt Foundation, Germany for her special support for outstanding African Scholars.

The book also is dedicated to the poor and hungry people in the African Continent who have woken up today to uncertainty, insecurity and poverty.

FOREWORD

Research on biotechnology and climate change issues is of major importance for developing countries. This peer-reviewed publication provides an overview of current Nigerian research projects on these topics. The book, containing peer-reviewed articles, is based on a conference, which took place at Obafemi Awolowo University in Ile-Ife, Nigeria, in August 2009 and which was mainly sponsored by the Alexander von Humboldt Foundation.

The Humboldt Foundation is a German non-profit organisation promoting academic cooperation between excellent scientists and scholars from Germany and abroad. Every year, the foundation sponsors approximately 1,800 research fellowships and awards.

The greatest asset of the Humboldt Foundation is its international alumni network. It embraces 42 Nobel Laureates and approximately 23,800 scientists and scholars from all disciplines in more than 130 countries who are closely associated with Germany. Nigeria has one of the strongest Humboldt networks on the African continent. It comprises about 180 scientists and scholars from all major Nigerian universities.

To support its international network, the Humboldt Foundation provides financial support to organise regional and specialist conferences (so-called "Humboldt Kollegs"). The Humboldt Kollegs have rapidly become one of the most popular instruments for strengthening regional and specialist networks. The majority of participants in these conferences are Humboldtians from a specific region or a major specialist field.

The Humboldt Kolleg at Obafemi Awolowo University has been part of the "Africa Initiative 2008-2009" that the Humboldt Foundation has launched with special support of the German Foreign Office to strengthen the local and regional networks in Africa. The Humboldt Foundation is grateful to the organisers and co-sponsors of the conference for their commitment.

FROM THE EDITORS

It is our joy to publish the full texts of the peer-reviewed articles presented at the Humboldt Conference of August 3-7, 2008. We thank the Alexander von Humboldt Foundation, Bonn, Germany for providing the funds for the Conference and for the publication of this book. The Editors also appreciate the painstaking efforts of the reviewers who responded promptly to peer-review requests. Reviewers' comments went a long way to improve the academic qualities of all the articles contained in this book.

We are certain that the articles contained in this book will be of immense values to undergraduate, postgraduate, postdoctoral and full-time researchers on topics that are related to food, health and environmental issues in developing countries.

Editor-In-Chief:

Odunayo C. Adebooye PhD, MCRA, Humboldtian

Co-Editors:

Kehinde A. Taiwo PhD, Humboldtian

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ASSESSMENT OF FISH FARMERS' PERCEPTION OF CLIMATE CHANGE AND ADAPTATION STRATEGIES IN NIGERIA: OSUN STATE EXPERIENCE.

***ADESOJI S.A and **A.J. FARINDE**

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Abstract

The study assessed adaptation of Osun State fish farmers to climate change with a view to providing sustainable adaptive strategies to vagaries of weather in Nigeria.

Quantitative data were collected with an aid of structured questionnaire. Descriptive statistics such as frequency distribution, percentages, mean and standard deviation were used to summarise the data while Multinomial Logit Model and Adaptation Strategy Index were used to determine the choice of Adaptation Strategies and the extent of use of the strategies by fish farmers in the State. The results showed that the mean age of fish farmers was 48 years and the mean fish farming experience was 8 years. About 75 percent of the respondents perceived climate change but only 29 percent of them took actions to reduce the impacts of the climate change.

Adaptation strategies used to reduce the impacts include reinforcement of dyke, provision of shade, and practice of polyculture. Others include, ensure free flow of water, change stocking periods and provision of reservoir. Adaptive Strategy Use Index showed that reinforcement of dyke was mostly used among the adaptive strategies followed by provision of shade, practice of polyculture, free flow of water, change stocking period and provision of reservoir. Also Multinomial logit model showed that fish farming experience, education, information and size of fishpond are important factors to be considered when planning climate change programmes for fish farmers.

The study concluded that many fish farmers perceived change in climate but few of them attempted to reduce the impacts of the change by adopting different adaptation strategies.

INTRODUCTION

Nigeria is one of the countries of the world that are frequently affected by disasters as a result of natural processes. About three quarters of these disasters are related to extreme weather and climate events including droughts, floods, extreme temperature, thunderstorms and desertification (Ayeni, 2004). These usually result in destruction of properties and loss of many socio – economic activities. Significant changes in the frequency and intensity of draught, strong wind leading to desertification have been noticed in recent years . Nigeria has not fully recovered from the impact of the 1973 Sudano-sahelian Drought, which is the longest and severest in the country. Both the flora and fauna ecosystems were affected by change in climate. It is clear that climate change in many parts of the world, adversely affects socioeconomic sectors, which include water resources, agriculture, forestry, fisheries and human settlements, ecological systems and human health (IPCC, 2001). Apart from the landless and urban poor, small-scale farmers including fishers and fish farmers are among the most disadvantaged and vulnerable groups in the developing world. The challenge now is how to prevent or reduce the impact of climate change on livelihood style among Nigerians. Since it is very difficult to control many of these natural phenomena like drought and flood, the best approach to reduce the impact is adaptation.

Adaptation is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which reduces harm or exploits beneficial opportunities (IPCC, 2004). Oluwatayo (2008) opined that adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realise new opportunities. Agriculture is the economic mainstay accounting for about 20-30 percent of GDP in sub-Saharan Africa and representing up to 55 percent of the total value of African export (Sokona and Denton, 2001). In fact, 70 percent of all Africans and nearly 90 percent of their poor works primarily in agriculture (World Bank, 2000).

In Nigeria, the effect of climate change on agricultural productivity is particularly important in that agriculture is the single most important occupation (employing over 65 percent of Nigerians) and second largest export earner after petroleum. Because of Nigeria's heavy dependence on agriculture, the effects of climate change on productive croplands and aquatic activity are likely to threaten both the welfare of the population and the economic development of the country (CBN, 2004; Oluwatayo et al., 2009). As indicated by Dabi et al., (2007), many rural households in Nigeria typically have low capacity to adapt because of very limited financial, natural, physical, human and social capital. In Nigeria and other parts of Africa, fish is produced either through artisanal (open water fisheries) or fish farming, which is the raising of fish species in a controlled volume of water. VSO (2002) reported that Egypt and Nigeria among countries in Africa have recently shown growing output in fish production. Fish production contributed 43.97 billion naira to GDP in Nigeria in 1998. This increased to 128.29 billion naira in 2004. Also production from fish farming has steadily increased from 42,000 tonnes in 1998 to 232,000 tonnes in 2006. However, this production is still very low when compared to artisanal fish production that increased from 190,000 tonnes in 1998 to 230,700 tonnes in 2004 (CBN, 2004).

FAO (2008) reported that fisheries and aquaculture contribute significantly to food security and livelihoods especially in the developing countries. For example: Fish (including shellfish) provides essential nutrition for 3 billion people and at least 50 per cent of animal protein and minerals to 400 million people from the poorest countries. Over 500 million people in developing countries depend, directly or indirectly, on fisheries and aquaculture for their livelihoods. Aquaculture is the world's fastest growing food production system, growing at 7 per cent annually.

Overview of Climatic Situation in Nigeria

Climate change impact depends on a range of the climatic parameters such as the countries socio-cultural, geographical and economic backgrounds. The location and size of, and the characteristics relief in Nigeria give rise to six varieties of climate ranging from mangrove, fresh water swamp and rain forest to the south while guinea savanna, sudan savanna and sahel savanna are to the northern part of the country. The climate of the country strides from a very wet coastal area with annual rainfall greater than 3,500mm to the sahel region in the northwestern and northeastern parts with annual rainfall less than 600mm. The inter-annual variability of rainfall, particularly in the northern parts is large; often result in climate hazards, especially floods and droughts with their devastating effects on food production and associated calamities and sufferings. More often than not, certain parts of Nigeria receive less than 75 percent of their annual rainfall and this is particularly worrisome in the north. By virtue of Nigeria's location primarily within the lowland humid tropics, it is generally characterized by a high temperature regime almost through the year. In the far south, mean maximum temperature is between 30^{o}C and 32^{o}C while in the north it is between 36^{o}C and 38^{o}C. However, the mean minimum temperature is between 20^{o}C and 22^{o}C in the south and under 13^{o}C in the north, which has a much higher annual range. The mean temperature for the country is between 27^{o}C and 29^{o}C, in the absence of altitudinal modifications (Oluwatayo *et al.*, 2008).

Based on the projection of Intergovernmental Panel on Climate Change (IPCC, 2001), the humid tropical zone of southern Nigeria, which is already too hot and too wet, is expected to be characterized by increase in both precipitation (especially at the peak of the rainy season) and temperature. Already, temperature increases of about 0.2^{o}C - 0.3^{o}C per decade have been observed in the various ecological zones of the country, while drought persistence has characterized the sudan-sahel regions, particularly since the late 1960s. For the tropically humid zones of Nigeria, precipitation increases of about 2-3 percent for each degree of global warming may be expected (Oluwatayo *et al*., 2009).

Thus, it is reasonable to expect that the precipitation would probably increase by approximately 5-20 percent in the very humid areas of the forest regions and southern savanna areas. The increase in temperature in these areas would also possibly increase evaporation, reducing the effectiveness of the increase in precipitation.

According to IPCC projections, rainfall in the very humid regions of southern Nigeria is expected to increase. This may be accompanied by increase in cloudiness and rainfall intensity, particularly during severe storms. It could also result in shifts in geographical patterns of precipitation and changes in the sustainability of the environment and management of resources. However, since the increase in temperature could increase evaporation and potential evapo-transpiration, there would be tendency towards "droughts" in parts of these humid areas of the country. In fact, recent studies have shown that precipitation decrease in the humid regions of West Africa, including southern Nigeria. Since the beginning of the century, it is about 10-25 percent or about 2-5 percent per decade. If this trend persists, rainfall in the humid regions of southern Nigeria may be about 50-80 percent of the year 1900 values by the year 2100. With increase in ocean temperatures, however, there could be increase in the frequency of storms in the coastal zone of the country. In contrast to the humid areas of southern Nigeria, the savannah areas of northern Nigeria would probably have less rainfall, which, coupled with the temperature increases, would reduce soil moisture availability. Recent studies have indicated that the sudan-sahel zone of Nigeria has suffered decrease in rainfall in the range of about 30-40 percent or about 3-4 percent per decade since the beginning of the nineteenth century. Already, these savanna and semi-arid areas suffer from seasonal and inter annual climatic variability, and there have been droughts and effective desertification processes, particularly, since the 1960s (Ifidon, 2008).

Climatic change will affect fisheries, both the fish farming and catches in open water. Abandonment of some active fishponds was noticed in Osun State for some years back. Among the reasons given by the owners (victims) of these fishponds during the study include dryness of source of water, flooding of fishpond, spillage due to destruction of dykes by flooding and low marginal profit of the enterprise. Though, some of these problems could be traced to poor knowledge level of fish farmers, majority were attributed to climatic change. Knowledge of the climate conditions of Nigeria and the adaptation options available to fish farmers would assist policy makers to decreasing vulnerability of fish farmers to problems of climate change.

OBJECTIVES OF THE STUDY

The specific objectives of the study are to

(i). identify the socio-economic characteristics of fish farmers in Osun State, Nigeria;

(ii). determine the perception of fish farmers to climate change;

(iii). determine factors responsible for the choice of adaptation strategies by fish Farmers; and

(iv). identify adaptation strategies of fish farmers and the extent of use of the Strategies.

METHODOLOGY

The study was carried out in Osun State, Nigeria. Osun State is made of thirty Local Government Areas (LGAs). It is situated in the rainforest zone of the country with pockets of derived Savanna. Osun State is found in the southwestern part of Nigeria. It lies between Longitude 21.65^0 and 6.75^0 East of Greenwich meridian and Latitude $6^o59'$ and 9^0 North. Ondo and Oyo State bound it in the East and West, respectively while Kwara and Ogun States are its boundaries in the north and south respectively. The State has landed area of 925,100 hectares or 9251 square kilometres with population of 3,423,535 according to 2006 population census in Nigeria. Fish farmers were the targets of the study. The State was divided into three agricultural zones namely Iwo, Osogbo and Ife/ijesa under the Osun State Agricultural Development Programme (OSSADEP). The division was due to climatic variability as experienced by the vegetation in each zone.

DATA COLLECTION

Data were collected from active fish farmers in Osun State. These are the farmers that carry out routing management practices on their fish farms as at when due. Proportionate sampling technique was used to select three hundred (300) fish farmers from the three agricultural zones. The proportion of number of registered fish farmers in each agricultural zone was used to select respondents. The number of respondents selected was 72, 103 and 125 from Ife/Ijesa, Osogbo, and Iwo zone, respectively. Data collected include perception of climate change, adaptation strategies to climate change, and the extent of use of the adaptation strategies apart from socio – economic variables. The adaptation strategies for this study were based on asking farmers about their perceptions of climate change and the actions they took to reduce the impacts of climate change.

ANALYTICAL METHODS

Dependent variables are the adaptation strategies. This is the number of adaptation strategy indicators employed by each farmer. These are reinforcement of dyke, provision of shade, practice of polyculture, ensure free flow of water, change stocking period and provision of reservoir.

Multinomial Logit (MNL) model was used to determine the extent of usage of the adaptation strategies. . Kurukulasuriya and Mendelsohn (2006) and Seo and Mendelsohn (2006) used MNL model to analyse crops and livestock respectively on choice of respondent's adaptation on the negative impact of climate change. MNL was used because it permits analysis of decision*s* across more than two categories, allowing the determination of choice probabilities for different categories.

In MNL model, if y denote a random variable taking on the values of {1,2…J} J denotes a positive integer, and if x denote a set of conditioning variables. In this case, y denotes adaptation options and x contains respondents attributes like age, education etc.

Let χ be a l x k vector with first element unity. The MNL model has response probabilities:

$$P\,(y = j|x) = exp\,(x\beta_j) \,/\, [1 + \sum_{h=1}^{j} exp(x\beta h), J = 1 \ldots$$

Information on climate change was also positively significant with Reinforcement of Dyke and Change of Stocking Period; Where β; is k x1, j =1….j

For this study, the adaptation strategies were six:

(1) Reinforce the dyke with clay or even concrete
(2) Provision of shade with plantain or other crop
(3) Practice polyculture
(4) Ensure fresh water frequently
(5) Change stocking period due to climate change
(6) Provision of reservoir between fishpond and source of water.

Parameter estimate of MNL model require that the probability of using a certain adaptation option (that is Pj |Pk is independent of the remaining probabilities).

Uj = βj Xj +∑j and Uk = β k Xj +∑k..

Uj and Uk are perceived utilities of adaptation options j and k, respectively, Xj is the vector of explanatory variables that influence the perceived desirability of the method, Bj and Bk are parameters to be estimated, and ϵj and ϵk are error term (Green,2000).

The parameter estimates of the MNL model provide the direction of the effect of the independent variables on the dependent (response) variables. Parameter estimate coefficient provides the actual magnitude of change or probabilities in SPSS. The marginal effects measures the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Koch,2007).

Adaptive Strategies Use Index (ASUI)*:* ASUI was used to access the extent of use of the different climate change adaptive strategies by fish farmers. In analyzing the extent of use of any of the options by fish farmers, an Adaptive Strategy Index (ASI) was developed by ranking. The extent of use of the ASI was then expressed using a four-point scale with the scoring order 3, 2, 1 and 0 for frequently used, occasionally used, rarely used and not used respectively. The formula to obtain the ASI score was adapted from Islam and Kashem (1999) where they estimated the use of Ethno-veterinary medicine in livestock management and rearing. This was modified to obtain the ASI as: N_1 x3 + N_2 x2 + N_3 x 1 +N_4x 0

Where,

ASUI = Adaptive strategies use index

N_1= Number of fish farmers using a particular ASI frequently

N_2= Number of fish farmers using a particular ASI occasionally

N_3= Number of fish farmers using a particular ASI rarely

N_4= Number of fish farmers not using any of the adaptive strategies.

The ASUI was used in rank order to reflect the relative position of each of the ASI in terms of their use. The extent of use of the ASI was then obtained for the sampled fish farmers in the study area.

RESULTS AND DISCUSSION

Characteristics of Fish Farmers

Data in Table 1 show that the mean age of fish farmers in Osun State was 48 years. Majority (92%) were male. This shows partial involvement of female in fish farming in the State. This supports the findings of Adesoji (2009). Also majority (96.7%) were married. This means that fish farming is a major occupation for the married people in the study area probably for obvious family labour supply.. Only 7.6 percent of respondents had no formal education. The mean year of schooling was 12 years and standard deviation of 5.4. Majority (77.5%) of fish farmers were part time farmers while the mean years of fish farming experience was 8 years. Extension contact was not very encouraging, only 51.7 percent had contact with extension for training in fish farming practices. This may be due to the fact that very few farmers joined fish farmers association and extension is tending more towards group demand-driven extension advisory services in Nigeria.

Fish Farmers' Perception of Climate Change

Data in Figure 1 show that majority (74.5%) of fish farmers in Osun State perceived that there is a change in climate, which affected their fish farming. These changes are high temperature leading to low level of water, low rainfall and at times very high and stormy rainfall which may lead to flooding and spillage of fishpond dyke. But only 28.1 percent of these farmers attempted to take precautions (adaptation) that could reduce the impacts of the climate change. The adaptation strategies that farmers reported are reinforcement of dyke, provision of shade, practice of polyculture, ensure free flow of water, change stocking period and provision of reservoir.

These were assumed that their actions and perception were driven by climate factors rather than profit based on Maddison (2006) method.

Data in Table 2 show the parameter estimate for marginal effect (coefficient) of Multinomial Logit Model that measures the expected change in probability of a particular choice of adaptation with respect to a unit change in an independent variable.

Age of respondents show a positive sign towards all the strategies of adaptation. This shows that as the age of fish farmers increases, the probability of increase in the choice of adaptation strategies to climate change also increases. If the age of fish farmers were to increase by 1 year, the multinomial log of preferring reinforcement of dyke as an adaptation strategy would increase by 0.086 units while holding other strategies at a constant. Also, the probability of chosen provision of shade and practice of polyculture would also increase by 0.082 and 0.086 units respectively. If the age of fish farmers were to be increased by 1 year the choice to increase adaptation of ensuring free flow of fresh water, change of stocking period, and provision of reservoir by 0.085, 0.089 and 0.084 units, respectively. All the six adaptation strategies were positively significant at 1 percent for age of fish farmers in Osun State.

Fish farming experience, which is a factor of age, also influences the choice of some adaptation strategies. For example, if the fish farming experience of fish farmers in Osun State could be increased by 1 year, the probability of chosen reinforcement of dyke as an adaptation strategy would increase by 0.004 units. This is significant at 10 percent. Also the probability of chosen provision of shade as an adaptation strategy would also increase by 0.017 units, $P \leq 0.05$; and the choice of provision of fresh water significant at $P \leq 0.01$ and change of stocking period significant at $P \leq 0.05$ would increase by 0.013 and 0.004 units, respectively.

Education, which was measured by years of schooling, is another very important factor that influences choice of adaptation strategy by fish farmers in Osun State. All the six adaptation strategies considered in the study were positively significant at $P \leq 0.05$. If the years of schooling could be increased by 1 year, the choice of reinforcement of dyke as an adaptation strategy would increase by 0.085 units. Likewise, provision of shade, practice of polyculture and ensuring provision of fresh water's choice as adaptation strategies would increase by 0.081, 0.083 and 0.083 respectively.

Extension contact was positively significant at $P \leq 0.01$ with the choice of ensuring provision of fresh water as an adaptation strategy for fish farmers. An increase in extension contact by 1 unit would increase the choice of ensuring provision of fresh water by 0.289 units. Parameter estimate show a negative sign for choice of provision of shade, practice of polyculture and provision of reservoir. This means that the choice of these adaptation strategies would decrease with increase in extension contact. But the coefficient was not significant enough to influence their choice as adaptation strategies.

Information on climate change was also positively significant with reinforcement of dyke and change of stocking period as adaptation strategies. For example the Multinomial log show that if the source of information on climate change to fish farmers could be increased by 1 unit, the probability of choice of reinforcement of dyke as an adaptation strategy would increase by 0.453 units. Also if the sources of Information on climate change could be increased by 1 unit, the choice of change of stocking period of fish farmers as an adaptation strategy would increase by 0.395 units. Parameter estimate has negative effect for provision of shade, practice of polyculture, ensuring provision of fresh water and provision of reservoir as adaptation strategies. This means that when the source of information on climate change increases, the choice of these adaptation strategies will decrease. However, the coefficient was not significant enough to influence their choice as adaptation strategies.

Parameter estimate show a positive sign for size of fishpond and all the six adaptation strategies. This means that size of fishpond would positively influence choice of adaptation strategy of fish farmers. However, only reinforcement of dyke was significant at 10% level to be chosen. This shows that as the size of fishpond increases by 1 unit, the choice of reinforcement of dyke as an adaptation strategy would not increase (0.00). It is important to note here that sex, marital status, size of household; farm type and income have no significant effect for the choice of any of the six adaptation strategies discussed. This means that sex, whether male or female does not influence choice of adaptation strategy. Also whether married or single, (marital status) does not influence the choice of an adaptation strategy. Farm type, whether full or part time; and income do not influence the choice of an adaptation strategy of a fish farmer.

Determining factors influencing farmers' choice of adaptation strategies

The significant adaptation strategies could be used to determine important factors influencing fish farmer's choice of adaptation strategies. For example, education increases the probability of adaptation to climate change. Moreover, all the marginal values of education are positive across all adaptation strategies (shown by parameter estimate). This indicates a positive relationship between education and adaptation to climate change.

Age and fish farming experience also influenced adaptation to climate changes. All the marginal values are also positive. This indicates a positive relationship between fish farming and adaptation to climate change. Extension contact and information (information factors) in like manner influenced adaptation to climate change. Almost all the marginal values are positive across adaptation options indicating a positive relationship between institutional factors and adaptation to climate change. Size of fishpond is another factor that positively influenced adaptation of climate change. These factors are very germane to policy decision-making especially for fish farmers in Nigeria.

Adaptation Strategy Usage Index (ASUI)

Data in Table 3 show the frequency of usage of the climate adaptation strategies, using Adaptive Strategy Index (ASI). The results show that reinforcement of dyke ranked best among the six adaptation strategies considered in this study. This shows that flooding which can cause spillage was one of the problems troubling fish farmers in Osun State and they use dyke reinforcement to reduce the impact. This was followed by provision of shade. Provision of shade is a strategy that is prominent among small scale fish farmers. Osun State has majority of fish farmers as small scale (Adesoji, 2009). Practice of polyculture ranked third while ensuring free flow of fresh water ranked fourth. Polyculture is based on the idea that climate change may cause the death of some fish species while the hardy ones would survive the unpleasant climate. However, this may not be economically viable. Free flow of fresh water is necessary in fishpond, but it might be a mirage when the source of water is dried or getting dried to the extent that enough water could not be supplied. This could occur if the dry season is extended; and intensity of sunlight evaporates available water. Change of stocking period and provision of reservoir ranked fifth and sixth respectively among the six adaptation strategies. Changing of stocking period is possible when it is possible to predict that climate would be unfavourable. This would be possible when fish farmers have the knowledge of climate change variability. Provision of reservoir is an adaptation strategy that attracts few people; this might not be unconnected with the high cost of this strategy. The reservoir will conserve excess water that could cause flooding during the period of heavy rainfall; and such water is released into the fishpond when there is water stress during long dry periods. Apart from the fact that construction of reservoir is expensive, another challenge facing small-scale fish farmers that lined the wet lands and river banks with their ponds and use plantains and banana trees as shades is that most of the wetlands and river banks are completely submerged in water during all the peak periods of rainy season. This requires experience to get rid of excess water so that the fishpond may not be flooded. This makes their production seasonal when the experience is lacking.

CONCLUSION AND RECOMMENDATIONS

Climate change like high temperature, low rainfall and at times very high and stormy rainfall which may lead to flooding and spillage of fishpond dyke affects fish farmers like any other farmer. These farmers adapted to climate change by using different strategies such as reinforcement of dyke, provision of shade, practice of polyculture, ensure free flow of water, change stocking period and provision of reservoir. Majority of the fish farmers perceived climate change through extreme variations in weather conditions and its attendant effects on fish farming even though few of them made efforts to reduce the impacts.

The study identified some factors like fish farming experience, education, information and size of fishpond as vital factors that influences choice of adaptation strategies to climate change in fish farming; and could be considered when planning and implementing policy for fish farmers especially on climate variability.

RECOMMENDATIONS FOR POLICY MAKERS

1 Awareness about climate change should be raised through community and group approaches among fish farmers with appropriate adaptation strategies, which can be part of programme content for empowerment

2 Periodic information should be provided in print and electronic media for fish farmers on functional group basis through effective and relevant advisory services..

3 Adaptable fish species should be developed that will be resistant to harsh weather conditions. This will be a major focus of action for Ecological Fish Hatchery Centre as suggested by Farinde and Adesoji (2008).

4 Fish farming experience, education, information and size of fishpond are some of the important factors to be considered when planning and implementing adaptation strategy policies for fish farmers.

5 When fish farmers perceived heavy rainfall that may cause flooding, extension agents should be invited to guide them on the appropriate adaptation strategy and necessary adjustment to the fishpond.

6 In places of frequent high temperature leading to low level of water in fishpond, reservoir should be provided with the fishpond to supply water when the level of water becomes very low.

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Table 1: Distribution of fish farmers by Age, Sex, Marital status, Education, Extension contacts, and Fish farming experience

N =300

Variables	Freq.	Percentage	Mean
Age			
20 – 40	49	16.3	
40 – 60	244	78.1	
< 60	17	5.6	48
Sex			
Female	20	6.6	
Male	280	92.7	
Marital status			
Single	8	2.6	
Married	292	96.7	
Years of schooling			
No education	23	7.6	
1 – 6 years	27	9.0	
7 – 12 years	153	51.0	12
13 – 18	67	22.3	
> 18 years	30	10.0	
Fish farming experience			
1 – 4 years	66	21.8	
5 – 8	234	77.5	8 years
Extension contact			
No	144	47.7	
Yes	156	51.7	

Source: Field survey, 2009

Table 2: Parameter estimates and marginal effects from multinomial logit climate change adaptation model for fish farmers.

Explanatory variables	Reinforce dyke		Provision of shade		Practice polyculture		Ensure provision of freshwater		Change stocking period		Provision of reservoir	
	coeff	Sig.	Coeff	Sig.	coeff	Sig.	coeff	Sig.	coeff	Sig.	coeff	Sig.
Age	0.086^{***}	0.000	0.082^{***}	0.000	0.086^{***}	0.000	0.085^{***}	0.000	0.089^{**}	0.023	0.084^{***}	.000
Sex	-0.261	0.656	-0.317	0.590	-0.385	0.509	-0.360	0.539	-0.351	0.552	-0.387	0.506
Marital status	-0.432	0.635	-0.622	0.494	-0.532	0.557	-0.503	0.580	0.362	0.683	-0.528	0.559
Size of household	-0.228	0.343	-0.313	0.198	-0240	0.316	-0.232	0.332	-0.272	0.264	-0.229	0.337
Years of schooling	0.085^{***}	0.002	0.081^{***}	0.003	0.083^{***}	0.002	0.083^{***}	0.002	0.085	0.002	0.080^{***}	0.003
Farm type	0.008	0.995	0.108	0.929	0.162	0.896	0.101	0.936	0.213	0.874	0.160	0.897
Extension contact	0.299	0.300	-0.326	0.257	-0.292	0.309	0.289^{*}	0.094	0.309	0.283	-0.029	0.312
Fish farming experience	0.004^{*}	0.101	0.017^{**}	0.051	0.016	0.882	0.013^{***}	0.005	0.004^{**}	0.047	0.015	0.893
Information on climate change	0.453^{**}	0.044	-0.399	0.200	-0.283	0.684	-0.427	0.167	0.395^{*}	0.094	-0.424	0.170
Income	0.000	0.933	0.000	0.890	0.000	0.996	0.000	0.987	0.000	0.999	0.000	0.999
Pond size	0.000^{*}	0.080	0.000	0.147	0.000	0.132	0.000	0.126	0.000	0.152	0.000	0.126

xxx - 1%
xx - 5%
x - 10%

Source: Field survey,2009

Table 3: Ranking of Climate Adaptation Strategies by Frequency of Usage

Adaptation Strategies	Frequently used	Occasionally Used	Rarely Used	Not Used	ASUI	Percent of respondents	Rank
Provision of shade	200	20	15	9	655	25	2
Polyculture	107	62	7	24	452	17.3	3
Reinforce Dyke	160	104	98	64	786	30.0	1
Ensure Free Flow of water	110	4	32	60	370	14.1	4
Change stocking period	99	18	22	10	355	13.6	5
Provision of reservoir	0	0	2	102	2 ∑= 2620	7.6	6

Source: Field survey, 2009

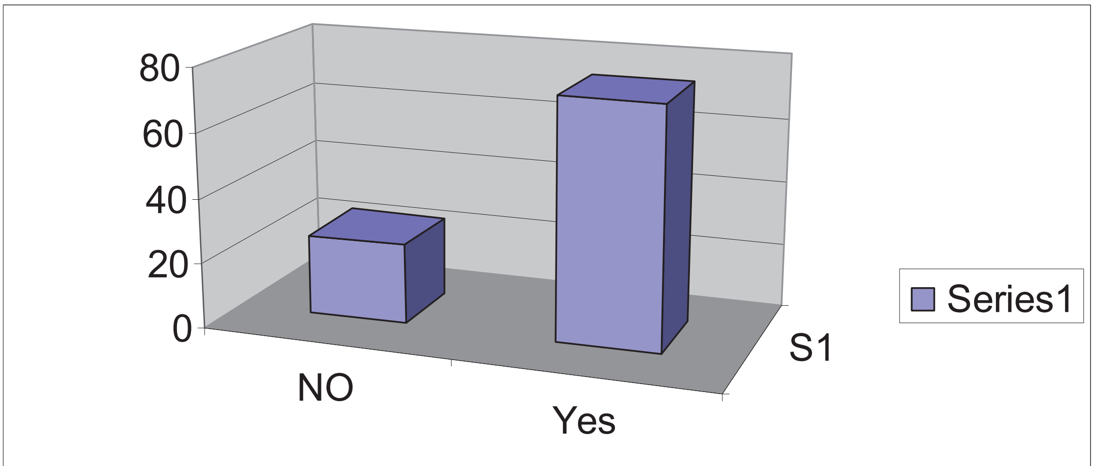

Fig.1:Perception of fish farmers to Climate Change

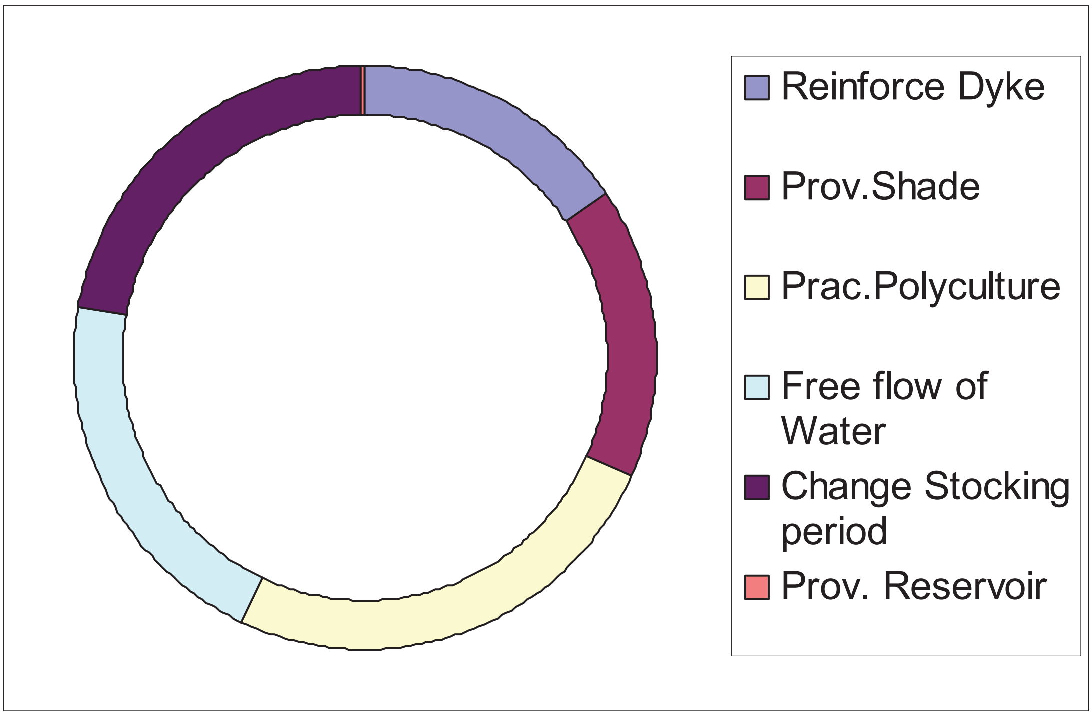

Figure 2: Adaptive strategies used by fish farmers to reduce impacts of climate change.

Source: Field survey, 200

GRAIN INSECT-PEST DISINFESTATIONS IN A SITUATION OF CLIMATE CHANGE: TOWARDS ADOPTION OF GENDER RESPONSIVE POSTHARVEST TECHNOLOGIES FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN NIGERIA.

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Abstract

The paper explores the relationship between stored-grain insect pests and climate change, distribution of losses along crop production chain, the conventional grain drying and storage systems among Nigerian farmers, relationship between postharvest biotechnologies and climate change; practical guiding principles for effective on-farm grain storage, and features of gender responsive on-farm technologies appropriate for curbing the escalating on-farm postharvest grain loss in Nigeria. Exploratory methodological approach was adopted in eliciting the secondary data used in this paper. Postharvest loss constitutes more than 70 percent of the annual loss experienced by average grain growers in Nigeria. On-farm postharvest grain loss is contributing significantly to the current food insecurity because of the inadequate drying and storage systems available to Nigerian farmers. Grain insect pests produce CO_2 among other respiratory products; contributing to the concentration of CO_2 in the atmosphere (although insignificantly), which is a potential greenhouse gas causing climate change. Climate change, particularly increase in temperature, on the other hand, enhances the multiplications of insects and micro-organisms within the stored-grain eco system, especially in the tropical region. Postharvest activities are traditionally women's responsibilities, coupled with the fact that women are the majority of the agricultural workforce in Nigeria. Consequently, adoption of gender responsive postharvest technologies will produce feasible sustainable agricultural development in Nigeria.

Keywords: Grain Insect pests, Disinfestations, Climate change, Gender, Postharvest technologies, Sustainable, Agricultural development, Nigeria.

INTRODUCTION

Growing cereals and protecting them until use for seeding and/or consumption have been major preoccupation of human being since the inception of the agriculture about 10, 000 years ago (Sinha, 1995). A larger population of Nigerian farmers grow cereal grains for consumption and sales. Grain is a major component of food in Nigeria, cutting across all age categories. Population of 53 developing countries derive 40% of all food energy from cereals (World Almanac and Book of Facts, 1991). Human population which consumes cereal food was estimated to be about 200 million in 1 A.D. as compared with 5.3 billion in 1990 and projections of 6.1 billion in 2000 and 8.1 billion in 2025 (World Almanac and Book of Facts, 1991). With the ever increasing demand for cereals for human consumption, any losses during production and storage can have an adverse effect on the human population.

The common knowledge about biotechnology limits its application to the production stage of agriculture, which involves the manipulation of the plants' and animals' genetically in order to increase food production. One of the less recognized aspects of biotechnology is its application at the postharvest stage of agricultural production. A broad definition of biotechnology is "The application of indigenous and/or scientific knowledge to the management of (parts of) microorganisms, or of cells and tissues of higher organisms, so that these supply goods and services of use to the food industry and its consumers" (Bunders et al., 1996). This definition encompasses the postharvest biotechnologies, which involves the application of scientific knowledge of the thermal properties of the insect pests and micro-organisms within various stored-crops eco-systems to manage their infestation through the application of scientific heating systems such as radio frequency and microwave. Biological engineering is a branch of engineering that focuses on biotechnologies and biological sciences, and includes different disciplines such as biochemical engineering, biomedical engineering, bio-process engineering, biosystems engineering, etc (Anonymous, 2009). Postharvest biotechnologies are the products of the biosystems engineering, focusing the postharvest stage of agricultural production. Postharvest biotechnologies become most significant in the developing countries' agricultural development, because lack of adequate postharvest handling systems is a major problem confronting the agricultural production in these nations.

When quantity and quality of crops produced outweighs quantity and quality distributed after production (due to post harvest loss) there is bound to be food insecurity. Food security is not based on how much is produced but how much is available for distribution and eventual utilization and consumption by the people. Hence, there can be hunger and food scarcity in the midst of plentiful food production if adequate strategies are not adopted to minimize crop loss after production.

Insect pests are the major infesters of stored grain. Over 100 species of insect pests have been found in stored grain and over 355 species of mites have been recorded in stored products (Sinha, 1991).Current primary natural reservoirs for stored product insect pests are bark and decomposing wood, nests and food caches of other insects, all of which can be found near man-made storage structures (Linsley, 1944), and infested grain residue and storage containers (Smith and Barker, 1987; Cink and Harien, 1989). The stored grain ecosystem is the most suitable environment for many categories of insect pests, especially fungivores and seed primary feeders. Proper drying of the grains after harvesting can minimise insect pest infestations during storage. The complex interaction among the animals as fungivores, granivores, predators or parasites, and the environment, the microflora and the stored grain or other food result in ongoing population fluctuations, species succession, and degradation of human food (Sinha, 1973a; b ; Wallace and Sinha, 1981).

Understanding of the complexity in the interaction between the grain insect ecosystem and the climatic conditions is significant to effective "war against climate change". Likewise awareness about the gender issues relating to postharvest activities is essential for effective gender responsive technological intervention required for sustainable agricultural development in Nigeria. Gender is a social construct which is based on societal cultural norms and values that defines the roles and responsibilities, opportunities and privileges, of an individual within the society. Gender responsive technologies are those innovations without any bias (social, biological, and economical) to the gender of the user. Some of the agricultural technologies adopted in Nigeria are gender specific; mostly designed for either men or women gender. Examples of such gender specific agricultural technologies are tractor, harvester, and most chemical application equipments, etc, are designed for men. Traditionally, women and children (male and females) are the majority of the agricultural workforce in Nigeria, especially the postharvest activities; hence gender responsive technologies will be more appropriate for curbing the prevailing postharvest loss in Nigeria.

OBJECTIVES OF THE STUDY

This paper was conceived to help define the complex relationship between insect pest ecosystem and climate change as a basis to identifying gender responsive postharvest technologies for grain pest disinfestations in Nigeria through the following specific objectives:

- Describe the relationship between stored grain pests and climate change;
- Discuss the distribution of loss incurred by grain farmers in Nigeria along the crop production chain;
- Document the conventional on-farm postharvest grain handling methods among Nigerian farmers;
- Describe the relationship between postharvest biotechnologies and climate change; Highlight the principles guiding effective on-farm grain storage; and
- Discuss the features of appropriate gender responsive on-farm postharvest technologies for Nigerian farmers' adoption.

STORED GRAIN INSECT PESTS AND CLIMATE CHANGE

A stored-grain bulk is a manmade ecological system in which deterioration of the stored products results from interaction among the physical, chemical, and biological factors (Jayas, 1995). Post harvest food losses are estimated to range from 9% in the United States, but up to 50 % in some developing nations (Sinha, 1995).

Effective grain storage involves minimising the infestation of the grain by pests. Much of the loss results from invasion of the grain mass by microflora, arthropod, and vertebrate pests. Most developing countries lack appropriate technological devices to store excess cereal grain produced during bumper seasons. Investigations by the lead author identified conventional grain disinfestations strategies among Nigerian farmers such as: hanging the grain-bulk over fire sources in the house, sun drying, spraying with fumigants, storing in local airtight containers such as drums and sacs, underground and under house-roof storage, etc. These conventional grain disinfestations are mostly inadequate as they can not be used conveniently for considerably large quantity of grain over a longer period of time. Losses of food grain in developing countries arise from deficiencies in farmers' handling and storage methods (Sode *et al.,* 1995).

Heat, moisture and CO_2 are produced during deterioration of grain by the pests. The generated heat, moisture, and CO_2 move within and out of the grain mass, even to the surrounding atmosphere. The CO_2 produced is consequently released into the atmosphere thereby contributing to increase in greenhouse gases in the atmosphere. Greenhouse gases effect in the atmosphere results in global warming and consequently, climate change. Climate change is a phenomenon whereby the weather conditions becomes unpredictable due to alteration caused by the emitted heat by the greenhouse gases interruption such as CO_2, water vapour, and others from the earth surface to the atmosphere.

The survival and reproduction of biological agents (insect pests, micro-organisms, etc) in grain bin are dependent to a great extent on the external temperature and moisture levels. Heat produced from the respiration of the biological agents in the stored grain bulk is transferred to the surrounding environment based on the temperature gradient. According to Sinha (1995) the climate and storage conditions are generally more favourable for pests in the developing countries as compared with developed countries.

The amount of solar radiation striking the storage structure is dependent on the annual number of cloud free hours and the latitude and altitude of the location (Jayas, 1995), which influences the multiplication of the biological agents inside the grain bin. The higher the rate of multiplication of the pests inside the grain bin, the higher the level of CO_2 produced and discharged to the surrounding atmosphere. The higher the concentration of CO_2 and other greenhouse gases in the atmosphere, the higher the intensity of the consequences of climate change such as increase in atmospheric temperature; which often enhances multiplication of the stored grain pests, especially in the tropical region, including Nigeria. When humidity conditions are favourable in materials with relatively high moisture contents, the insects and mites multiply rapidly to form dense populations and have rapid developmental periods and short life span (White, 1995). Dispersal is important to the success of insect species; stored product insects usually walk in temperate regions but they may fly on warm days if they are morphologically able to do so, and in tropical regions they fly frequently (Taylor, 1971). Increase in temperature is a basic consequence of climate change in the tropical region, which enhances the movement of the pests from one place to another thereby increasing their chance of survival.

Agricultural and industrial activities on the earth has contributed significantly to the destabilization of the CO_2 and other green house gases in the air, thereby causing a geophysical mechanism called global warming. Fumigants such as Methyl Bromide (MeBr), Phosphine, etc are still conventionally used in postharvest grain handling at the farm, household and industrial levels. MeBr has been found to contribute significantly to the depletion of ozone layer of the atmosphere since 1992 (Wang and Tang, 2004), apart from its negative impact on human health. About 80% to 95% of the MeBr used for a typical commodity treatment eventually enters the atmosphere (Wang and Tang, 2004). Use of chemical fumigants in postharvest crop handling is particularly common among the less technologically developed countries like Nigeria. Developing counties were required to freeze consumption and production of MeBr in 2002, reduce it by 20% in 2005 and phase it out by 2015 (USEPA, 2001). The impact of the ban on the use of fumigants in crop preservation is most felt by the developing countries due to their low level of technological development, especially in postharvest crop handling.

DISTRIBUTION OF LOSS ALONG CROP PRODUCTION CHAIN IN NIGERIA

Figure 1 gives an illustration of the distribution of the loss encountered by average Nigerian grain farmers along the crop production chain.

An average Nigerian farmer starts experiencing loss from the point of planting the seed on the field to the last stage of marketing the agricultural produce. Most of the loss encountered is attributed to the use of crude implements common among Nigerian farmers.

The global climatic change is aggravating the difficulty of predicting the climatic condition. Nigerian farmers traditionally depend on the frequency of the rainfall to predict the appropriate time to plant crops. Nowadays, farmers often fail in their predictions due to uncertainty of climatic condition warranted by climate change. Farmers usually plant crops after two or three consecutive rainfalls; they often end up losing a large number of the seeds that managed to germinate due to unexpected subsequent high temperature resulting from climate change. Rodents often take the advantage of the onset of raining season, which boost bush growing especially around the farmland to further attack and destroy some of the seed planted and the ones that survived the intensive temperature on the field. Other sources of crop loss are insect and microorganisms infestations, both in the field and during storage.

Taylor (1977) postulated that although losses in stored products are not always apparent or fully appreciated, they constitute a major proportion of loss resulting in decrease in the quantity and quality of food available for consumption, income, and standard of living of agricultural producers. Agboola (1985) indicated that inefficient postharvest and storage techniques and practices (such as sun drying, storage in local containers, etc) which led to extensive spoilage and waste were the most important factors responsible for the present food shortage in Nigeria. Onayemi (1981) stated that the major causes of postharvest food losses include biological, microbiological, mechanical and physiological factors as well as insufficient drying, inadequate storage facilities, transportation and marketing facilities and poor processing equipment. Illustration in Fig. 1 also affirms that most of the losses occur at the postharvest stage of crop production chain. The moisture content of the grain before storage usually influences the effectiveness of the storage facility used in disallowing pest infestations.

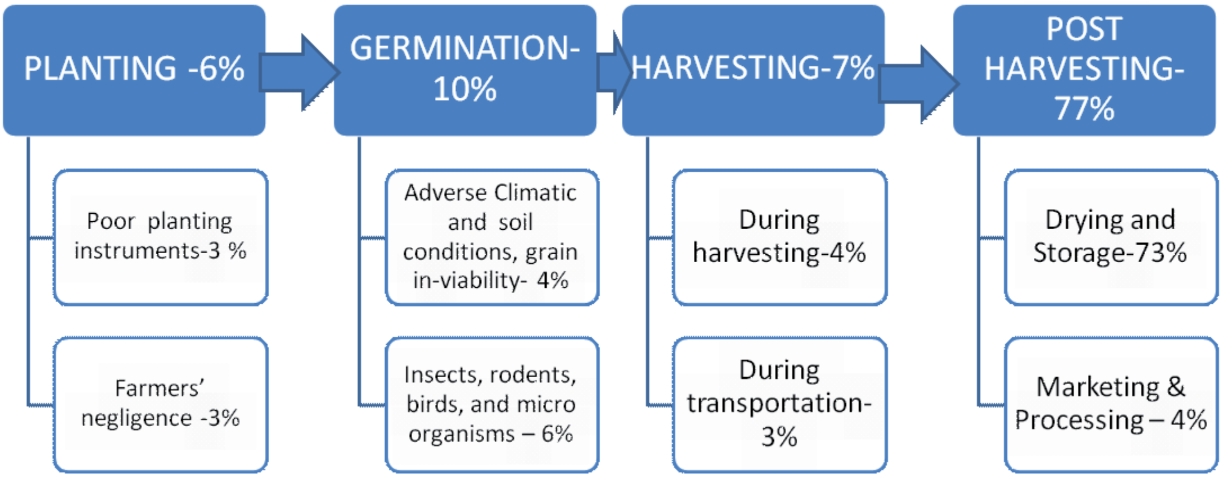

Figure 1: Hypothetical Model Showing the Distribution of Loss Experienced by Nigerian Farmers along the Crop Production Chain (Deji, 2008a).

CONVENTIONAL GRAIN DRYING AND STORAGE SYSTEMS AMONG NIGERIAN FARMERS

Most of the postharvest grain handling in Nigeria is carried out at the farm and household levels, which is the focus of this paper. There is low level of industrial postharvest grain handling in Nigeria, compared to the developed countries.The most common conventional grain drying method among Nigerian farmers is sun drying. Grains are dried under the sun on the field before harvesting, and after harvesting. Sun drying becomes more popular among the farmers in the tropics because it is cheap and readily available over a longer period of time annually. Chancellor (1965) and, Soetoyo and Soemardi (1979) demonstrated that paddy can be dried from 24-26% moisture to 14% moisture at depths of 50-100 mm at a rate of 3.3 kg/m².h for stirred paddy and 1.9 kg/m².h for unstirred paddy. To minimize cracking and over heating of the grains during extremely hot weather, the paddy can be covered with a transparent but good heat permissive sacks or at best sun drying can be done under a shady platform; although longer period will be required for desirable drying.

Grains are also sun- dried on a concrete platform or raised platform (crib) under the sun. Traditionally, a specific location is cleared and leveled, around the farmland for the purpose of drying crops and other farm produce on yearly basis. During the dry season, the grain is left on the ground for days with regular turning and raking on a daily basis to enhance uniform heat distribution required for maximum and uniform drying. Regular uses of an area for sun-drying smoothened the ground and reduce level of contamination of the crop with unwanted materials. Cribs are often used for secondary drying and storage of the grains after it has been removed from the open smoothened ground. Drying is mostly through solar radiation and depends on the intensity and availability of solar energy. Conventional sun-drying methods in Nigeria expose the grains to contamination by insect pests, micro-organisms, and dockages that influence insect infestation and grain deterioration. Other traditional grain disinfestations practices among Nigerian farmers include; storing the grain with dried whole or grinded pepper, and use of chemical fumigants, such as Methyl Bromide, Phosphine, etc.

Okereke and Nwosu (1987) reported the regional variation in conventional grain drying and storage strategies among Nigerian farmers. Maize grains in South Eastern part of Nigeria are traditionally stored in tree trunks, on platforms or vertical poles, or heaped on the bare floor at one corner of the living apartment with no additional care. Platforms are constructed over the fire places to hasten drying and ward off insects, rodents, and micro-organisms infestations. In the North, grains are stored traditionally in the underground pits and in a rhombus. The rhombus is a cylinder bowl made of clay and grasses with a dome shaped top. It rests on large stones to minimise direct contact with the ground. It is fairly cheap to construct, simple, and relatively effective.

The general problem associated with the conventional grain storage methods in Nigeria is that they do not totally eliminate deterioration and subsequent loss (Okereke and Nwosu, 1987). In addition, the interaction of the grain bulk, thermal properties of the storage facilities, and ambient temperature fluctuation, cause unequal moisture distribution within the grain mass. This condition generates thermal gradient within the grain mass. If there is no outlet for the accumulated moisture within the grain mass, condensation will occur. Moisture condenses when the dew point is reached leading to deterioration of the stored grain and consequently invasion by fungi and insects (Okereke and Nwosu, 1987). Pre-storage moisture content of the grain influences the effectiveness of storage facility or method adopted.

The microbial deterioration of cereal grains are relatively high in the Southern Nigeria where such crops are harvested during the wet/rainy months of the year (Oyeniran, 1973; 1978). At the time of harvesting, the moisture content of corn is about 25% which is well above the safe moisture level of 13% (Adesuyi, 1970). The level of solar energy needed to bring freshly harvested grains to the safe moisture level of less than 14% is usually not easily available. Even when the farmers succeeded in reducing the moisture level of the harvested crops to the safe level through a combination of conventional drying systems, the grains are susceptible to attack by insects, rodents, and micro-organisms during storage in the poor storage facilities available to the farmers. Hence, both drying and storage are significant in determining effective postharvest grain handling.

Grains are highly susceptible to mould infestation when not sufficiently dried before storage, especially during the wet season of the year, when relative humidity is usually high. The specific way by which moisture plays its role in microbial deterioration were suggested by Oyeniran (1978) as condensation and moisture migration. Formation of water as a result of condensation of moisture migration in stored dry products encourages attacks by moulds, some of which causes discoloration of the products, loss of flavour and production of aflatoxin (Oyeniran, 1978). Oyeniran *et al.* (1983) in their microbiological studies on maize isolated the following, moulds from maize stored in miniature silos: *Aspergillus flavus, A. niger, A. famari, Fusarium moniliforme, Paecillomyce varioti, Penicillium spp*. and *Rhizopus arrhizus*. *A. flavus* was most abundant of the fungi and the most serious storage fungus of grain, especially corn. *A. Flavus* is the organism that produces aflatoxin in mouldy grains. Oyeniran (1977) reported that aflatoxin and mould content of corn increased with increasing moisture content. Morris (1962) has shown that certain relationships exist between the water activity (a_w), temperature, and nutrition. First at any temperature, the ability of micro organisms to grow is reduced as the a_w is lowered. Secondly, the range of a_w over which growth occurs is greatest at the optimum temperature for growth; and thirdly the presence of nutrients increase the range of a_w which the organisms can survive. Thus a change in temperature or nutrient content might permit growth at lower values of a_w. Investigations by Marth and Calonog (1976) showed that the optimum temperature for aflatoxin production appears to be at 24-28 ^{o}C, which is the normal ambient temperature of grain storage in Nigeria. Aflatoxin production can occur under any and all conditions that allow for good fungal growth.

Among human conditions believed to result from aflatoxin ingestion is the EFDV syndrome of Thailand, Reye’s syndrome of Newzealand (Butler, 1974) and acute hepatome observed in South African Bantus who consume mouldy grains. Deger (1976) has shown that two men who worked with purified aflatoxin developed colon carcinoma. Thus the danger concerning mould infestation of grains is not only with the quantity and quality loss of nutrients but also with the possible harmful effects of the toxic metabolic by-products of their activities in the grains on human beings.

BIOTECHNOLOGIES, CLIMATE CHANGE, AND WOMEN FARMERS’ EMPOWERMENT

Insects infested 11% of grain stored in a temperate region such as Germany in 1976 but declined to 1.2% in 1986 because of better storage management, indicating that effective techniques are available for pest control in developed countries (Stein, 1991). The current modern postharvest technologies for grain drying and storage include the use of electromagnetic radiation such as radio frequency and microwave energy. Microwave and radio frequency energy can be used to control insects in stored cereals and cereal products (Vadivambal *et al*. 2007).

Postharvest biotechnological development such as radio frequency and microwave grain disinfestations systems are products of biosystems engineering research and are currently at the research stage in most developed countries; however the knowledge is yet to be popular in most developing countries. Women farmers are the majority of the agricultural workforce in most developing countries, especially at the postharvest stage in Nigeria. They participate actively at all stages of agricultural production, but most prominently at the postharvest stage. Hence, they are positioned as significant stakeholders and beneficiaries in the interplay between climate change, agriculture, and postharvest biotechnologies (Fig. 2).

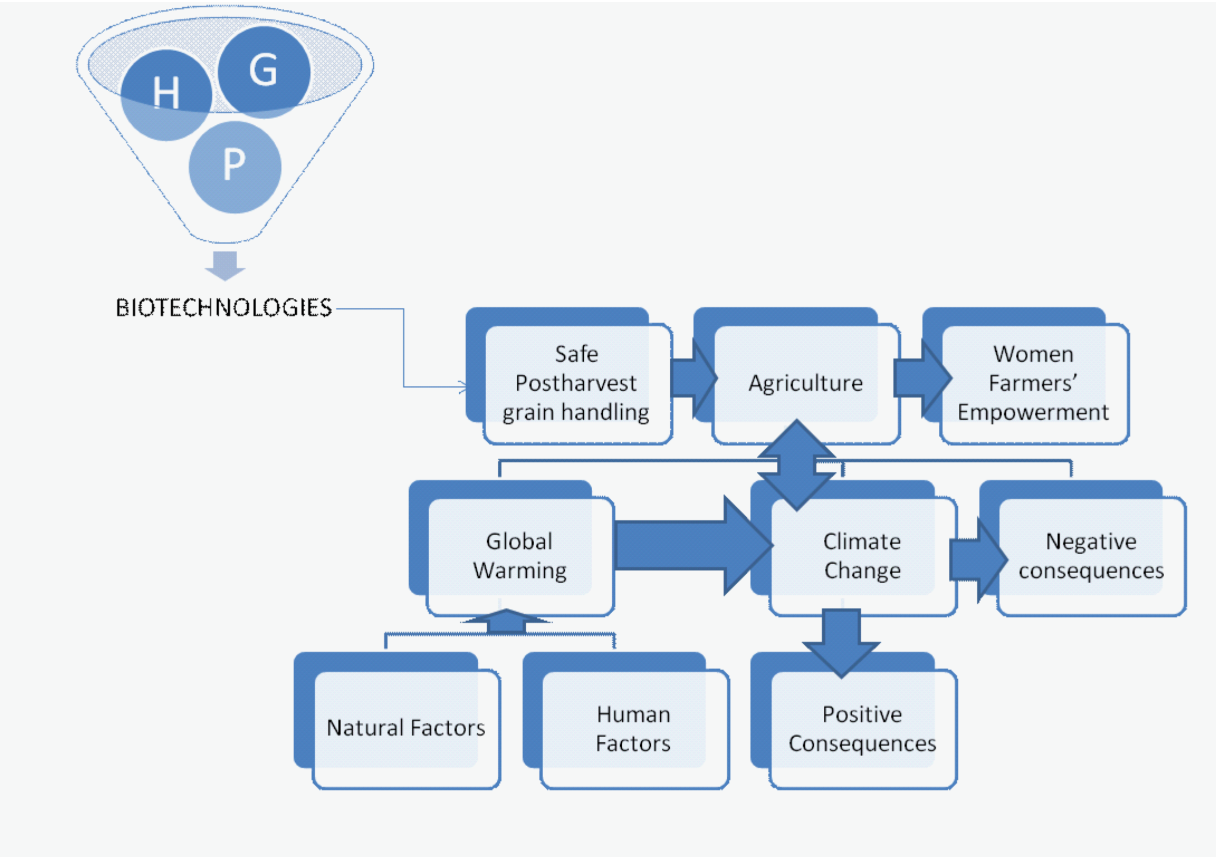

Figure 2: Relationship between Biotechnologies, Climate Change, Agriculture, and Women Farmers' Empowerment (Source: Deji, 2008b)

Keys to the Figure: G = Germination; H = Harvesting; P = Post-harvesting

Small-scale farming provides most of the food produced in Africa, as well as employment for 70 percent of working people (Maxwell, 2001). Higher proportion of the losses encountered by Nigerian farmers (due to climate change and other causes) during crop production, feature prominently at postharvest stage. Harvesting and postharvest activities are traditionally women's roles in Nigeria. All these activities are conventionally and manually performed by women. The conventional and traditional practices sap women's energy, are labor intensive, and most of the times are with little or no economic returns.

Postharvest biotechnologies such as radio frequency and microwave heating are environmentally and culturally sustainable. Adoption of postharvest biotechnologies can be tried at small scale at the industrial and nationally levels in Nigeria, because of its high cost. If it is found cost effective storage bins of large capacity with either radio frequency or microwave heat source can be established in strategic locations of large grain cultivation, accessible to grain farmers in Nigeria. Postharvest bioengineering research can be encouraged to produce the on-farm prototypes of such storage bins at the farming community level in Nigeria. Adoption of postharvest biotechnologies will contribute to the alleviation of climate change, and reduce agricultural production losses in Nigeria. It will significantly empower the women farmers socially (creating time to attend to other social activities during the harvesting season) and economically (by improving the net returns from grain cultivation), and also improves their health (stress usually incurred during postharvesting grain handling will be drastically reduced). Hence, adoption of postharvest biotechnologies will reduce the risk and ill-health often associated with the use of most conventional systems of postharvest grain handling, as well as enhances food security in Nigeria.

PRACTICAL GUIDING PRINCIPLES FOR EFFECTIVE ON-FARM GRAIN STORAGE

The best model for grain disinfestations is the one that comprises both the drying and the storage compartments. However the following practical steps are important for effective grain storage, especially in the tropical regions:

i. Properly clean the storage bin and leave empty for some days before loading the fresh grain;

ii. Keep the distance between the drying and storage points as minimum as possible to disallow contamination by agents of insect infestation, such as contact with water, dockages, etc especially during rain season;

iii. The temperature of the storage facility should be maintained at the lethal temperature levels for the less susceptible insect pest of the grain;

iv. The storage facility should be raised a little bit above the soil surface to disallow temperature gradient between the soil and the stored grain;

v. Vertically positioned storage facility is preferred to the horizontal for easy loading and offloading, uniform temperature distribution, and easy control of insect re-infestation;

vi. Loading should be done once, as much as possible, to reduce the probability of contamination by insect pests;

vii. The storage bin should be water proof coated, with internal layer of heat insulator;

viii. The storage bin should be properly closed after uploading the grains and remain closed until when ready to be offloaded;

ix. If there is any cause to open the storage bin during the storage period other than offloading the grains, heat up the storage bin to the lethal temperature of the less susceptible insect pest of the grain before and immediately after re-opening;

x. For long term storage, heat disinfestations should be combined with other methods such as cooling, or complete sealed storage (e.g. use of Wise Joseph bags), to reduce re-infestation;

xi. The stored-grain temperature should be kept as uniform as possible within the storage bin;

xii. Never add freshly harvested grains into the previous year's grain in the storage bin without properly assessing the soundness of older grain.

FEATURES OF GENDER RESPONSIVE ON-FARM POSTHARVEST TECHNOLOGIES FOR NIGERIAN FARMERS' ADOPTION

Postharvest technologies for sustainable agricultural development in Nigeria must have the following composite features in order to attract mass and continued adoption, and consequently be able to alleviate the escalating postharvest grain loss experienced by Nigerian farmers. Radio frequency and microwave heating storage systems are mostly appropriate for large scale and industrial crop storage. Most of the storage of crops in Nigeria is done at the farm level. However, there are two principles that are basic for effective selection of on-farm postharvest technologies for Nigerian farmers' adoption, these are: gender responsiveness; and appropriateness.

The principle of gender responsiveness becomes imperative due to the gender stereotype feature of agricultural occupation and postharvest activities in Nigeria. Postharvest activities in Nigeria are traditionally women's responsibilities. Too many actions failed due to the lack of socio-economic figures and mainly because the role of women in the postharvest system had been underestimated (Sode *et al*. 1995). Hence postharvest technologies must be convenient for women to handle without causing any cultural or physical risks to them in the society. The principle of appropriateness mostly concerned with compatibility of the technology with the social, cultural, and economic situations of the users within the society must be adhered to. It also involves environmental compatibility. An important aspect of sustainability is that the technical development to take place should be in accordance with expected future environmental requirements (Sode, *et al.* 1995).

Low cost/ Cheap

An appropriate postharvest technology must be cheap to be affordable by an average farmer in Nigeria, without any gender bias. The cost of a technology is a significant factor influencing the farmers' adoption behaviour in Nigeria, where women farmers are the majority of the poorest of the poor. Farmers often mull over the price of a technology before considering the relative advantages it promises. The popular sources of finance to an average Nigerian farmer are relatives and self, which guaranteed only a petite amount usually not reliable and consistent. Many farmers swim in bankruptcy on yearly basis due to crop deterioration after harvesting as result of inadequate and poor storage facilities.

Readily Available and Accessible

For postharvest technology to gain popular adoption among Nigerian farmers, it must be readily available and accessible to the poor farmers. It must be available at the common market where farmers can have access to it at any time of the year regardless of their gender.

Higher Relative Advantages

Appropriate gender responsive postharvest technologies must possess higher relative advantages over the old system. The relative advantages should be easily seen and attained during operation regardless of the gender of the operator.

Simple to Operate and Maintain

An appropriate gender responsive postharvest technology must be easy for an average Nigerian farmer to operate and maintain regardless of the farmer's gender and formal educational status. The low level of formal education among Nigerian farmers would hinder easy operation of any complex technology. An appropriate postharvest technology must be easy to understand by farmers, within a short time. Women farmers, who are the majority of the workforce at postharvest stage of agricultural production in Nigeria, engaged in other economic and domestic activities, hence often become uninterested with a technology that is taking longer period to understand and operate.

Operation and maintenance of an appropriate postharvest technology designed for Nigerian farmers should not require high level of technical competence, which may be scarce to find among Nigerian farmers majority of who are illiterates. In addition, the operation and maintenance of an appropriate gender responsive postharvest technology not pose any threat to the health of either male or female gender.

Can be Operated at any Period of the Day

An appropriate gender responsive postharvest technology should be used at any time of the day by any gender without any risk. There is a gap of difference between men and women farmers' daily time schedule because of the differences in their roles. Likewise the leisure period of farmers differs on gender basis. Hence a gender responsive postharvest biotechnology should be operated at any time of the day by any gender.

Household Environmentally Friendly

Farmers should be able to operate an appropriate post-harvest technology within the home environment without posing any environmental threat or injury, especially to the children around the home.

Value-addition Advantage

An appropriate postharvest technology should give value addition to the grains/crops at the end of the storage in terms of improved / better taste, odour, and texture, so as to increase the market value of such crop. Technologies that promise improved market value often win farmers' attention, because such would enhance the socio-economic status of the farmers.

Locally Available Spare Parts

An appropriate gender responsive post harvest technology must be easy to construct and repair using locally available materials. The spare parts for maintaining such a technology must be readily available within the local environment of the farmers.

Economically Suitable for Small Scale Grain Handling

Majority of the farmers in Nigeria are small scale farmers. An appropriate postharvest technology should be economically appropriate to be used at the small scale level of farming.

Compatible with the Existing Culture

Nigerian farmers are culturally conservative. An appropriate technology that would attract popular adoption among Nigerian farmers must be compatible with the existing norms and values guiding farming operation and human relationship within the society.

CONCLUSION

More than 70 percent of the loss experienced by average Nigerian grain farmers occurs at the postharvest stage of crop production chain. Grain loss at the postharvest stage is usually due to insect infestations resulting from poor drying and storage methods by Nigerian farmers. Stored-grain insect pests contribute to the concentration of CO_2 and other greenhouse gases in the atmosphere, which are significant causes of climate change. Climate change enhances stored- grain insect multiplication, especially in the tropical countries like Nigeria.

The prevailing increase in postharvest grain loss in Nigeria is a proof that the conventional grain drying and storage methods used by farmers are inadequate. On-farm postharvest biotechnology that would alleviate stored-grain insect infestations in Nigeria must be gender responsive. Adoption of gender responsive postharvest biotechnology will reduce insect-pest infestations of stored-grain, empower women farmers, enhance sustainable agricultural development in Nigeria, and consequently contribute to alleviating the global climate change.

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EVALUATION AND DATA INTERPRETATION TO RAINFASTNESS OF FOLIAR-APPLIED AGROCHEMICALS

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Abstract
Rainfall is the most important environmental factor influencing deposit characteristics of foliar-applied fertilizers and agrochemicals. As documented in the general literature, rain modifies pesticide deposits on plant surfaces by dilution, redistribution and removal, having major consequences for the efficacy of phytosanitary treatments. Besides of the negative economic implications due to the need of reapplication, active ingredients (a.i.) removed by rain will reach non-target organisms, soil and waterbodies, resulting in unnecessary environmental contamination. The term rainfastness is very often used to indicate the remaining biological efficacy of a given product after exposure of the treated plants to rainfall. However, in case of several products biological efficacy does not correlate well with pesticide load, since a little fraction of the applied product reaching the target-site is enough to deploy satisfactory biological performance. In this context a definition of rainfastness which considers just the biological efficacy and neglects the amount of a.i. washed-off from the plant surfaces seems to be imprecise. Rainfastness is the final result of complex interactions between several single factors influencing the adsorption-desorption behaviour of xenobiotica in leaf and fruit surfaces. In addition to rain characteristics such as droplet spectrum, kinetic energy of single droplets, and rainfall duration, the physicochemical properties of the active ingredient, product formulation, environment conditions during deposit drying, and macro- and micromorphology of the surface are decisive for efficacy of treatments. This paper aims to reinforce the necessity of a standardized and objective rainfastness evaluation of foliar-applied agrochemicals and foliar fertilizers. Once standardized, information may be used 1) by authorities as decision support for pesticide regulation, 2) by farmers for estimation of the real need of agrochemical reapplication after rain, and 3) by agrochemical producers for labelling their commercial products.

Keywords: Active ingredients, wash-off, environmental contamination, biological efficacy, evaluation methodology, standards.

INTRODUCTION

Rainfall is the most important environmental factor influencing deposit characteristics of foliar-applied agrochemicals. It modifies pesticide deposits on plant surfaces by dilution, redistribution and removal (Thacker and Young, 1999), with major consequences for the efficacy of a phytosanitary treatment. Besides the negative economic implications due to the need of reapplication, active ingredients (a.i.) removed by rain will reach non-target organisms, soil and waterbodies (Wauchope *et al.*, 2004), resulting in unnecessary environmental contamination. The propensity for a.i. wash-off is determined mainly by adhesion forces at the deposit-leaf interface as well as by water repellence of the deposit surface (Ryckaert *et al.*, 2007; Spanoghe *et al.*, 2005; Roggenbuck *et al.*, 1993). The main factors for rainfastness are the timeframe between application and rainfall, environmental conditions during the drying period, water solubility of a.i., commercial formulation of pesticide, tank-mix-

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adjuvants, and type of crop (Green, 2001). Moreover, the rain-intrinsic characteristics such as quantity, intensity and droplet volume have a decisive impact on the final result (Hunsche *et al.*, 2007).

After exposing pesticide-treated plants to a rainfall, there are two ways of interpreting the obtained data. The first one is based on the pesticide load remaining on the plant or leaves or alternatively, the pesticide amount removed by rain. The second way considers the remaining biological efficacy of the agrochemical. In both cases, results are handled as “rainfastness”. Beside of advantages and disadvantages of both methods, the lack of standardization leads to misinterpretation. In this brief article we want to present some aspects which should be considered for a standardized evaluation of rainfastness in leaf-applied agrochemicals.

RAINFASTNESS VERSUS BIOLOGICAL EFFICACY AFTER RAIN FALL

According to our understanding *Rainfastness* denominates a particular property of a pesticide deposit to withstand the mechanical impact of falling rain droplets and the carry out potency of the water film formed after junction of individual drops. This implies that only the active ingredient residing on target surface at rainfall onset, and so effectively rain-exposed, can be considered for rainfastness. For such evaluations, the amount of a.i. washed-off or the remaining a.i. on the leaves needs to be quantified analytically. Thereafter, rainfastness can be calculated taking into account the pesticide amount on rain-unexposed leaves. In case of substances which penetrate into the plant tissue, the amount of penetrated a.i. during the timeframe of pesticide application and rainfall onset should be considered or kept constant when percentage of rainfastness is calculated. If so, two products differing in penetration rate can be compared without restrictions.

The second point of view is the evaluation of “rainfastness” based on the remaining biological efficacy after rain. This interpretation has the advantage of showing an easy-to-obtain and comprehensive result, meeting the expectations of farmers. In this context studies on bioperformance are necessary and welcome. However, one has to consider that most pesticides are biologically active at very low concentrations and correlations between amount of active ingredient and biological efficacy are usually weak or even very weak. A representative example is given in Figure 1, showing no correlation between agrochemical load i.e. rainfastness (left) and the biological efficacy (right) of a contact fungicide after rain. In addition, rain may have positive effects on phytosanitary treatments for pathogen control such as documented for the fungicide prochloraz on winter wheat (Cooke *et al.*, 1989). In this case, rainfall redistributed the active ingredient to the lowest leaves of the canopy, which were not adequately covered with the fungicide during agrochemical spraying.

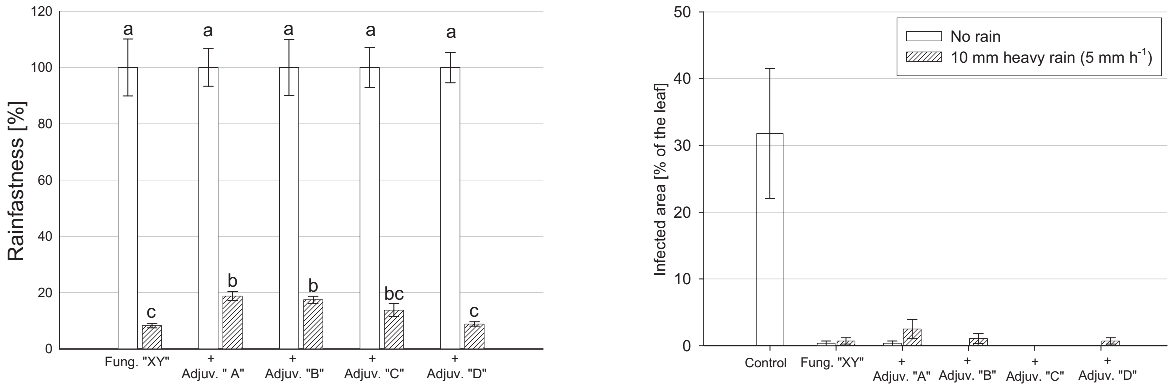

Figure 1. Influence of selected adjuvants on the rainfastness (calculated on basis of the remaining a.i.; left) of a contact fungicide sprayed to apple leaves. Plants of the same experimental batch were inoculated with spores of *Venturia inaequalis* and the area with scab symptoms was estimated. Despite of an a.i. wash-off ranging between 80 and 90 percent, disease establishment and development (14 days after inoculation) was only possible on untreated leaves.

Another example is the slightly enhanced biological efficacy of the systemic herbicide glyphosate after light rain (Hunsche *et al.*, 2007b; Hunsche *et al.*, 2007c). In this case the high relative humidity may have facilitated a.i. penetration through plant cuticle with consequences for weed control. In such a situation it would be incorrect to affirm that “rainfall has increased the a.i. rainfastness”. For this reason, studies on bioperformance without complementary information about pesticide concentration on leaves, determined analytically, do not allow accurate conclusions on rainfastness but merely on biological efficacy of the pesticide formulation in dependence of rain.

CONSIDERATIONS ON THE EVALUATION METHODOLOGY

As mentioned before, the interaction of several single factors (Figure 2) determines desorption and wash-off of active ingredients. As a consequence, rainfastness of an active ingredient is specific for a given formulation and plant surface (Hunsche *et al.*, 2006; Spanoghe *et al.*, 2005; Kudsk *et al.*, 1991; Bruhn and Fry, 1982). Furthermore, methodological aspects such as drying time and rain characteristics influence decisively a.i. removal and should therefore be considered for an objective evaluation of rainfastness.

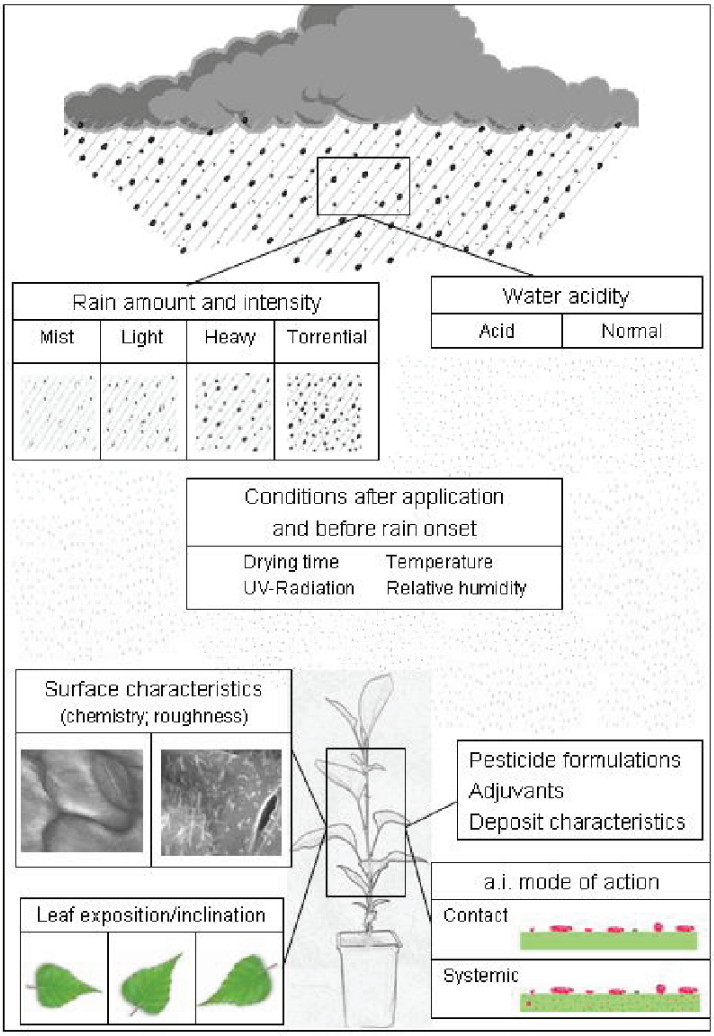

Figure 2. Major factors with influence on rainfastness of foliar-applied agrochemicals (Hunsche, 2006).

Drying period and environmental conditions

Agrochemical deposits require a minimum of time for drying down on the target surface to withstand the mechanical impact of rain droplets. In order to study the influence of drying time, experiments are commonly designed to compare very short (e.g. few minutes) and very long (e.g. few hours or days) drying periods. In this context, methodological shortcomings are frequently made by comparing rainfastness of different products or formulations after a defined, but very short drying period. Deposits of different products and formulations dry-down at different rates, and it is obvious that already dried deposits at rain onset will show a higher rainfastness than deposits which are still in a paste-like or liquid form. In fact, experiments testing several drying times after application render important information about the shortest rain-free time required for reducing pesticide loss. On the other hand, in order to compare rainfastness of different products and formulations a standardized period which is long enough for deposit drying should defined to make results and conclusions comparable. In addition, environmental conditions during drying time should be controlled, since relative humidity and temperature can influence the degree of pesticide wash-off by rain decisively (Ditzer, 2002). According to our experience, for comparing rainfastness of non-penetrating products and formulations on several surfaces a drying time of 4h is adequate, whereas longer timeframes e.g. one or more days may influence results due to changes in size and weight of the leaf lamina.

Rain quantity and intensity

A rain event (Table 1) is characterized by its quantity, intensity, droplet spectrum, energy of the droplets and duration (Park *et al.*, 1983; Simmons, 1980; Green, 2001). Intense rainfalls e.g. heavy and torrential precipitations are characterized by bigger droplets which fall at higher speed, having a greater mechanical impact on exposed surfaces due to the higher kinetic energy (Park *et al.*, 1983; Simmons, 1980). Hence, rain droplets with greater impact can dislodge pesticide deposits more easily (Kudsk *et al.*, 1991; Park *et al.*, 1983). Besides, the process of deposit removal is facilitated and even enforced by a.i. transport with the laminar film of water and consecutive wash-off (Lauver and McCune, 1984). One should note that, whereas a heavy rainfall produces a constant water film leading to run-off (Hartley and Graham Bryce, 1980), during misting and light rain the run-off occurs only periodically, after junction of isolated water droplets (Suheri and Latin, 1991). In addition, as shown by several studies, the greatest part of a.i. is removed by comparatively little rain quantity, while the residual deposit remains in a stable form, difficult to displace with even more rain (Hunsche *et al.*, 2007a; Wauchope *et al.*, 2004; Fife and Nokes, 2002; Bruhn and Fry, 1982).

The withstand of a pesticide deposit to removal by rain is given by its resistance to mechanical impact, particularly the big rain droplets, as well as the a.i. dissolution rate (Kudsk *et al.*, 1991). Nevertheless, results concerning the influence of intensity and amount of rain vary greatly due to the additional impact of other factors (active ingredient, plant material, drying period, environmental conditions, etc.). For example, irrespective of a.i. and plant surface evaluations have shown that rain quantity affects the wash-off to a greater extent than rain intensity (Mashaya, 1993; Kudsk *et al.*, 1991), while others have shown the opposite (Taylor and Matthews, 1986). Complementing, some researchers observed similar impact of rain amount and rain intensity (Mashaya, 1993), while others observed that rain intensity and duration affect active ingredient removal from the plant foliage independently (Hunsche *et al.*, 2007b; Fife and Nokes, 2002). In summary, these findings were the result of interactions between active ingredient and plant surfaces, whereas also rain characteristics may have had significant influence. In the past, several experiments overlooked key parameters of rainfall, so that simulation of rain events did not reflect natural precipitations (Ditzer, 2002).

Table 1. Classification of rainfall types according to their major characteristics.

Type of rain	Rain intensity [mm h^{-1}]	Droplet radius [µm]	Droplets fall speed [m s^{-1}]	Duration
Mist	< 0.4	50 - 250	low (0.25 - 2)	short to long
Drizzle / Light rain	0.42	250 - 500	medium (2 - 2.8)	long (8h - 24h)
Heavy rain	4.2	500 - 1500	medium (4 - 6)	medium (2h - 6h)
Torrential rain	42	1500 - 2500	high (6 - 8.9)	short (10min.)

Adapted from: Ditzer, 2002; Park *et al.*, 1983; Simmons, 1980.

IS HIGH RAINFASTNESS OF AGROCHEMICALS ALWAYS BENEFICIAL?

As a rule, a high rainfastness is being intended in order to assure an adequate coverage and amount of active ingredient on the target surface, with the assumption, it will guarantee the expected biological efficacy. However, in case of agrochemicals with a contact mode of action and especially the fungicides, a high rainfastness will only be suboptimal if residues are located in a restricted area of leaf surface. Therefore a “qualitative rainfastness” with an appropriate amount of pesticide remaining after rainfall, well distributed over the target surface, would be optimum. Furthermore, high rainfastness does not necessarily mean high bioperformance, since several interactions between pathogens and plant-environment-system determine the final result of phytosanitary treatments. In addition, it should be considered that enhancement of rainfastness with sticker adjuvants could reduce the biological availability of the a.i. since it may be entrapped in an organic film. Examples of deposit modifications due to rain are given in Figure 3.

Moreover, a high rainfastness may also result in lower a.i. redistribution on leaf surfaces or canopy leaf levels, impeding indirect corrections of pesticide distribution after a poor application. At last, a high rainfastness may lead to high pesticide residues on fruits or vegetables when recommendations of Best Management Practice such as number of applications, a.i. concentration and harvest delay after application are disregard. In such cases, the overload would not be washed off and recommendations about pesticide concentration in spray solution as well as number of applications should be reconsidered. However, besides these concerns, the positive aspects of a high rainfastness such as minimised environmental contamination of non-target organisms, soil and waterbodies as well as the reduced number of repeated applications and their associated costs should be highlighted.

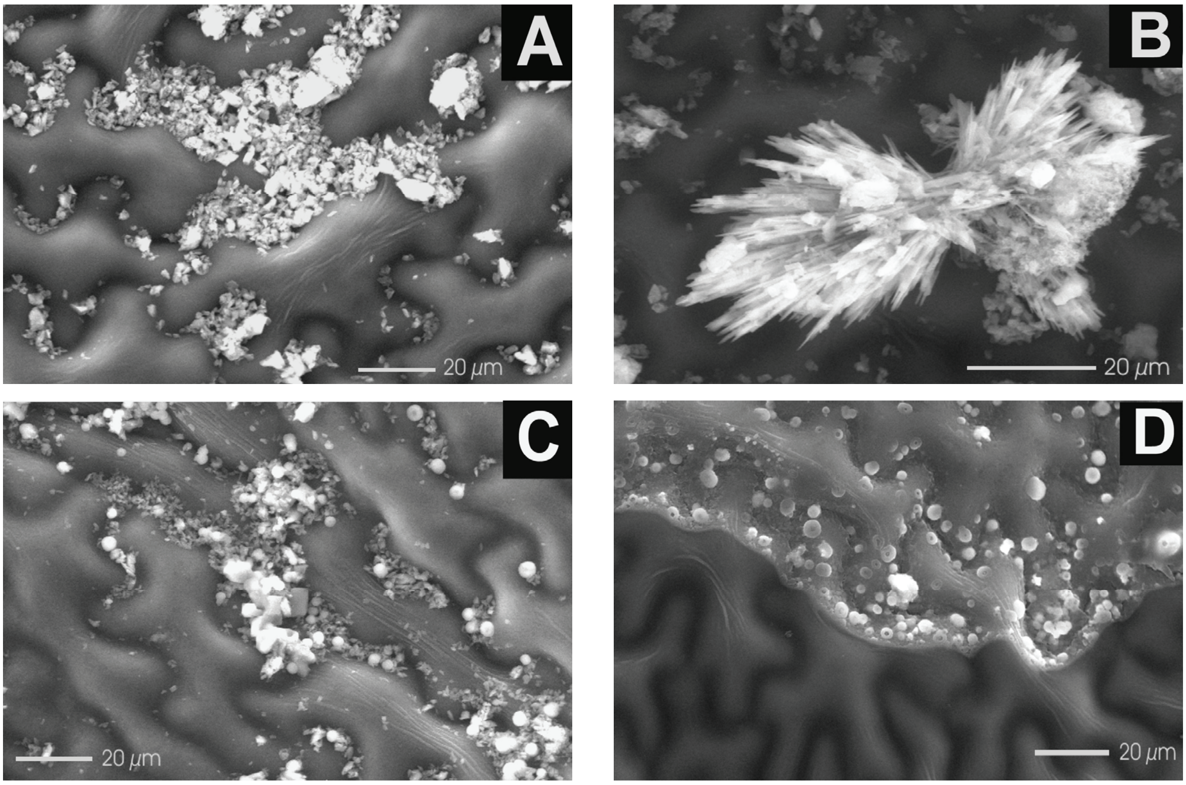

Figure 3. Scanning electron microscope images of Mancozeb deposits on control (A and B) and rain-exposed (C and D) apple seedling leaves. After rain, a considerable part of the a.i. formed of little spheres and rings. In some cases, tank-mix-adjuvants may entrap the active ingredient within a film of organic nature.

PROPOSAL

As a consequence of the high variation in experimental designs and methods, many studies on rainfastness of pesticides can not be compared adequately. For an objective and comparable evaluation of agrochemicals' rainfastness, standardized experimental conditions are required. The greatest benefit of standard experimental protocols is the possibility to evaluate impartially rainfastness and compare data without restrictions. In addition, it helps researchers and industry to characterise and classify a given product according to its real rainfastness. Figure 4 shows the rainfastness of one dithiocarbamate contact fungicide in two formulations, "A" and "B", both produced by the same company. In this case the company claims a higher rainfastness for formulation "B", which was confirmed in our experiments. However, is it adequate to rank formulation "B" as highly rainfast if approximately 70% of the original deposit is washed-off by 10 mm rain?

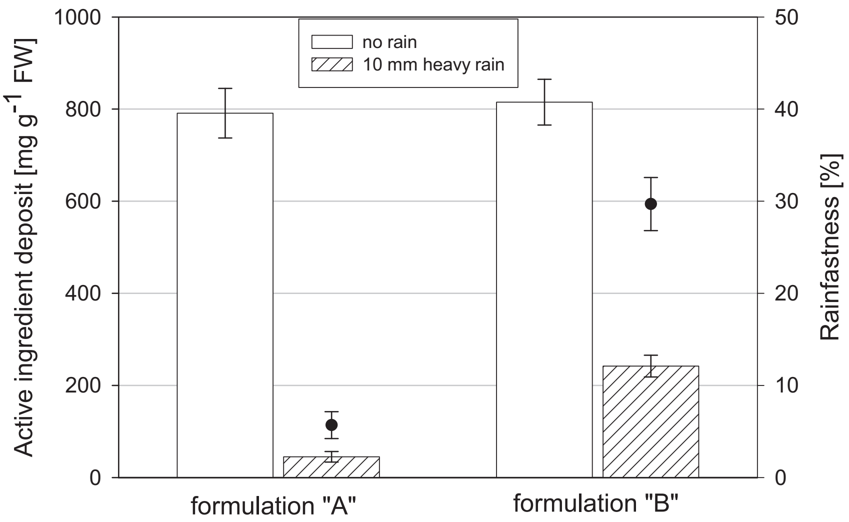

Figure 4. Influence of the commercial formulation on the rainfastness of a contact fungicide.

Over the years we have made excellent experiences using a drying period of pesticide deposit of 4h (T = 20ºC, RH = 60%) and a 10 mm heavy rain (Table 1). However due to the high penetration rate of some hydrophobic systemic compounds in this timeframe, the period of 4h may be too long. As first step for a standardized classification of pesticide rainfastness (%) based on the remaining a.i. after rain or alternatively the amount of a.i. removal by rain, we propose the ranking presented in Table 2.

Table 2. Rainfastness degree of agrochemicals according to the remaining active ingredient on target the surface or amount of active ingredient washed-off by rain.

Rainfastness degree	Active ingredient remaining on target surface after rain [%]	Active ingredient washed-off from target surface by rain [%]
Very high	> 80	< 20
High	61 - 80	21 - 40
Moderate	41 - 60	41 - 60
Low	21 - 40	61 - 80
Very low	< 20	> 80

CONCLUDING REMARKS AND OUTLOOK

Since rainfastness of pesticides is affected by several factors, it should be evaluated in selected species and labelling should be related to the species tested. In addition, indications about the rainfastness of a given pesticide should be made based on active ingredient removal by rainfall rather than on its bioperformance, by conducting experiments under controlled, standardized conditions. Considerations about the use of one or more synthetic surfaces with defined characteristics as references should also be taking in to respect.

Moreover, efforts should be made to develop a index for rainfastness considering rain and environmental characteristics (drying time, rain amount, rain intensity, and rain acidity), pesticide attributes (water solubility, molecular weight, etc), and surface properties (microroughness, wax load, wax chemical composition, etc.). However this is not an easy to solve task, since the development of such a model requires additional efforts in research which for sure will be acknowledged by industry, public interest and federal agencies for its recognition and implementation.

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ASSESSMENT OF LAGOSIANS' PERCEPTION OF CLIMATE CHANGE AS A PUBLIC HEALTH CONCERN

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Abstract

The study examined the perception of Lagosians on climate change and its likely public health concerns. Three variables- gender, level of education and occupation were used to examine the peoples' perception on climate change. The population of the study consists of residents of Lagos metropolis. Purposive/convenient sampling technique was used to select six hundred (600) respondents as the sample size, but only five hundred and seventy-six (576) questionnaires were good enough for data analysis. A self-structured questionnaire with a reliability of (0.7098) 0.71 was used for data collection. T-test and ANOVA analyses were used to test the three (3) hypotheses that were generated, but all were rejected. This implies that all the variables examined had influence on Lagosians' perception of climate change. Based on these findings some recommendations were suggested among which are: the need for environmental education as far as climate change is concerned; the need for the government and policy makers to carry the masses along in the formulation and implementation of environmental health policies.

Keywords: Lagosians, perception, climate change, public health concern.

INTRODUCTION

Climate change is the greatest environmental challenge facing the world today. According to scientific evidence, rising global temperatures will bring changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather. The effects will be felt locally, nationally, regionally and internationally; especially in many developing countries that are particularly vulnerable.

The concerns for climate change and its perceived catastrophic consequences worldwide were responsible for the creation of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED) (also known as the Earth Summit informally), held in Rio de Janeiro, Brazil from June 3 to 14, 1992.

The treaty is aimed at stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. According to the terms of the UNFCCC, having received over 50 countries' instruments of ratification, it entered into force on March 21 of 1994. About 198 countries are signatory to the treaty (UNFCCC, 1997).

Since 1994, several annual follow-up conferences have been convened by the UNFCCC. Such conferences are known as Conference of Parties to the treaty (or simply, COP). They are aimed at assessing progress in dealing with climate change. For example, beginning in the mid-1990s, these annual conferences negotiated the Kyoto Protocol that established legally binding obligations for developed countries to reduce their greenhouse gas emissions (UNFCCC, 1997).

Nigeria, being one of the signatories to the convention, was ably represented in all these conferences over the years. However, apart from the top-level government officials that shuttle to attend these conferences, there have not been public consultations, debates or legislative oversight regarding this very weighty international commitment. Hence, not much is known of the Nigerian general public perception of this global phenomenon.

Studies made of public perceptions of environmental problems therefore, should include investigations of the way in which the issues are understood by different sections of society and their evaluation of and attitude towards them (Bostrom, Morgan, Fischhoff & Read, 1994). The relative importance of environmental issues to other public concerns has been investigated, as has the degree of public support for action at political, community and personal levels through risk analysis techniques (O'Connor, Bord & Fisher, 1999).

There are a numbers of international comparisons which seek to explore differences between different societies either through large scale surveys (Bord, Fisher & O'Connor, 1998) or in-depth work with small groups (Dunlap, 1998).

Since we now live in highly pluralist societies a single unique 'public attitude' or 'opinion' on any specific environmental issue is unlikely, although some societies display a more developed consensus than others. In general, the different constituencies of the public must be expected each to present a spectrum of opinion.

Similarly it can be expected that there will be considerable differences between the most commonly held views of the different publics. There is, therefore, an issue about the general relevance of work done on public perception, even where the results are taken from a sample chosen to represent a cross section of the wider public in a particular society. There is also a question about the degree to which perception should be translated into a propensity for action. Where surveys suggest support for particular official positions or policy initiatives, does this continue to apply even where the consequences might be problematic at an individual level? (Bord, Fisher & O'Connor, 1998; Blake, Guppy & Urmetzer, 1997; Berk & Shulman, 1995)

Despite these methodological issues, several broad common themes have emerged from the work on public perception of the environment. This section aims to describe some of these themes as they apply to the specific issue of health and climate change.

However, within the study of public understanding of the environment, the problem of health impacts of climate change is highly specific and there is little work available. The principle route into the topic is therefore through a combination of work on the broader issues of climate change and health and the environment.

There is a large amount of published work on public understanding of climate change. Much of it derives from interest in the cognitive or psychological processes by which people make sense of the risk associated with climate change (McDaniels, Axelrod & Slovic, 1996). There are also works on the understandings people acquire from the representations of the climate change as shown, for example in the media (Bell, 1994). There are a few studies of the way in which the understanding reached is embedded in (and affected by) the broader notions of citizenship and individual and institutional responsibility in different societies (Harrison, Burgess & Filius, 1995).

The following is an attempt to summarize the broad themes that emerge from this work.

There is considerable consensus amongst investigators that the problem of global warming is now understood by lay publics as a reality and as an issue of concern within society. It tends to dominate discussions of global environmental problems. However, most studies suggest that global warming is no longer peoples' main social or environmental concern; crime and unemployment commonly rank above the environment for and of environmental concerns, air pollution and toxic waste are generally perceived as more pressing than climate change (Witherspoon, 1994).

Studies also show that people have a strong tendency to use 'global warming' as a catch-all phrase, so that the problems of stratospheric ozone depletion and air pollution in general often become included within it (Kempton, 1991). There is also evidence that there is a tendency to confuse climate and weather (Gowda, Fox & Magelky, 1997). Some investigators believe this to be driven, at least in part, by the media treatment of recent episodes of severe weather. It is widely recognized that there are cycles of media attention and that these have a powerful role in influencing the type and framing of issues within the public arena for debate (Hilgartner & Bosk, 1988). Environmental issues, including global environmental change, are subject to these cycles of attention (Mazur, 1998) and where periods of higher media attention to environmental issues coincide with particular catastrophic events or risk issues; these are often conflated in both the framing strategies of the media and in lay discussions (Harrison, Burgess & Filius, 1995).

Apart from increased incidence of severe weather, people may attribute changed agricultural yield, species extinction and health effects to climate change; the health impact is seen largely in terms of an increase in skin cancer (Bostrom, Morgan, Fischhoff & Read, 1994). When environmental issues are framed as health concerns any gender variation in the perception of risk tends to disappear (Bord & O'Connor, 1997).

People's perception of the responsibility for action seems diffuse. There is wide understanding that pollution from energy conversion and industry is the prime cause of climate change, but few people make the link between their own energy consumption and greenhouse gas emissions. This is a common finding in studies of public understanding of climate change: the failure to link global impacts to the personal action of individuals (Kempton, 1991).

Studies of public reaction to environmental risk issues suggest a considerable mistrust of governments companies or experts. However, there seems to be a strong belief that governments should take the lead in resolving environmental problems (O'Connor, Bord & Fisher, 1998). This is linked to feelings of lack of personal efficacy identified above, as well as the social desire for institutional accountability.

There appears to be a moderate degree of trust in the ability of experts to address climate change effectively, more so than in their ability to address other key concerns such as crime or traffic accidents. However, there is less confidence in expert ability to address climate change than environmental pollution in general or health risks such as AIDS or heart disease (O'Connor, Bord & Fisher, 1998).

Studies of perception between different societies suggest that the patterns described above are broadly repeated, though with differing emphasis. A comparative study of public understanding in the UK and the Netherlands, for example, found that the mistrust of claims of safety was particularly pronounced in the UK. The citizens of the Netherlands had a firmer 'social contract' with their government and institutions, and seemed more willing to accept change (Harrison, Burgess & Filius, 1995).

At a local scale, people routinely include issues of health in their evaluations of their environment.

In particular, the main issue associated with traffic pollution is that it is a threat to health (Boyes & Stanisstreet, 1998).

Perceived risk to health seems to be a major factor in determining whether or not individuals will take environmental action (Seguin, Pelletier & Hunsley, 1998). Studies of claims made by campaigning groups and the media suggest that such groups tend to focus on the health aspects of environmental issues, probably because these make a powerful and direct appeal to the individual, motivating people politically but without making an overtly party political point (Garvin & Eyles, 1997).

Experience in the United Kingdom suggests that the most effective campaigns for both non-government organizations (NGOs) and government are those where health effects can most directly be linked to environmental pollution in public perception. The unleaded petrol campaign in the UK was driven by the health impacts of exposure to lead. In Germany the leading issue was that unleaded petrol was essential for the introduction of new vehicle technology (catalytic converters) to reduce other pollutants from petrol driven vehicles. This was translated into action in the two countries in different ways. In Germany there was political and individual support for the Federal German Government campaign in Europe for stringent emission standards, but little interest in unleaded petrol as an issue in its own right. In the UK the Government ran an aggressive campaign to promote unleaded petrol with vigorous NGO and public support, but failed to elicit much enthusiasm from the public for the campaign on vehicle emission standards.

The main focus of public concern at a global level seems to be the belief that the stratospheric ozone layer will be affected by global warming, with the threat of increasing levels of skin cancer (Bostrom, Morgan, Fischhoff & Read, 1994).

This is interesting in itself as it suggests that the link between the ozone layer and health has been established, even in countries like the UK with generally low levels of sun. There seems therefore to be no intrinsic reason why an issue of global concern cannot be linked to local health impacts. Despite the considerable volume of published and well publicized work on health impacts of climate change, there are few studies which have explored the detailed public understanding, beyond the general appreciation that there may be health effects mostly linked to skin cancer. However, it is likely that the issue will enter the public domain more forcefully following the publication of this report. As the debate moves from scientific and policy circles to the public arena an explosion of contested understandings and competing claims can be expected. There will then be a vigorous public debate with the potential for a more informed discussion of public health in a changing climate. There will also be an opportunity to study public understanding of the specific health issues likely to arise as climate changes.

Despite considerable public awareness of climate change there is little evidence to indicate whether there is good understanding of its health impacts. Such evidence as there is tends to the conclusion that public understanding conflates climate change with the depletion of the stratospheric ozone layer and thus skin cancer. There is, however, the prospect that the connection between climate change and health, once established by the public, will invigorate the debate on the scale and nature of action to be taken. Therefore the objective of this study is to assess the perceptions of Lagosians regarding climate change as a public health concern.

STATEMENT OF THE PROBLEM

Africa is the continent most vulnerable to the impacts of change because widespread poverty and low levels of technical development limit adaptation capabilities.

The impacts of climate change are predicted to affect the livelihood of Africans in many ways. Climate change is likely to affect the distribution patterns of infectious diseases e.g. there is likely to be an increase in mosquitoes which spread dengue and yellow fever.

Climate change has been documented in the literature to have negative impact on human as a result of human activities which is responsible for green house gas emission into the atmosphere. Lagos is an industrialized city which is densely populated. Considering the activities of the residents, there is possibility of increasing the release of green gas emission into the air. Since behavioral intervention has been noted to be a product of perception, it is therefore imperative to determine the perception of Lagos residents on climate change as a public health problem for better intervention.

The following research hypotheses were generated and tested for the purpose of the study:

1. There is no significant difference in the perception of male and female respondents on climate change as a public health concern in Lagos, Nigeria.

2. There is no significant difference in the perception of the respondents based on level of education in Lagos Nigeria.

3. There is no significant difference in the perception of the respondents based on occupation in Lagos, Nigeria.

METHODS

Design

This is a descriptive survey research, which employed the questionnaire for the purpose of collecting data on Lagosians' perception of climate change as a public health concern.

Sample and Sampling Procedure

Six hundred subjects were drawn from the five (5) divisions of Lagos State (Ikeja, Badagry, Ikorodu, Lagos Island & Epe) with the use of purposeful/convenient sampling technique (120 respondents per division). 576 out of 600 copies were retrieved in good condition giving a response rate of 96%, same were coded and analyzed.

Instrumentation

The instrument was a self structured questionnaire which consists of two sections.

Section A: demographic information and Section B: perception of climate change as public health concern.

The questionnaire was validated using test-retest method giving reliability co-efficient of 0.71.

Procedure

The researchers visited the different divisions along with three research assistants that were trained in the administration of the questionnaires. Apart from soliciting for co-operation, the respondents were informed of the purpose of the study and the need for factual and objective response. Participants filled the questionnaire at individual pace and the completed copies were retrieved immediately. 576 out of 600 copies were retrieved in good condition giving a response rate of 96%, same were coded and analyzed.

Data Analysis

Frequency counts and percentages were used to present data in tables, while T-test and Analysis of variance (ANOVA) were used to test the hypotheses at 0.05 significant levels.

RESULTS

Table 1: Distribution of the respondents by sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	306	53.1	53.1	53.1
	FEMALE	270	46.9	46.9	100.0
	Total	576	100.0	100.0	

The table shows that 53.1% of the respondents were male while 46.9% were female.

Table 2: Distribution of the respondents by age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24YRS	90	15.6	15.6	15.6
	25-31YRS	279	48.4	48.4	64.1
	32-38YRS	117	20.3	20.3	84.4
	39-45YRS	63	10.9	10.9	95.3
	46-52YRS	18	3.1	3.1	98.4
	56-59YRS	6	1.0	1.0	99.5
	60YRS & ABOVE	3	.5	.5	100.0
	Total	576	100.0	100.0	

The above table shows that 15.6% of the respondents were between ages 18-24, 48.4% were 25-31years, 20.3% were between 32-38years, 10.9% were of 39-45years, 3.1% were between 46-52years, 1.0% was of 56-59years and .5% were above 60years.

Table3: Distribution of the respondents by level of education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NONE	18	3.1	3.1	3.1
	BELOW FIRST DEGREE	198	34.4	34.4	37.5
	FIRST DEGREE	288	50.0	50.0	87.5
	MORE THAN FIRST DEGREE	51	8.9	8.9	96.4
	PROFESSIONAL QUALIFICATION	21	3.6	3.6	100.0
	Total	576	100.0	100.0	

This table revealed that 3.1% of the respondents had no education, 34.4% of them were below fist degree, 50% which was the highest percentage had their fist degree, 8.9% had a second degree and 3.6% of them had an additional professional qualification.

Table 4: Distribution of the respondents by occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Industrial worker	306	53.1	53.1	53.1
	Self employed	96	16.7	16.7	69.8
	Civil servant	174	30.2	30.2	100.0
	Total	576	100.0	100.0	

This table revealed that 53.1% of the respondents are industrial workers, 16.7% are self employed and 30.2% are civil servant.

Testing the hypotheses:

Hypothesis 1: There is no significant difference in the perception of male and female respondents on climate change as public health concern.

Sex	N	X	SD	df	T	Sig
Male	306	38.86	6.55	574	-2.278	0.023
Female	270	39.99	5.11			

Table 5 shows a t-value (-2.278) is significant at (0.05), p<0.05.Therefore, there is significant difference in the perception of male & female respondents on climate change as a public health concern with female having a better perception, i.e. female mean is greater than male. Hypothesis 1 was therefore rejected.

Hypothesis 2: There is no significant difference in the perception of the respondents based on level of education.

ANOVA

PERCEPTION

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2373.463	4	593.366	18.890	.000
Within Groups	17935.646	571	31.411		
Total	20309.109	575			

From table 6, the t-value (18.89) is significant at 0.05 (p< 0.05). It follows that respondents significantly differ from their perception based on level of education. The table below shows where the difference lies.

Multiple Comparisons

Dependent Variable: PERCEPTION
Scheffe

(I) EDUCATIO	(J) EDUCATIO	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
NONE	BELOW FIRST DEGREE	-5.20*	1.38	.007	-9.46	-.93
	FIRST DEGREE	-2.45	1.36	.520	-6.66	1.76
	MORE THAN FIRST DEGREE	.44	1.54	.999	-4.31	5.19
	PROFESSIONAL QUALIFICATION	2.21	1.80	.824	-3.35	7.78
BELOW FIRST DEGREE	NONE	5.20*	1.38	.007	.93	9.46
	FIRST DEGREE	2.75*	.52	.000	1.15	4.35
	MORE THAN FIRST DEGREE	5.64*	.88	.000	2.92	8.36
	PROFESSIONAL QUALIFICATION	7.41*	1.29	.000	3.44	11.39
FIRST DEGREE	NONE	2.45	1.36	.520	-1.76	6.66
	BELOW FIRST DEGREE	-2.75*	.52	.000	-4.35	-1.15
	MORE THAN FIRST DEGREE	2.89*	.85	.022	.26	5.52
	PROFESSIONAL QUALIFICATION	4.66*	1.27	.009	.75	8.58
MORE THAN FIRST DEGREE	NONE	-.44	1.54	.999	-5.19	4.31
	BELOW FIRST DEGREE	-5.64*	.88	.000	-8.36	-2.92
	FIRST DEGREE	-2.89*	.85	.022	-5.52	-.26
	PROFESSIONAL QUALIFICATION	1.77	1.45	.828	-2.72	6.26
PROFESSIONAL QUALIFICATION	NONE	-2.21	1.80	.824	-7.78	3.35
	BELOW FIRST DEGREE	-7.41*	1.29	.000	-11.39	-3.44
	FIRST DEGREE	-4.66*	1.27	.009	-8.58	-.75
	MORE THAN FIRST DEGREE	-1.77	1.45	.828	-6.26	2.72

*. The mean difference is significant at the .05 level.

Hypothesis 3: There is no significant difference in the perception of the respondents based on occupation.

ANOVA

PERCEPTION

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	421.819	2	210.910	6.077	.002
Within Groups	19887.290	573	34.707		
Total	20309.109	575			

Multiple Comparisons

Dependent Variable: PERCEPTION
Scheffe

(I) OCCUPATI	(J) OCCUPATI	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
CIVIL SERVANT	INDUSTRIAL WORKER	-2.38*	.69	.003	-4.07	-.69
	SELF EMPLOYED	-.82	.56	.339	-2.20	.55
INDUSTRIAL WORKER	CIVIL SERVANT	2.38*	.69	.003	.69	4.07
	SELF EMPLOYED	1.56	.75	.116	-.28	3.39
SELF EMPLOYED	CIVIL SERVANT	.82	.56	.339	-.55	2.20
	INDUSTRIAL WORKER	-1.56	.75	.116	-3.39	.28

*. The mean difference is significant at the .05 level.

Table 7 shows that the F-value (6.077) is significant at 0.05 ($p< 0.05$). Therefore, respondents significantly differ in their perception based on occupation. The multiple comparisons on table 7 revealed that the difference is significant between industrial workers and civil servants.

DISCUSSION OF FINDINGS

The findings have revealed that women perceived climate change as a public health concern more than their male counterpart. This implies that climate change cannot be perceived directly in the same way by individual because of the temporal scale associated with it. In addition, human perception of climate is strongly influenced by expectations, which may have little relationship to the true nature of climate as provided by the instrumental record (Rebetez, 1996). This finding also concur with the study of Semenza, Hall, Wilson, Bontempo, Sailor and George (2008) which found out that almost all respondents (USA) have heard about climate change or global warming, are rather concerned (women more than men) and some 50% reported behaviour changes like decreased energy usage at home, reduced gasoline consumption, increased recycling and some other behaviors. Furthermore, respondents significantly differ from their perception based on level of education. This means that education play a major role in supporting efforts toward addressing climate change. The outcome of the study is also in line with the position of Leal et.al (2007) .Occupation as one of the variables under study has also influenced the perception of the respondents and the difference is significant between industrial workers and the civil servants. The finding support the outcome of (Thompson & Jayapaul ,1997) that industrialist among other workers have perceived climate change has a public health problem.

CONCLUSION

There is clear linkage between the environment and health problems. Climate change would likely have an increasingly severe impact on health particularly with regard to vector and water borne diseases. With change in climate and other stress factors, peoples' perception and behaviour must also change in order to effectively cope with the situation. Carbon dioxide has an effective lifetime of about 100 years. This means that any changes in the atmosphere will take a long time to develop. If we cut down on the amount of carbon dioxide we use, the rate of climate change will slow down. The challenges of climate change however, calls for meaningful cooperation between individuals and government. Furthermore, climate change issue is not a monopoly of the Ministry of Environment and Forest (MOEF). Other relevant ministries such as health, agriculture, livestock, water resources, planning etc should work together to mitigate and combat the impacts of climate change

RECOMMENDATIONS

- There is the need for continuous education on climate change; hence, government should intensify efforts in raising further awareness on the causes and consequences of climate change which will serve as further means to work towards a reduction in greenhouse emission.
- The need for government/policy makers to carry the masses along in the formulation and implementation of environment and health policies is recommended.
- Integrate gender concerns and perspectives in policies and programmes for sustainable development.
- Extended range weather forecasts are fundamental for all climate change adaptation strategies.
- Individual-level mitigation can be a policy option under favourable contextual conditions but must be accompanied by mitigation efforts from industry, commerce and government.

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IMPORTANT ENGINEERING ISSUES IN THE POST HARVEST TECHNOLOGY AND QUALITY ASSURANCE FOR FRUITS AND VEGETABLES IN AFRICA+

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Abstract

Africa is naturally blessed with land, water, agricultural and climatic resources for the production of both arable and tree crops. Africa is next to Asia in the global production of fruits and produces fruits such citrus, mango, cashew, pineapple, pawpaw and guava in very large quantities but, there are prevalent problems of food insecurity and malnutrition due to poor storage facilities and inadequate machines to process the raw agricultural materials. The predominant mode of farming in Africa is subsistent, small holding and peasant. The peasant farmers practice farming as a means of surviving and not as business. Therefore, industrial development is mostly very low in the rural areas where agricultural production is highest. Coupled with the non-business-like attitude of the African peasant farmers, a lot of farm produce are lost during the post harvest handling as a result of poor road net work.

The paper reviews the engineering issues of very high rating that will promote the production, processing and storage of fruits and vegetables in Africa. Majority of commercial food processing equipment in Africa are imported at very high cost and maintained by expatriates. The machineries are sophisticated and have problem of climatic adaptations. However, in Africa, fruit processing machines such as juice extractor, pasteurizer and bottling machines are already developed in various academic institutions through research efforts and spotted records are available in literatures on some indigenous fruit processing machinery. But, such machines are mostly not produced at commercial levels. Therefore, there is the need for concerted collaborative efforts to develop functional indigenous food and fruit processing machineries for mass production and commercialization in Africa.

The paper advocates that the African farmers should consider the production and processing of fruits as industry and scale up the production of fruits. The rural communities in Africa should up graded by providing engineering infrastructures such as roads, water supply and steady electricity to promote agricultural production. Indigenous machines should be developed and commercialized for the processing of the fruits into juice, concentrates and other products in order to enhance added value, minimize post harvest loses and improve the intake of the natural vitamins and minerals provided by the fruits. This shall lead to the establishment of fruit processing industries, create jobs for the teaming unemployed youths, alleviate poverty, improve the social life in the rural communities, reduce rural-urban migration and promote the manufacturing of fruit processing equipment in Africa.

Keywords: Africa, Fruits, Vegetables, Engineering infrastructures, Rural development

FRUITS: IMPORTANCE, UTILIZATION AND PRODUCTION STATISTICS

Fruits and vegetables are ready sources of minerals and vitamins, and are natural raw materials for the pharmaceutical and juice processing industries. For example mango fruit has vitamin A (0.2 mg) and vitamin C (300 mg), per 100g fresh weight (Ibiyemi et al, 1990). Citrus contains 60 mg of vitamin C in 240 ml of juice, which is more than the minimum daily requirement. Citrus fruits are also good source of folic acid, sugar, pectin, cellulose, vitamin B, thiamine and potassium (Naggy et al, 1993). Sweet orange has 11.8% solid, 0.38% ash, 0.06% ether extract, 0.65% protein, 0.05% crude fibre, 10.7% carbohydrate and 41 kilo cal per 100g energy. It has a laxative effect (Ihekoronye and Ngoddy, 1985). Cashew is especially rich in vitamin C, containing 262 mg/ 100 ml of juice, about five times the vitamin C content of orange (Egburomu, 1996).

Fruits are also known for their medicinal, pharmaceutical, industrial and other economic values. Some fruits, their seeds or components have high level of antioxidants (Fakuda, et al, 1997), low glycerin index (Jarquera, 1996), very strong antimicrobial activities ((Bailey et al, 1998), high stearic acid and essential oils (Julia, 1987). Some fruits or their residues are useful for reduction of cholesterol level (Jarquera, 1996), protection against cardiovascular diseases and cancer (Heber, 2005), burning of body fats (Edward et al, 1997) and feeds for animals and soil enrichment (Julia, 1987). Many products are derivable from fruits including, pickles, chutney, puree, nectar, juice, squash, jam, jelly, squash, wine, powder, flakes and dehydrated products, which are industrial raw materials for food and pharmaceutical industries (Mircea, 1995).

The leading production statistics of sweet orange provided by Mc Donald and Low (1984) include 18,256,500 metric ton (Brazil), 11,729,900 metric ton (India), 3,969,810 metric ton (Mexico), 868, 000 metric ton (Egypt), 697,000 metric ton (Argentina) and 606, 000 metric ton (Morocco). Brazil was the largest producer of orange juice in the world followed by the USA (World Book Encyclopedia, 2001). The ten leading nations producing grape and pummelo, as identified by FAOSTAT (2002) are USA (155, 974 metric ton), China (57,128 metric ton), Mexico (43,947 metric ton), Israel (42, 632 metric ton), Cuba (38, 540 metric ton), South Africa (36, 212 metric ton), Argentina (28, 990 metric ton), Turkey (25, 580 metric ton), India (24, 215 metric ton) and Tunisia (12, 278 metric ton).

The first ten leading nations in global mango fruit production, as identified in FAOSTAT (2002) are India (11, 400, 000 metric ton), China (3, 130, 000 metric ton), Thailand (1, 750, 000 metric ton), Mexico (I, 523, 160 metric ton), Pakistan (1, 036, 000 metric ton), Indonesia (891, 566 metric ton), Philippines (880, 000 metric ton), Nigeria (730, 000 metric ton), Brazil (542, 000 metric ton) and Egypt (326, 063 metric ton). Despite the fact that mango is mostly grown wild in Nigeria, the nation ranked 8th position in global mango fruit production with an estimate of 730,000 metric tons per annum. This is instructive as it suggests the potential of Nigeria in the production of tropical fruits. The major mango producing States in the Nigeria include Benue, Jigawa, Plateau, Yobe, Kebbi, Niger, Kaduna, Kano, Bauchi, Sokoto, Adamawa, Taraba and the Federal Capital Territory (FAOSTAT, 2002).

African is rated high in the global production of tropical fruit with Nigeria playing a leading role (FAOSTAT, 2002, Adewumi, 2008a). Despite the high production records, the high post harvest losses limit the availability of fresh fruits in Africa throughout the year (Kazembe, 2005, Olukunle, 2007, Adewumi, 2008b). Where the fruits are scarcely available, they are very expensive during off season and unaffordable for the general masses. There is therefore the need for effective storage, processing and handling of fruits in Africa.

Raw fruits generally have low shelf life because of the high moisture level and activities of micro organisms (Adewumi and Akerele, 2003). These have led to high level of losses both on and off – field. Post harvest losses of fruit and vegetable in the extreme cases are as high as 70% in Africa

(Kazembe, 2005, Olukunle, 2007). There is therefore need for concentrated attention to solve the problem of wastage of fruits and vegetable in Africa. Engineering applications is one key approach in solving the problem of wastage of fruits and vegetable in Africa. The paper therefore concentrates on important engineering issues in the post harvest technology and quality assurance for fruits and vegetables in Africa.

FRUIT PROCESSING AND QUALITY ASSURANCE

Fruits are living material with metabolic activities such as respiration which result in deterioration. Undesired ripening, and change in texture, color, firmness occur as a result of uncontrolled metabolic activities in fruits and vegetables. Post harvest processing and handling are therefore required soonest after harvest to address the problem of high level of and fast rate of deterioration of fruits. Post harvest handling is sometimes required to remove field heat soonest after harvest in the tropics using coolers or ice bags to arrest the activities of field micro organisms and fermentation.

Processes such as washing, color or size grading, peeling, slicing, crushing/ milling, juice extraction, sieving/ screening, inclusion of preservatives, homogenization, pasteurization, concentration, bottling/ canning, refrigeration and storage are essential (Adewumi, 1999, Ademosun et al, 2003). Adequate storage environment in terms of relative humidity and temperature must be provided for fruit storage (Adewumi and Akerele, 2003). In large storage systems, non compatible crops must not be stored together in the same system or structure (Adewumi and Oduwole, 1995, Okunola et al, 2007).

Micro organism infestation and mechanical bruising on fruits are very high on field and during post harvest handling respectively (Adewumi, 2009, Adewumi and Alokun, 2009). These consequently affect fruit quality. Micro organism infestations result in change in taste, flavor and color. Mechanical injuries and bruises on fruits expose fruit surface to accelerated micro organism infestations and contaminations.

Processing of fruit into juice, jam, concentrate and other durable products has numerous advantages, including the under listed, as identified by Adewumi (2008a, 2009b)

- increases the storability and shelf life
- improves profit margin
- reduces the transport costs, spoilages, and wastages
- value addition, employment & industrial activities
- makes the product available all year round at moderate cost
- provides quality assurance

Quality assurance is very essential in fruit processing and handling to enhance good market and pricing. Processing and handling of fruits much be done such that quality and quantity losses are minimized. The minerals, vitamins, unique taste, flavor, integrity, firmness and other essential quality parameters of fruits must be preserved. Components of the machines for processing and handling fruit materials must be made of high quality materials such as stainless steel to avoid contaminations. The environment under which fruit and vegetable processing is done must be highly hygienic. Where products are for export market, high quality assurance measures and CODEX requirements are essential (Adewumi, 2006).

ENGINEERING ISSUES IN THE POST HARVEST TECHNOLOGY AND QUALITY ASSURANCE FOR FRUITS AND VEGETABLES

Major engineering issues to support the production, processing and quality assurance of fruits and vegetables in Africa include:

- increased production via mechanization
- reduction of post harvest losses and increase in shelf life by adequate processing
- development of infrastructures to support agricultural production
- Industrialization of the rural areas
- energy in agriculture
- agricultural waste management

Increased Production via Mechanization

Major scientific means of rapidly increasing the rate of agricultural production include the development of high yielding and disease resistance breeds/ variety, use of biotechnology and applications of agricultural mechanization. Agricultural mechanization as defined by Anazodo (1986), is the process of development and introduction of mechanized assistance of all forms and at any level of sophistication in agricultural production in order to reduce human drudgery, timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of agricultural products, provide better rural living conditions and markedly advance the economic growth of the rural sector. He further explained that agricultural mechanization means more than availability and use of tractors and modern equipment and does not necessarily imply large mechanized farming.

Africa is generously blessed with land resources. Africa is the second largest continent in the world after Asia and with a total land area of more than 3,025.8 million hectares (ha). Its landmass is more than three times that of the United States of America (UNEP, 2007). Despite the land mass and the large population (70%) involved in agricultural production, a lot of the land is wasting and not utilized. A reasonable mass of arable land both in the savanna and forest zones are not yet open for cultivation. Sometimes, the problems of the cultural beliefs, land tenor system and inconsistent government policies on land ownership in Africa, are major problems to land utilization in Africa. A lot of restrictions are placed on the use of some land portions based on cultural and religious beliefs. In some cultures in Africa, some forest areas are exclusively sacred and reserved only for some gods which places restrictions on the use of these areas for agricultural practices. The private ownership of small parcels of land in a number of African countries makes agricultural production highly subsistent and is a great hindrance for mechanization. Land disputes are also frequent in Africa.

The skillful use of heavy agricultural equipment such as crawling tractors, tree pushers, and tree fellers to open virgin lands, and wheeled tractors and farm implements to till and cultivate the land are major break troughs in agricultural production. The use of tractor for land tillage and cultivation is widely accepted in Africa. But, it is unfortunate that all brands of tractors that are not adaptable for African soils are imported by African Governments and many of such tractors get spoilt soonest after acquisition and are not functional (Atanda, 2005a, b, Atanda et al, 2008). This has resulted in colossal waste of financial resources of Africa. Also, the abuse of the use of heavy equipment for opening virgin lands by non professionals and quacks in Africa has subjected African soils to high erosions (Adewumi, 2008a).

African Governments should address the problems of importation of unprofitable and sub standard machineries for land preparation and cultivation. The unique climatic conditions and soil types in Africa, and other relevant technical information must be considered before embarking on the importation of agricultural machinery. Professional advises should be carefully considered before importations.

Reduction of Post-harvest Losses and Increase of Shelf Life by Adequate Processing

The use of mechanical systems to process and handle raw fruits can reduce post harvest losses and increase their shelf life. The use of drying systems for moisture reduction has sharply reduced the activities of micro-organisms on agricultural materials and prolonged their shelf life. Some important post harvest handling processes such as sorting, cleaning, slicing, crushing/ milling, juice extraction, homogenization, concentration, pasteurization, packaging, canning, refrigeration and storage require machines. The use of such machines assist in reducing moisture/ weight, reduce spoilage, allow added value chain, increase farmer's profit margin, reduce transportation cost, enhance new product development and make product available all year round (Ademosun, 1997, Ademosun et al., 2002, 2003, Adewumi, 1998, 1999, 2004, 2005, 2007a, b).

One of the greatest problems of fruit processing in Africa, Nigeria inclusive, is unavailability of machinery for handling, storage, drying and processing (Adewumi, 2005, 2008a). A number of machines for handling, storage, drying and processing of agricultural materials are already developed within Africa via research efforts but not available to the public (Adewumi, 2007a, 2008a & 2009a). Some of the reasons for the non availability of the machines developed by research efforts to the end users in Africa were identified by Adewumi (2006b, 2007, 2009a, b, c) to including:

- poor quality of engineering materials
- inadequate locally technology transfer procedures
- inadequate extension services
- inconsistent government policy
- energy and power problems

Development of Infrastructures to Support Agricultural Production

One of the major roles of engineering in agricultural development is the development of basic infrastructures. Such infrastructures include:

- farm roads for access
- dams for water supply and irrigation
- Hydraulic structures to support irrigation and drainage
- Farm houses for the farmers
- Animal housing and plant storage structures
- Communication and electronic devices/ panels for monitoring & sensoring
- Agricultural land reclamation system/ facilities
- Machines for handling, drying and processing agro materials (including pre harvest, harvesting and post harvest machines)

Industrialization of the Rural Areas

Rural communities are the main centres of production of agricultural materials, which are the main raw materials for many industries (Adewumi, 2007b). It is therefore reasonable to developed feasible rural communities as industrial centres to promote rural development (Adewumi, 2008a). The proposed 'engineering in agriculture' must promote rural sociology via industrialization. It should minimize or arrest the migration of the masses from rural to the urban centres and encourage intensive rural development.

To promote rural development and industrialization, all industries responsible for processing raw agricultural material to agricultural produce should be sited in such key rural centres. Basic infrastructures (such as road, communication net work, electricity, water, etc) to support the proposed industrialization should be provide in these rural centres. In addition to sharp rural development and improvement in rural sociology, the consequent positive effects of the provision of such industrial activities include:

- mass employment
- increase in net profit
- reduction in unit price of commodities
- increase in agricultural production
- reduction of crime rate
- reduction of rural poverty level
- empowerment of farmers & rural dwellers
- reduction of rural migration, etc

The poverty level in the African rural communities shall sharply reduce when such industrial activities are initiated in the rural areas.

Energy in Agriculture

Electricity which is generally regarded as neat and conventional source of energy is not commonly available in Africa, especially in the rural areas which are the centres of agricultural production. Alternative and renewable sources of energy are therefore advocated for Africa, especially solar, bio-methanation, wind, hydro and geo-thermal, bio-fuel, etc.

Bio-energy is the renewable biomass resources, which are used to produce an array of energy related products including electricity, liquid, solid and gaseous fuels, heat, chemicals and other materials. Bio-energy ranks second to hydropower in renewable U.S primary energy production and accounts for 3% of the primary energy production in the United State. Biomass include any plant derived organic matter available on a renewable basis such as dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residue, aquatic plants, animal wastes, municipal wastes and other waste materials. Societies have used bio-energy for thousands of years, ever since before burning wood was used to cook food or heat a home. The use of bio-energy has the potential to greatly reduce green house gas emissions (Ellington et al., 1993, Berndes et al., 2003).

Hydropower energy is derived from flowing water. The most common types of hydropower plant use a dam on a river to store water in a reservoir. However, hydropower does not necessarily require a large dam. A small carnal can be used to channel the river through a turbine. Geo thermal energy is derived from the heat in the earth. Geothermal energy technologies use the heat of the earth for direct use applications, geothermal heat pumps and electrical power production. Geothermal energy sources are favored because they releases little or no air emissions compared to convectional energy resources (De Laquil, et al., 2003). Solar energy is used in providing heat, light, water, electricity and cooling. Photovoltaic (PV) systems are the easier means of providing electricity from the sun using solar cells (Kelly, 2003).

Inadequate handling and management of agricultural waste can lead to epidemics and mass casualties. Proper handling and management of agricultural waste can positively turn the wastes into abundant source income generation and business, bio gas production been a good example. Agricultural waste management systems must be provided in the rural communities, not only urban areas.

Agricultural Waste Management

Agricultural waste is associated with very high pollution characteristics, especially effluents from fruit and vegetable processing. It has detrimental effects on the soil, plant, surface & underground water and pollutes the air. It could be a very serious problem resulting in disease spread and epidemic if not properly managed. On the other hand it could become a source of income generation if well managed.

Engineering applications are essential in the design, construction and maintenance of:

- waste collection facilities such as rakes, collection bags/ buckets, etc
- waste disposal facilities such as drainage channels, tippers, etc

- waste management systems such as dumping ground, aerobic and anaerobic ponds, incinerator, septic tank, bio-methanation tank, etc
- Waste conversion/ recirculation facilities

The use of agricultural waste as bio-fuel, essential oil and organic fertilizer are means of making wealth from waste, and should be encouraged in the African nations.

CONCLUSION

About 70% of Africans are involved in agricultural production, yet Africa is not food sufficient. Whereas, in the developed nation, less than 5% of the population is involved in agriculture. This minority of people produce sufficient for national consumption and excess for export as a result of the applications of science and engineering. Engineering applications in the production and processing of fruits and vegetables must be encouraged in Africa.

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CLIMATE CHANGE, AGRICULTURAL PRODUCTIVITY AND BIOTECHNOLOGICAL IMPLICATIONS IN SOUTH - WESTERN NIGERIA

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Abstract

In South-western (SW) Nigeria, evidence of climate change include rainfall variability over time and space, decreasing rainfall duration, changing time (month) for the beginning of the raining season, shrinking raining season, chronic rainfall deficit, changing ecosystems, increasing drought and flood frequency and incidence, desert encroachment, coastal erosion, etc, all of which translate into water and food deficit. With an agricultural sector mostly rainfall dependent, the impact of climate change on agriculture was assessed using secondary data on rainfall, cultivated area, yield, price and income per ha for major crops in the zone. Data from 1995 to 2006 were analysed using mean, standard deviation, coefficient of variation, Curve Estimation models and ANOVA. The results indicate negative rainfall trend from 2001 and greater variability of yield and income for all five major crops considered (0.28 in average) with an overall rainfall variability of 0.14. Sorghum presents the highest variability in total area planted among the crops. Of all crops analysed, yam and sorghum show a constant decrease in yield over time, while cowpea yield remained stable in the area. These results imply that more research attention in terms of biotechnological adaptation to climate would still be needed despite the ongoing efforts from National and International Research Agencies on such crops like yam and sorghum. In order to break the current trends in yield decline the efforts would mean more adapted agricultural practices policies like irrigation calling for an adaptation biotechnology development compatible with such new practices which would also be coupled with variables like changing tastes in order to ensure food security and agricultural sustainability in South-western Nigeria.

Keywords: rainfall, crops areas and yield, price, trend an variability estimation, South-western Nigeria

INTRODUCTION

Climate change is the long term pattern of change in trend and variability in weather indicators such as temperature, rainfall, solar radiation, winds, etc. (Wikipedia, 2009) resulting in changing events such as increasing desertification, frequent drought, flooding, freeze and changing ecosystems leading to natural disasters and catastrophes with associated economic effects such as famine, widespread diseases, poverty and increasing conflicts over environmental resources. The current causes of climate change are natural and anthropogenic. Natural factors include changing earth orbit, solar events, etc. while anthropogenic factors result into global warming as a result of industrialisation, aggressive technology, intensive use of fossil fuels, aerosols, etc. and the derived rapid population growth. Of the three of natural events, population growth and technological progress experts unanimously agreed that anthropogenic factors especially Greenhouse Gases generating technologies are the fastest causes of climate change and global warming and Africa would be one of the continents of the world to be most vulnerable to climate change (Rosenzweig and Parry, 1994; UNFCCC, 2006; IPCC, 2007). Studies also report that some adaptation measures are taking place; however, this may be insufficient to curtailing future effects of the changes in climate. According to IPCC the Sahelian region of Africa, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops while in southern Africa, longer dry seasons and more uncertain rainfall and sea-level rise with population growth are together contributing to losses of coastal wetlands. Temperatures change in the area range from 0.2 to 1.0^{0} C for the period 1970-2004 with associated disturbances that include flooding, drought, wildfire, insects attack and other global changes in land use, pollution, and over-exploitation of natural resources. According to IPCC it was expected that “By 2020, between 75 million and 250 million people would be exposed to increased water stress due to climate change. Agricultural production, including access to food, in many African countries and regions is also projected to be severely compromised by climate variability and change. Lands area to agriculture, the length of growing seasons and yield potential, particularly in the semi-arid and arid areas, are expected to decrease by up to 50% by 2020. According to the *Third Assessment Report the Intergovernmental Panel on Climate Change in its* scenarios over the next 30 years global food production will need to double to feed the planet’s growing population. For Africa the report concluded that many countries would experience a fall in grain yields and would be vulnerable to droughts, floods and other extreme events that would put greater stress on water resources, food security and human health.

The United Nations Framework Convention on Climate Change (UNFCCC) identifies two options to address the climate change issue: *mitigation* of climate change by reducing greenhouse gas emissions and *adaptation* to the impacts of climate change. Mitigation comprises all human activities aimed at reducing the emissions of greenhouse gases such as carbon dioxide, methane and nitrous oxide. Adaptation in the context of climate change refers to any adjustment that takes place in natural or human systems in response to actual or expected impacts of climate change, aimed at moderating harm or exploiting beneficial opportunities. According to UNFCCC (2006), both mitigation and adaptation are essential in reducing the risks of climate change. For Agriculture, climate change may call for mitigation or adaptation, but UNFCCC (2006) recommends adaptation rather than mitigation in tackling the effect of climate change.

The climate change has some implications on agriculture and its long term sustainability in terms of resources use and future availability. This therefore calls for constant agricultural productivity adjustment adaptation.

Worldwide, the technological strategies adopted to face the agricultural productivity variability challenges include the use of drought and diseases resistant-early maturing varieties (food crops, livestock, vegetables and trees), soil fertility management techniques, and environmental protection measures (including wind-break techniques), development of irrigation technologies adapted to small farming environment, etc.

Two approaches are being canvassed in tackling the problem of agricultural adaptation to climate change: the conventional crop breeding approach and the biotech engineering approach. But, in a 2002 interview with Actionbioscience on Biotechnology and the Green Revolution, the renowned Scientist

Norman Borlaug stated that the conventional approach of crop improvement only, used to adapt agricultural production seems inadequate in front of the projected high speed of climate change in the near future. This ineffectiveness therefore suggests the use of the new strategy of biotechnological engineering application. Biotechnological measures, in addition to promoting environmental friendly tropical agriculture may include genetically modified organisms (GMO) such as transgenic crops (corn, rice, tomato, soya, fruits, sweet potato, etc) incorporating herbicide-tolerant gene, transgenic animals (cows, sheep, pigs, rabbits, etc), etc. and the need for increased productivity using less land area in order to stop hunger in developing countries of Africa and Latin America. He also suggested to first considering crops that are most basic to the country's food system.

CONCEPT OF BIOTECHNOLOGY

Biotechnology could be defined as either a technique or method of producing new technology or substance using life materials (micro organisms, plants and animals). It involves the technique of breeding, genetics, embryology, biochemistry, cell biology, molecular biology, bioengineering, etc. According to Wikipedia (2009) it is technology based on biology and can be classified into green biotechnology (agriculture), red biotechnology (health), blue biotechnology (marine science) and white biotech (industry). Biotechnology in agriculture would increase yields, produce drought and diseases resistant crops, reduce crops vulnerability to environmental stresses, improve nutritional quality and market characteristics of crops, reduce dependence on artificial fertilizers and agrochemicals and produce novel substances from plants and animals for human health and the industry.

THE SITUATION IN SOUTH WESTERN NIGERIA

Nigeria is a tropical country situated in West Africa. Its climatic zones include the Dry Guinea savannah in the Northern part, Humid Guinea savannah in the middle and the rain forest in the south. The South Western Nigeria is geographically located between the longitudes 2^0 24' and 6^0 03' E and latitudes 5^0 49' and 9^0 17' N (Balogun, 2003), and comprise the Guinea savannahs and the humid dense forest climate characterised by two seasons: dry season and wet seasons. The mean annual rainfall varies between 500 and 1800 mm per annum and the mean temperature between 22^0 and 30^0 C with relative humidity between 75 - 95%. The agricultural output grew only by 2.7 percent per annum against 3.1 percent annual population growth, denoting en environment of constant food deficit in quantity and quality serving the basis for huge bill of food imports.

Administratively the SW Nigeria is made up of six States namely Lagos, Ogun, Oyo, Ondo, Osun and Ekiti covering a total area of 72,000 km^2 with an estimated population of about 27 millions people. The population in the area are mostly Yoruba with agriculture as the predominant occupation practicing mixed cropping and mixed farming. The SW Nigeria, with a population density of around 400 habitants per km^2 is characterized by a rain-fed agriculture, a predominantly small-scale farming using traditional crops and practices with a high rate of shrinking farming space due to gulley and wind erosion and increased wind incidence during cropping including coastal erosion. Some international organizations operate in the area like ILRI, IITA, including national agricultural and research centres trying to alleviate the area's food problems. Farmers are constantly faced with poverty and food insecurity challenges. The major cops grown in the area include maize, yam, cassava, cowpea, guinea corn, vegetables, fruits, etc. while poultry, small ruminants and cows are the major livestock raised.

Natural Indicators of climate Change in SW Nigeria

Agriculture in SW Nigeria is also rain-fed. It is practiced in majority by small scale farmers using traditional crops and practices. The area is also marked by a growing population and fast depleting natural resources as a result of the impact of the climate change posing a pressing challenge for growth and agricultural sustainability. Some of the visible indicators of climate change in the area include: shifting raining period and length, late and shorter rains, inter-annual rainfall variability, seasonal water scarcity, instable rainfall level, increasing natural evaporation as a result of changing temperature, decreasing water table, fast drying and shrinking rivers, shrinking ecosystems, growing desertification… The impact on local agriculture include: frequent rain deficit and drought with intermittent storms followed by sporadic floods, depleting soil resources, eroding soil fertility, shrinking agricultural lands and grazing space, increasing poverty incidence, growing conflicts over natural resources among farmers and between farmers and transhumant livestock herders; this partly as a result of long age population migration from the northern part of the country. Of great concerns are shifting and unpredictable start of the rainy season coupled with shrinking days and high fluctuations of the rainfall, an unprecedented pest and disease incidence that constitute current adaptation challenges for agriculture and calling for prompt biotechnological applications. Eleri (2007) and Adejuwon (2009) noted that policies to make Nigerian Agriculture less vulnerable to climate variability must include the development of heat tolerant varieties and improved seeds and cultivars.

The objectives of this study were to analyse the effects of climate change on some major agricultural products in the SW Nigeria in order to recommend appropriate biotechnological adaptations measures that would ensure sustainable productivity in the area. Specifically the study:

- Analyses the trend and variability of the climate in SW Nigeria;
- Assesses the effect of the climate change and variability on five major crops;
- Identifies necessary biotechnological research direction for the area.

MATERIALS AND METHODS

Time series data from CBN and National Bureau of Statistics for the period 1995-2006 were analysed using descriptive and inferential statistics. Trend analysis (with quadratic or cubic curve estimation models as suitable), coefficient of variation ($\mathbf{CV = \sigma_x/\mu_x}$) and Analysis of variance (ANOVA) were used to analyse the data. Curve estimation regresses smoothed data of annual total rainfall, cropland areas, yields, deflated average prices and income per ha, over time. Trend analysis helps assess any climate change and biotechnological impact while the CV indicates the level of variability and risk in production for the crops. The crops considered for the analysis include maize, yam, cassava, cowpea and sorghum and the states covered are Lagos, Ogun, Ondo, Osun, oyo. The inflation rate (base 1985) from National Bureau of Statistics (2006) was used to deflate the price and income series.

Computation of deflated price and income

The real price and income were computed as follows:

$$X_t^* = X_t (1- f_t)$$

Where,

X_t^* = real value

X_t = nominal value

f_t = inflation rate (%)

RESULTS AND DISCUSSIONS

Trend and Variability in Rainfall

The results of Curve estimation with quadratic model over the period 1995 – 2006 shows a significant positive trend up to 2001 followed by a decline thereafter (b1 = 121.68, b2 = -7.32; F = 8.248***[2]). Rainfall also shows instability with a coefficient of variation of 0.14 over the period. Total Rainfall trend beak-down by state shows: a non significant increase followed by a decrease in Lagos (b1= -85.18, b2=11.078; F =1.090^{NS}), Ondo (b1= 4.54, b2= -0.19; F = 0.155^{NS}), and a non significant decrease followed by an increase in Ogun (b1= -31.78, b2= 0.69; F =1.81^{NS}), Osun (b1= - 0.77, b2= 0.258; F = 1.36^{NS}) and Oyo (b1= -5.45 , b2= 0.31; F = 0.59^{NS}).

A comparative analysis by state shows rainfall coefficient of variation classified in decreasing order as follows: Oyo (0.23), Ogun (0.22), Osun (0.21), Lagos (0.19) and Ondo (0.16) respectively. These results confirm the assumption of decreasing trend and rainfall instability in SW Nigeria, both constituting serious challenges for future agricultural sustainability and food security in the zone.

The results of the analysis of the implications are discussed per crop.

Maize

The maize land area with a CV of 0.11 displays a significant sinusoidal curve with a positive trend since 2003 after a decline from 1998 (F=3.47*) with no significant decreasing overall linear trend. This is, on the decrease in Ogun (F= 3.58**), Ondo (F=3.47*), Osun (F=2.28^{NS}[3]) and Oyo (F = 3.59*) but, shows a significant positive trend in Lagos state only (F=324***).

The maize yield in average shows an overall significant positive trend (F= 44.50***) and a coefficient of variation of 0.06 indicating yield stability. Maize yield shows increasing trend in Lagos

[2] *; **; *** = 10; 05 and 1 percent level of significance.

[3] ^{NS}: not significant

(F= 38.35***), Ondo (F=0.47^{NS}) and Oyo (F=10.71***) States, but a non-significant decreasing yield in Ogun (F= 0.80^{NS}) and Osun (F= 2.1^{NS}).

In the northern part of the zone (Oyo) with the highest coefficient of rainfall variation there is palpable indication of chronic maize yield deficit. The CV of Maize yield per state is as follows (0.14) in Lagos, Ogun (0.0033), Ondo (0.056), Osun (0.000032) and Oyo (0.12). Lagos and Oyo state present the highest maize yield variability. Oyo state present both high rainfall and maize yield instability reinforcing the relationship maize yield and rainfall variability. It means any rainfall deficit would translate automatically to some extent into deficit in maize production and yield therefore into less income to farmers. Both maize real price and income per ha show a significant positive trend (F= 41.44*** and F= 42.98*** respectively) over the period while the CV of real price and income are 0.36 and 0.39 respectively.

The positive trend in maize yield would see the impact of technological research and adoption by farmers in the SW Nigeria. The results in all would denote maize intensification policy through faster technological change induced by research in the area, when combining decreasing land area, though not significant, with an increasing and stable yield and an increasing but less stable maize market price and income to farmers.

Yam

The land area to yam crop shows a significant positive trend in the SW Nigeria (F= 9729.51***). A break-down by state shows a positive trend in all states as follows: Lagos (45.51***), Ogun (1.73^{NS}), Ondo (F=13.80***), Osun (F = 18.75***) and Oyo (F = 1.74^{NS}), with increase in yam land area significant for Lagos, Ondo and Osun only over the period 1995-2006. The CV of yam area is 0.21, denoting an unstable year to year land area to yam in the region.

The yam yield under the rainfall system with the quadratic model shows a significantly negative trend

(F= 2.97*), meaning a decreasing productivity of yam crop in the area following a period of increase. The break down by state shows: Lagos (F=1.023^{NS}), Ogun (increase, F=5.58**), Ondo (increase, F=6.70**), Osun (increase, F=24.81***), Oyo (F= 0.40^{NS}). The quadratic model results mean Ogun Ondo and Osun displayed a significant increase in yam yield, while Lagos and Oyo show a non significant change in yam yield over the period of analysis.

The CV of yam yield is 0.15 and a break-down by state shows Lagos (0.074), Ogun (0.0006), Ondo (0.04), Osun (0.54) Oyo (0.43) meaning Osun and Oyo states in the northern part present the highest inter-annual yam yield instability.

Yam price shows a significantly positive then declining trend since 2002 (0.176; F=19.24***) including income (b1 = 48384, b2 = -2996.71; F=8.82***). This tendency to declining real price and income may be a discouraging signal to farmers in the long term. The CV of yam price and income are 0.36 and 0.39 respectively meaning high uncertainty to farmer for agricultural financing and modernization of yam farm.

In summary, the results denote increasing demand for yam due to increasing land area in an environment of decreasing productivity. There is urgent need for biotechnological adaptation of this crop for increased productivity that would reduce demand for land expansion. But there is a risk that any biotechnological adoption by farmers be hindered by the non stimulating negative trend in income.

Cassava

Of the linear, quadratic and cubic models, only the cubic curve estimation shows a significant sinusoidal fluctuation in cassava land area showing a positive trend since 2004 after a decline from 1997 (F=4.61**; sinusoidal positive) with a CV of 0.11 and a non significant negative linear trend. Yam area trend by state shows: Lagos (F=134***; linear positive), Ogun (F=2.96*; sinusoidal positive), Ondo (F=4.008**; sinusoidal positive), Osun (F=3.88**; sinusoidal positive), Oyo (F=2.96*; sinusoidal positive).

The yield also displays a sinusoidal form with a significant positive trend especially since 2004 (F=3.45*; sinusoidal positive) probably due policy measures of the Federal Government towards more cassava production for export and industrial use. The CV of the yield is 0.031 showing cassava yield stability in farm environment. These results show the technological impact of research for the crop in the area. By state: Lagos (F=4.61**; sinusoidal positive), Ogun (F $=1.69^{NS}$ sinusoidal negative not sig.), Ondo (F=9.24***; quadratic positive), Osun (F= 21.22***; sinusoidal negative), Oyo (F=3.43*; sinusoidal positive). Therefore only yield trend in Lagos, Ondo, Osun and Oyo were significant.

A significant positive trend in real price and income (F=39.14*** and F=48.38*** respectively) to farmer also indicates an encouragement to production by small farmers making the bulk of producers with a CV of price and income of 0.37 and 0.39 respectively.

Because of the technological impact the effect of climate change could be said to have been mastered for this crop through the yield as farmers seem to be responding positively in terms of technological adaptation, following for instance the introduction of virus resistant cultivars by Research Institutes. But this yield improvement in farmer's environment should translate into decreasing trend in cassava land area; we have a seemingly non significant effect probably because of land area expansion due to new farmers entering the business.

Cowpea

The quadratic and cubic models that fitted better the data show that cropland under this crop declined from 1995 up to year 2001, then steadily increased from there on (F=4.094*; convex positive from 2001) with an associated CV of 0.10. By state, Lagos (F=114.3***; concave declining since 2003), Ogun ($F=2.048^{NS}$, negative NS), Ondo ($F=2.05^{NS}$; declining NS), Osun (NIL), Oyo (8.34***; convex positive from 2001). What then would explain the decline in cowpea land area within the period 1995-2001 in the SW Nigeria? Would scarcity of seeds explain this decline in cowpeas cropland? Is any cowpeas improved seeds scarcity for planting witnessed within the period in the area?

Cowpea yield (F =0.51^{NS} stable yield) shows yield stability with a CV of 0.14. By state: Lagos yield (F=3.91*; sinusoidal positive); Ogun (F= 2.4^{NS} negative), Ondo (F = 2.63^{NS}; concave negative from 2001), Osun (NIL) Oyo (F= 0.49^{NS}; negative NS trend).

The non increase in cowpea yield would mean a non significant on-farm impact of cowpea technologies developed by Research Institutions for the area.

The trend in cowpea real price and income show a significant positive trend (F=51.79*** and F=11.47*** respectively) which is an encouragement to cowpea production and the CV of cowpea price and income were 0.36 and 0.37 respectively.

These results show the need for an urgent biotechnological adaptation for this crop and also in terms of policy of massive adoption and acceptance by farmers. Would there be a problem of cowpea taste or of climate and pests management, especially in front of high cowpea demand in the area?

Sorghum

From 1995 to 2003, sorghum acreage in the area grew sharply then started a decline thereafter (F=174.92*** concave negative from 2003) for a CV is 0.24. By state Lagos (NIL), Ogun (NIL), Ondo (NIL), Osun (NIL), Oyo (F=174.92*** concave negative from 2003).

The average yield displayed a significant negative trend (F = 15.12***) and a CV of 0.18 over the period. By state we have Lagos (NIL), Ogun (NIL), Ondo (NIL), Osun (NIL), Oyo (F=15.12*** negative trend).

These results denote an absence of biotechnological adaptation or adoption for the crop in the area, probably because seen as local crop. This crop presents the highest instable in yield and land area in the SW Nigeria.

The real price and income for sorghum show significant positive trend (F= 20.24*** and F= 17.20*** respectively) with a CV of 0.36 and 0.33 respectively, meaning encouragement to production. In view of this there are therefore potential returns to biotechnological research adaptation needed for this crop in the area.

Summary of the Results

The results showed that total rainfall displays a significant variability and negative trend since 2001. In terms of cultivated cropland area, guinea corn and yam present the highest instability. Croplands allocated to maize and cassava both followed a significant sinusoidal trend with a positive trend from 2003 for maize and 2004 for cassava. Yam land area witnessed a significant steady increase over the period. Cowpea land area witnessed a significant decrease up to 2001 and started increasing thereafter while sorghum witnessed a significant contrary increase up to 2003 before starting a constant decline. Questions: what would explain the decline in cowpea area for the period 1995 -2001? Would sorghum area increase in the same period make this crop a direct substitute to cowpea in farmer's environment?

In terms of yield variation, yam, cowpea and sorghum show highest yield variability while maize and cassava show stability.

In terms of yield trend, significant positive trend over the period was displayed by maize and since 2004 by cassava. It showed stability for cowpea yield, while yam and sorghum displayed a significant negative trend in yield.

The real Price and income for all five crops except income from yam show significant positive trend over the period.

CONCLUSIONS AND RECOMMENDATION

There is clear evidence of climate change and variability in SW Nigeria confirmed by rainfall instability associated with a decreasing trend. There is also cultivated croplands variability. Would the sharp opposite trend between sorghum and cowpea make these crops on-farm substitutes?

Of the five crops analysed sorghum presents the highest land variability.

In terms of yield trend, maize and cassava present a significant positive trend in yield, while yam and sorghum show a negative trend; and cowpea a yield stability denoting a lack of technological adoption. The highest yield risk was associated with sorghum followed by yam and cowpea, while maize and cassava present the lowest yield instability. Price and income of all crops show a significant positive trend except income from yam, but with variability in the same range for all five crops.

Yam, cowpea and sorghum therefore need more research attention in terms of biotechnology adaptation since all of these crops, assume significant positive trend as indicator for important returns to investments and also for long term food security.

In sum:

- There is evidence of effect of climate change and variability on Agriculture in SW Nigeria
- The declining rainfall trend means more irrigation policy and irrigation adapted technology would be required;
- The analysis shows a significant technological impact on two crops only: maize and cassava;
- Yam, cowpea and sorghum need more research attention in terms of biotechnology adaptation or adoption since all of these crops, assume significant positive trend in price, a potential indicator of returns to investments and also as a long term food security solution for the area;
- Finally, results show the need to encourage biotechnological research and biotechnological adoption that meet on-farm technical (tolerance, flexibility, resistance) economical (profit) and social (culinary, nutrition, taste, colour, size, etc) requirements.

Finally, the increasing agricultural water scarcity would also mean the need for irrigation technology policy that would call for crops technologies adapted to such an environment; all of this taking care of increasing demand and changing population structure and changing taste.

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Appendix

Fig1: Average Annual Rainfall in SW Nigeria for the 1995-2006

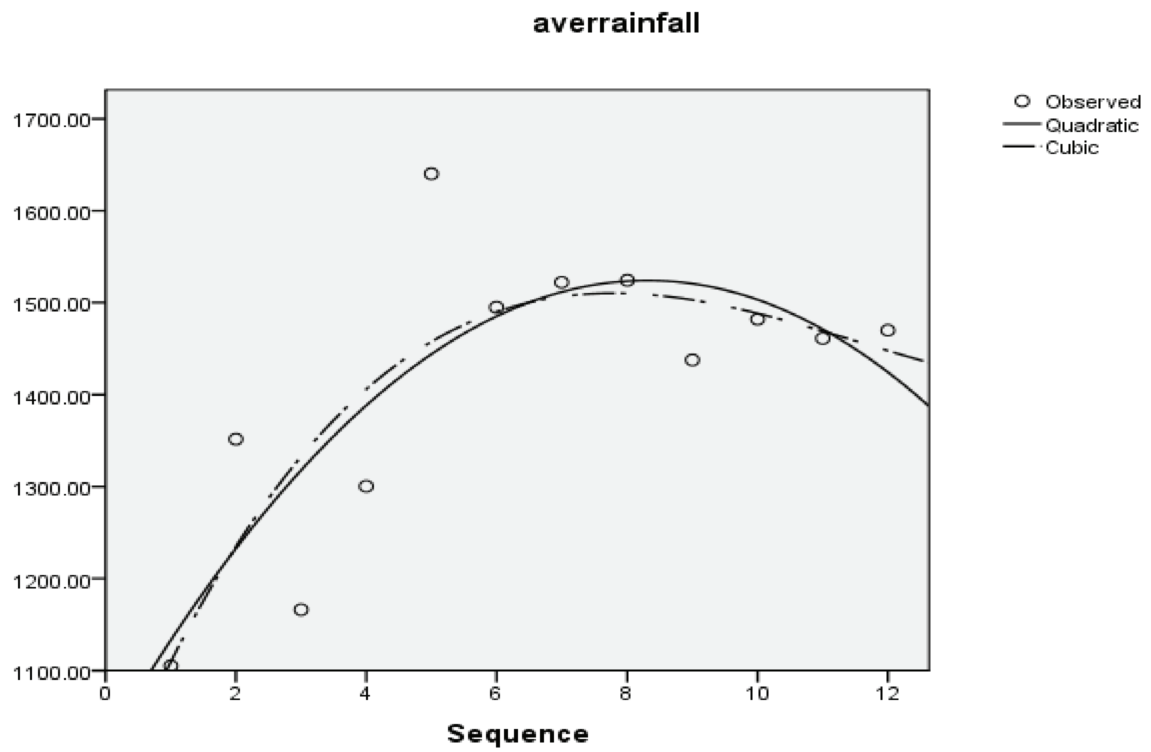


Fig2. Trend in yam yield over the period 1995-2006

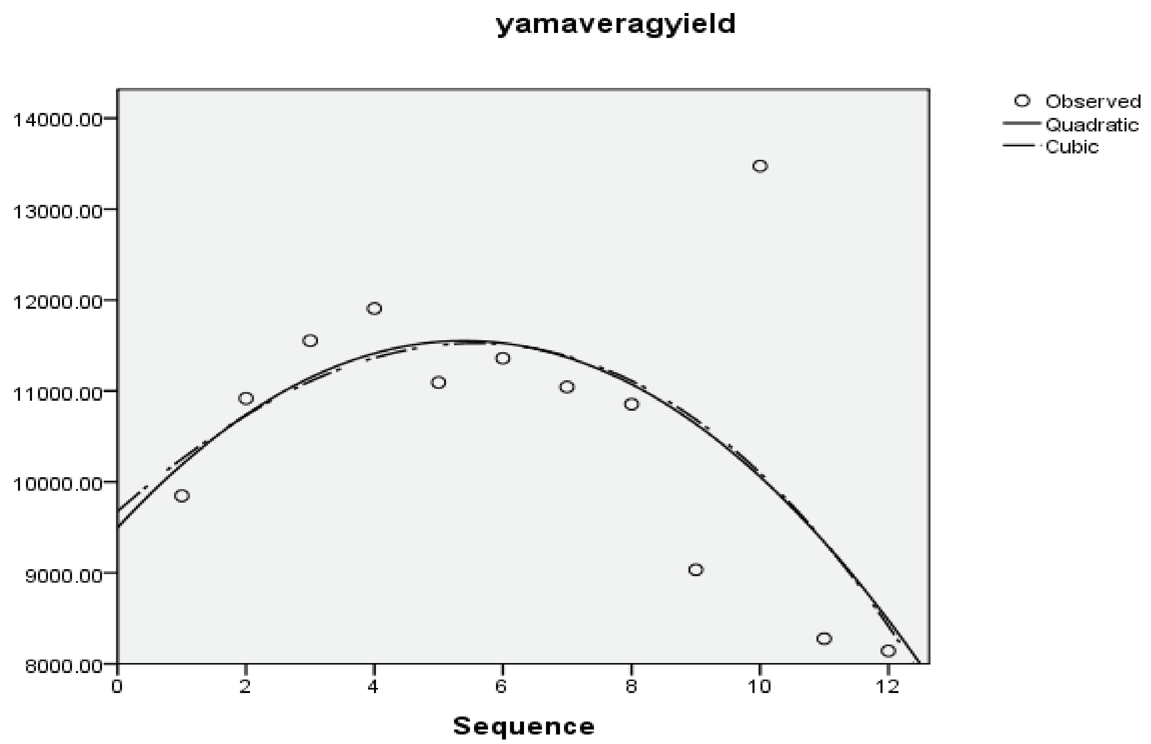


Fig3. Trend in sorghum yield over the period 1995-2006

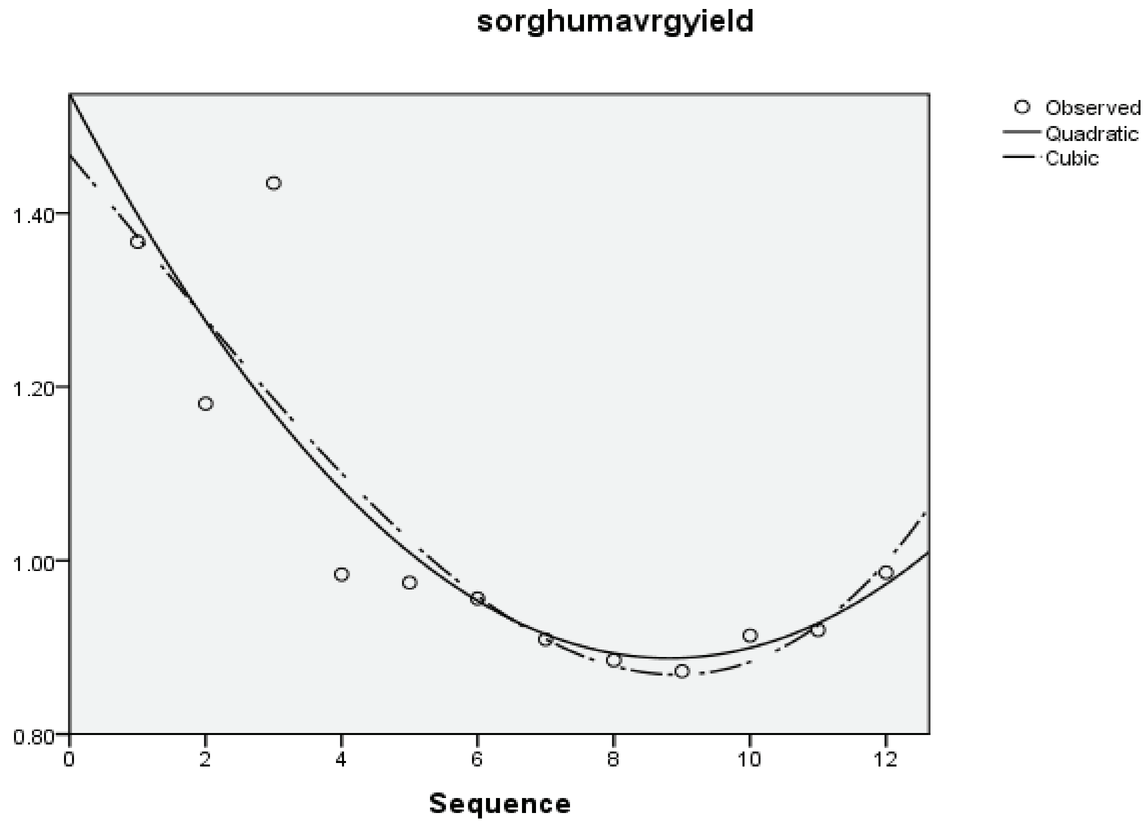


Fig4. Trend in cowpea area over the period 1995-2006

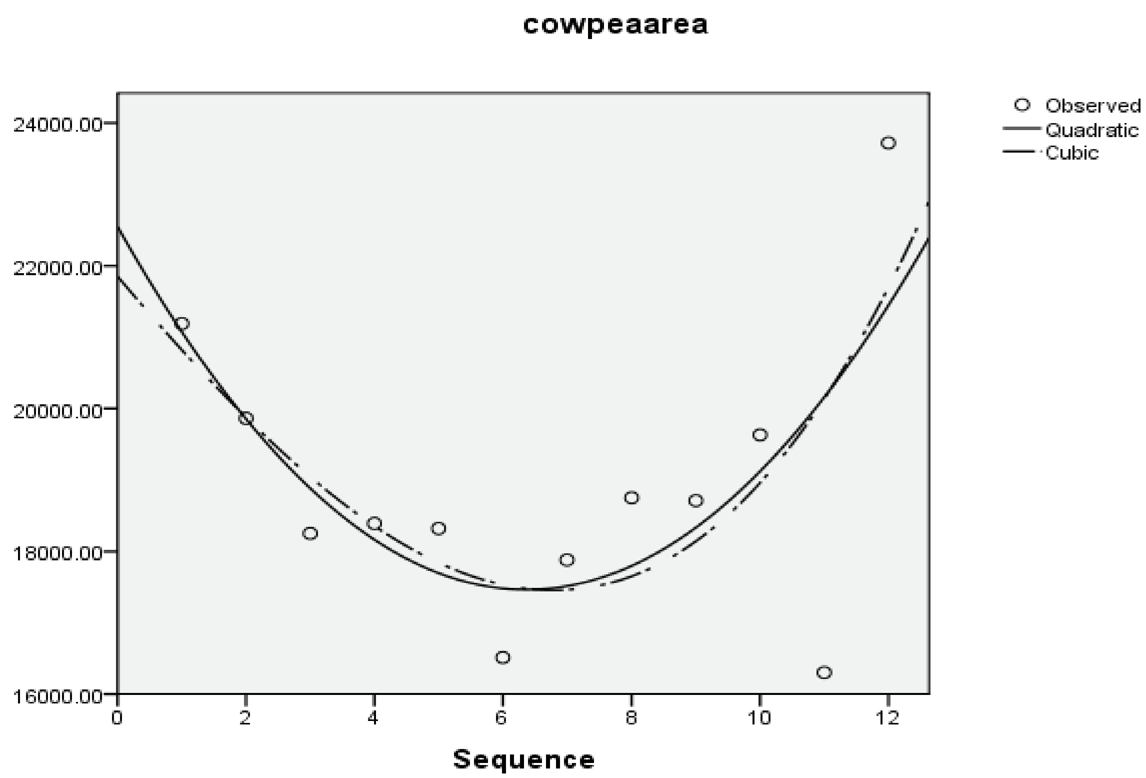
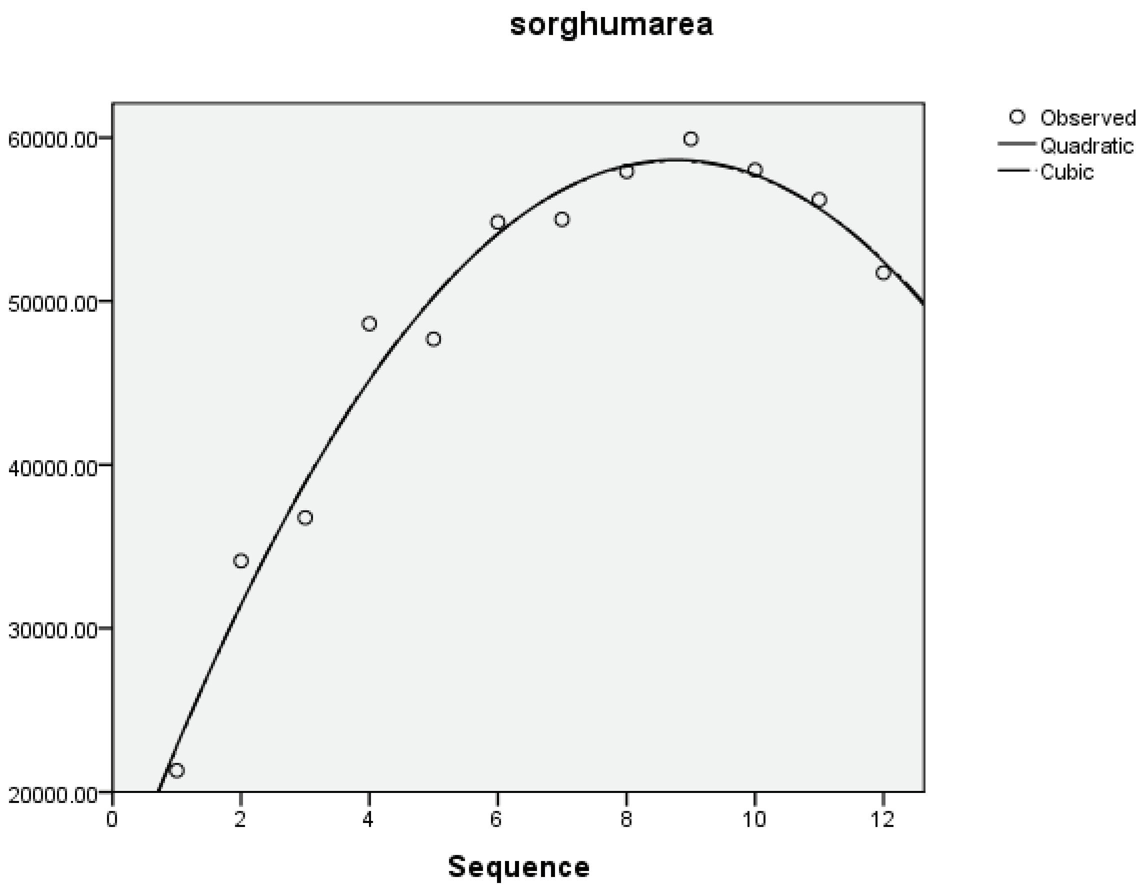


Fig5. Trend in sorghum area over the period 1995-2006



AGRICULTURE AND WEATHER VARIABILITY: HOW LOCAL FARMERS MITIGATE CLIMATE SHOCKS IN SOUTH-WESTERN NIGERIA[4]

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Abstract

Indigenous knowledge is pervasive in all the spheres of life of [the] rural people. Local-level decision making processes are thus guided by grassroots or local knowledge. Agriculture, which is the means of livelihood of the rural community dwellers, forms a major sector in which local knowledge is vital. Thus, farmers have read the weather as they wield experiences gained over the years to determine when to engage in farming operations [such as land preparation, planting, harvesting and processing, among others]. This paper employs a radical analytical approach to shed light on the politics involved in knowledge production. More importantly, it focuses on the identification of local strategies, which smallholder farmers [in south-western Nigeria] use in mitigating weather variability with a view to forestalling crop failures. The paper also probes what constitute weather variability to smallholder farmers; their impact on agricultural production; how these are mitigated by the farmers; and the problems with which these smallholders are confronted.

Keywords: Indigenous knowledge, agriculture, farmers, weather, variability, politics, grassroots, South-western Nigeria.

INTRODUCTION

The role of local knowledge in development cannot be gainsaid. As grassroots daily lives are guided by certain belief systems, local knowledge is seen as pivotal to rural livelihoods. Be it in agriculture, forest conservation and traditional medicine, to mention a few, indigenous knowledge forms the basis for local level decision-making of the rural people (See for instance Brokensha *et al.* 1980; Kolawole 2009, 2005, 2003, 2001; Warren 1990, 1990). Noted for their sensitivity, agricultural practices are engendered and directly influenced by geographical elements like rainfalls, temperature, soils and vegetations. They all interplay to influence the pattern of agricultural practices and productivity in a given locale.

Although becoming a global attention in the recent times, climatic change is not a new phenomenon. Hitherto 'unnoticed', the constant progression and growth of world's population combined with modernisation have over the years gradually and surreptitiously impacted on the environment. Indeed, the recent hues and cries about climate change have been informed by the sharp variations now noticed in global weather conditions (See Sachs 2008; IPCC 2007). Unheard, smallholder farmers have had to contend with this variability as the years went by. Through cognitive mapping and validations, smallholder farmers are thus able to discern the weather: they have developed local technologies to predict and adjust to the vagaries of weather. James Shikwati, Director of Inter Region Economic Network based in Kenya buttressed this claim succinctly thus:

> There was a time in Africa when elders would "talk" to the drought and negotiate their way into receiving rainfall. With their unique understanding of causation, elders would either sacrifice a black sheep or ask a virgin girl to bathe in a lake in order to draw the attention of the rain gods. Would that they could do so now (Shikwati 2009).

Shikwati's (2009) viewpoint may sound primitive and anachronistic, yet it is just the plain truth.

Over the years, weather variability has become a threat to poor people in sub-Saharan Africa (SSA). By and large, their livelihoods have been adversely affected as result of abrupt changes in weather conditions (Dobie *et al.* 2008: 1). Their resilience has thus been called to question as a result of a combination of factors ranging from economic, political, social and environmental concerns which tend to have overwhelmed these poor farmers. Unprecedented, warmer weather has been reported on [the] earth in the 20th Century by the Intergovernmental Panel on Climate Change (IPCC), World Meteorological Organisation (NMO) and United Nations Environment Programme (UNEP) (Obioha 2007: 1). As claimed by these bodies, the average surface temperature has now increased by about 0.6 ± 0.2°C making the earth warmer than at any other time 'during the past 1000 years...'

Anuforom and Okpara's (2004) study on *the influence of climate variability and climate change on agricultural production in Nigeria* is instructive. They had employed time series and variability analyses to investigate the general rainfall pattern (in terms of the amount, onset and cessation) in relation to agricultural production in four climatic zones[5] 'using data covering 60 years of monthly rainfall and 15 years of rainfall onset and cessation' (Kolawole *et al*. 2008). A 30-year trend data of agricultural yield and livestock production were also used. Their findings show '…some climatic variations which appeared as fluctuations of wet and dry years in and irregular pattern. Most rainfalls between 1944-1970 and 1991-2001 were above normal for the zones, while the rainfalls between 1972-1975, 1983-1989 (Sokoto, Kano), 1981-1988 (Maiduguri) were below normal'. But for Kano area, a decreasing rainfall trend was observed in the Sahel. The study also reveals that '…other climatic zones showed similar characteristics, except that the decreasing trend of rainfall was more serious and critical over the sahel (sic) region than the other zones…It is also observed that most of the zones received normal rainfall during the weak (1992-1994), moderate (1991) and strong (1972 and 1982) El Niño Southern Oscillation (ENSO) years' (See also Nigeria's First National Communication of the UNFCCC 2003).

Indications are that Anuforom's and Okpara's findings portray a dire situation for Nigeria as they show '…most of the climatic zones [including the rainforest of South-western Nigeria] are already under water stress or water scarcity...' affecting food and animal production in the affected areas. Kolawole *et al.* (2008) opine that many changes have occurred over the years as many rivers and streams have dried up. The *El Niño* phenomenon of 1994 experienced in Nigeria witnessed a period of long dry spell spanning the months of June and August when the rains should naturally have peaked.

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[5] The four climatic zones in Nigeria are the Mangrove forest situated along the coastline, Tropical Rainforest found in the southern part, Guinea savanna peculiar to the middle belt and the Sudan/Sahel savanna stretching across the northern fringe of the country (See Appendix 1).

In a way, this paper is particularly radical in its approach by shedding light on the politics involved in knowledge production. However, the discourse is principally concerned with the identification of local strategies/approaches, which smallholder farmers [in south-western Nigeria] use in mitigating weather variability with a view to forestalling crop failures. Probing on what constitute weather variability to smallholder farmers; their impact on agricultural production; how these are mitigated by the farmers; and the problems these smallholders are confronted with are addressed in the paper.

CONTEXTUALISING THE POLITICS OF DOING INDIGENOUS KNOWLEDGE RESEARCH

Nonetheless fragmented and contextual, knowledge by its nature is diffused and ubiquitous. Indigenous or local knowledge systems, which is the body of knowledge belonging to a group of people situated in a geographical location, is as old as the history of man. Grassroots people, particularly peasants and native philosophers, develop and hold this knowledge in trust. Although seen as pervasive in the developing world, local knowledge is neither mutually exclusive to the South nor to the North. Within both divides, traditions – being the basis of local knowledge – inform the interaction between grassroots people and their environments. More importantly, the politicisation of knowledge particularly amongst the modernists has thus engendered its delineation. Indeed, the contestations between modern science and local knowledge is rooted in the superiority once ascribed to the former by the modernists who had claimed that western science is 'organised' and 'systematic' as against the 'unscientific' form of knowledge based largely on mere oral traditions and without any deductive logic.

Contextually, some amongst us - senior academics and colleagues, do not see any relevance in doing research in local knowledge of grassroots communities. They make jest of those of us interested in the subject matter. These are Africans. Somehow, their western training has somewhat marred their objectivity. To them, it is rather retrogressive than progressive to be sympathetic towards *traditional* knowledge! Thus, studying indigenous knowledge is nothing to be encouraged at this time that the adoption and application of western knowledge only answer global demand and competitiveness. Sad enough, some of us have attempted publishing papers on indigenous knowledge for the umpteenth time in certain scientific journals in the West but to no avail; propagating such knowledge systems is out of place in the current dispensation. At the moment, research proposals on local knowledge are in most cases hardly funded [by donor and research agencies] if at all they had had their ways in the past. Research agendas are merely what donor organisations want and not what academics and researchers perceived as most appropriate in a particular locale. Thus, academics driven by the desire to get funding by all means possible, therefore, work to the rule of the game. In so doing, knowledge production is prejudiced and has thus been compromised. Nonetheless, it is parochial to think that local people's knowledge will completely be swept away by modernisation. Experience has shown that grassroots people will use whatever they have to overcome particular challenges when the occasion calls for it (Kolawole 2001: 13-15).

That said, it is acknowledged that Asian academics, unlike [the] majority of their African counterparts, tend to emphasise the importance of local knowledge in the development process. Many journals in the Pacific, for instance, are thus dedicated to reporting indigenous innovations and knowledges of grassroots communities. It is, therefore, of little or no surprise that Asia is moving fast on its path towards an all-round development. It must be said, however, that finding an intersection between western and local knowledges will go a long way in achieving global sustainable development now and in the future.

METHODOLOGICAL APPROACH

Study area

The study was carried out in five communities of *Osun* and *Oyo* states in South-western Nigeria. The communities were *Aye* Cocker, *Ita-Osa* and *Erefe* communities in *Ife* East Local Government Area (LGA) of *Osun* state, and *Yanbi* and *Oloya* villages in *Atiba* LGA of *Oyo* state. *Osun* and *Oyo* states were selected because Yoruba traditions have their history firmly rooted in them.

Sample procedure

Purposive sampling and snowball techniques were used to select farmers with ample years of farming experience in arable crops, tree crops, livestock, agro-forestry amongst others. This is to ensure that farmers who have experiential knowledge of weather variability are included in the interview. A total of twenty three (23) discussants were selected in five (5) groups, each comprising an average of four (4) members. Accordingly, five (5) FGD sessions were held among the discussants. FGD-guide translated in *Yoruba* was provided every discussant. The discussants had earlier given an oral consent to the interviews thus allowing us to do the audio recording of their responses. We also ensured their anonymity and confidentiality. So, qualitative data were gathered through FGD sessions just as secondary information was obtained through literature.

Data Analysis

The discussions elicit copious qualitative information and thus address multiple thematic areas. All discussions were audio-taped and transcribed into English with the help of field assistants. Transcripts were slightly edited to ensure easy readability and understanding of participants' responses. To achieve what Burnard (1991: 461-466) calls *immersion in the data*, transcribed texts were then read several times, and memos were written on the general themes arising from the data collected. As documented in Torimiro and Okorie (In press), the research team analysed the content of the memos developed from the data, relying on literatures, with three linked stages. The initial stage involved open coding to identify themes emerging from key sentiments captured in the expressions, responses, ideas, words, and phrases used by the responding discussants. This process continued until all ideas had been absorbed into themes. The second phase involved the exploration of theme properties and relationships. During this phase, themes and connections between them were elaborated to identify crosscutting ideas, issues, and scripts. The categories that emerged were then contrasted with one another to guarantee the mutual exclusivity and specificity of their properties. The final phase involved the organization of themes around prioritized core categories of cultural dimension of weather variability, ethno-meteorology, weather variability, farming enterprise, mitigation of weather variability, perception about weather variability, problems associated with mitigating weather variability in farming activities. As reported in Torimiro and Okorie (2009), our analysis and interpretation of categories were compared with what other scholars had written, especially about cultural dimension of weather variability, ethno-meteorology, weather variability, farming enterprise, mitigation of weather variability, perception about weather variability, problems associated with mitigating weather variability in farming activities. Colleagues at the Obafemi Awolowo University, Nigeria, also read through our memos and analysis to see if they were scientifically appropriate. They made very useful suggestions that helped in refining, validating, and directing our examination of the data. In many instances, verbatim quotations were placed in boxes to illustrate the discussants' responses on relevant issues and themes.

GENERAL DISCUSSIONS

The study population comprises both female and male gender. In all, 10 women and 13 men totalling 23 farmers were interviewed in the 5 groups considered for the FGDs. The age range of the participants in the group is from 25 to 60 years reflecting an average age of 41 years. In terms of farming experience, the average year of farming experience was 30 years. Farming enterprises with which participants are engaged in the study areas include maize, cassava, yam, beans, groundnut, melon, pepper, okra, vegetable, orange, kolanut and cocoa.

Major areas of concern in the analysis are presented below:

Ethno-meteorology

The approach used in reading and predicting the weather by grassroots people is referred as ethno-meteorology. Framers do this to enable them make the right decision on when to plant and do other farming operations. Viewpoints on how local farmers do this are presented in Box 1.

Box 1: Reading weather through elemental signs, symbols and cultural festivities

We read weather through signs in the sky and through reactions of certain trees to changes in weather. Specifically, when Baobab trees begin to shed flowers, it is an indication of the end of dry season and the beginning of the rains. Also, sighting certain mushrooms is a proof of heavy impact of the rains on soils. This is a good signal to be rest assured that all is well in a particular farming year – Farmers in Ile-Ife, *Osun* state, Nigeria.

We discern whether the rains will either be abundant or not in a particular year at the on-set of the rains. For instance, whenever early rains come regularly in the morning at the beginning of a rainy season, this portends rain scarcity in that planting year. It is otherwise if the rainy season starts with evening rains – A farmer in Ife East LGA, *Osun* state, Nigeria.

Serving as a guide in our farming operations, when the clouds begin to gather together, we start pre-

planting operations. Thick cloud or cloudily sky provides a clue to when it will rain. However, what precedes a bright weather condition or *harmattan* is the dew or overcast weather condition - A farmer in *Oyo*, *Oyo* state, Nigeria.
Once it rains in March we start maize planting operations. We start to plant in the first week of April. When the height of maize plant reaches about 30cm [1 foot], we then plant cassava cuttings. We grow groundnuts in April, beans in May and yam from September to October (early yam) and December to January (late yam) in favourable weather condition. We harvest early yam in June and July while late yam is harvested in October and November - Some participant farmers in *Oyo* state, Nigeria
For us, the planting season begins from March with land clearing followed by planting of melon and maize. Planting of melon coincides with the period when the fruits of locust beans mature. In October, the behaviour of locust beans tree informs us [the farmers] that it is the time to plant yam - Participant farmers in the savanna area of *Oyo* State, Nigeria.
In the past, during celebration of *Luwo* in Ife and *Osun Osogbo* festivals which come up in August, there used to be continuous dew and rainfall but this year [2009], there has neither been continuous dew nor rainfall; the weather has, thus, changed – Participants in *Osun* state, Nigeria.
During the *Egungun* (masquerade) festival we usually experience continuous rainfall but this things are no longer happening and we believe this is what the yam needs for good performance in our farms - A participant in *Oyo* state, Nigeria.
Source: field survey (2009)

The viewpoints above shows the confidence local farmers repose in some natural elements, symbols and festivities to read weather conditions within their locality. Relying on previous experiences, farming decisions are made based on the signs farmers perceived as either favourable or detrimental to good crop performance. Of interest is the observed pattern of early rains at the beginning of the wet season. It is affirmed that it is ominous for early rains to commence with early morning downpours; this is perceived as a year of drought. Culture, which is the totality of the way of life of a people, is seen as important in weather reading. Thus, the celebrations of some *Orisa* festivals in *Yorubaland* have been juxtaposed with weather variability by smallholder farmers.

Farmers' definitions of weather variability

The understanding of smallholder farmers about weather variability is sought to know what this concept means to them. The following responses are provided by the groups of farmers interviewed in both *Osun* and *Oyo* states, Nigeria.

Box 2: The meaning farmers assign to the vicissitudes of weather conditions; their experiences and perceptions
Rain starts in March and most of the time pours down heavily between April and July. During this period, we grow crops like maize, cassava, yam, and groundnut. Also it rains continuously within the first two weeks of August and breaks at the end of the second week in August. We rely on rainfall after the August break for the planting of late maize. Weather changes determine seasons and seasons determine what we plant... In the olden days, our forefathers used to have rains in the first week of January but the situation now-a-days indicates that the weather has changed - Participants in *Osun* state, Nigeria.
In the past, it used to rain continuously in late July/early August. Then, it was hard for somebody to go on outings or do farm business. But nowadays, the weather has changed. In the recent times, raining season now starts in the first week of April. This year for instance [2009], the rains have ceased since the first week of August. Instead of having the usual rainfalls, what we have had has been dew drops. *Our sins may have caused this* [Emphasis ours]. You see, there are many bad things

that people do nowadays which were never done in the days of our great grand fathers. Every change in the weather that affects human activities is God's punishment for the evil things that people are doing nowadays. Look, in the days of our fathers, we used organic manure and there was no case of stealing manure... What do we have today? Inorganic fertilisers, which our so called politicians divert, cheating poor farmers... these are evils... - A farmer in Ife East LGA, *Osun* state, Nigeria.

Usually, the rains become heavy in May while it rained profusely in June and July. What follows the rains is a very cold weather. During this period, it is neither rainy nor sunny. This period could be detrimental to plant and animal health. Diseases spread during the time of warm and damp weather. What then follows is the *harmattan*, with its accompanying dryness and hotness, which of course destroy some crops but enhances the healing of farmers' physical injury/wound - A farmer in Ife East LGA, *Osun* state, Nigeria.

More importantly, when it fails to rain, the temperature rises and most of the time becomes unbearable particularly so in the recent times. Again, these vagaries tell a lot on both human health and agricultural activities... we uproot already established plants and have had delays in time of planting due to inclement weather condition. We have incurred losses in our farming enterprises because of crop failures. And sometimes we have had delays in farming activities due to the erratic change in weather conditions - Some participants in *Oyo* state, Nigeria.

Many years back, old people had warmth during *harmattan* by sitting or sleeping close to the fire place. But now-a-days, they wear just thick cloth because the *harmattan* of now-a-days is a far cry from what we used to have - A farmer from *Osun* state, Nigeria.

Source: Field survey (2009)

The viewpoints of farmers in Box 2 speak volume of the many dimensions of weather variability. Farmers see the link between human health and agricultural production. They believe delay in the rains engenders low agricultural production as warranted by unfavourable temperature and dryness. On the other hand, the period of dryness is seen as a time for farmers' physical wounds to heal up! Interestingly, these farmers have noticed some significant changes in the intensity of *harmattan* in the recent times. It is believed that the impact of *harmattan* is longer felt as it used to be in time past. The all encompassing viewpoint - '[o]ur sins may have caused this' - speaks volumes of farmers' perception on the vagaries of weather conditions at the moment. Perhaps seen from the scientific dimension, 'our sins' here might mean human activities, which have jeopardised the environment. The capitalist industrialists' activities and the political ecology of contemporary societies (Bryant and Bailey1997; Blaikie 1985; Watts and Peet 2006) may have jeopardised the resource-poor farmer's situation in relation to the resultant inclement weather conditions engendered by some nefarious modernisation projects. Closely linked with this is the political economy of agricultural production in Nigeria. Farmers' view was that rent-seeking politicians have always cornered agricultural inputs meant for the poor majority of farmers.

Impacts of weather variability on agricultural production

How do the vagaries in weather conditions affect farming activities? This sub-section addresses this all important issue on how smallholder farmers perceive the adverse effect of erratic changes in weather conditions on agricultural production.

Box 3: What farmers say about weather variability and agricultural production
Weather variability has impacted on the time we plant, cost of production and quantity of crops harvested. In the course of controlling termite in cassava farm during inclement weather conditions [in a particular farming year], the cost of production does soar. We paid extra cost for replanting operation, bought and applied fertilizers for plants to cope with the vagaries of weather conditions – Some farmers in *Osun* state, Nigeria.
Our crops have suffered pest attack and this has reduced our income – A farmer in *Oyo*, *Oyo* state, Nigeria.
Reduction in *harmattan* period has adversely affected the production of some tree crops like orange, kola and oil palm. It has affected yam flour production in *Oyo* area, too, because we need harmattan to dry the boiled yam used for the yam flour production – A woman farmer in *Osun* state, Nigeria.
Changes in the *harmattan* period have adversely affected the production of melon and locust bean fruits. Too long dry season which sometimes result in extreme heat condition affects yam germination. Arising from this, we have incurred losses in our farming enterprises. Crops are destroyed; and sometimes we have had delay in farming activities due to changes in weather conditions - A farmer in *Oyo* state, Nigeria.
The problem of incessant changes in weather condition have forced us to shift to the planting of cassava [believed by them to be more weather tolerant]- An *Oyo* farmer's view.
Source: Field survey (2009)

The general viewpoints in Box 3 are that weather variability has engendered high cost of production and crop failures. Farmers have opined that fruit crops are adversely affected as a result of little or no *harmattan* in a particular planting year. In another dimension, too long dry spells or *harmattan* engenders low yam production. Generally, crops respond to varying degrees of temperature. Some those well in mild or cool temperature conditions. Some do better in warm climate. Fluctuations in weather and climate change as presently being experienced are bound to impact on crop performance (Battisti 2009). Also, pest invasion is associated with weather variability; incidences of pest and disease invasion may have been higher when there is a prolonged rainy condition. Essentially, farmers have resulted to planting cassava in a bid to forestall crop failures resulting from the planting of crops which cannot withstand long water stress.

Mitigations of weather variability

This sub-section highlights the local approaches used by farmers in reducing the adverse effects of weather variability in South-western Nigeria. Viewpoints of farmers are captured in Box 4 below:

Box 4: How small farmers mitigate weather variability
Weather variability cannot be reversed, said some of the farmers interviewed.
We accept whatever weather God gives. However, some following through with certain activities could help to reduce the problem... we wet our farms during drought, apply fertilisers to crops, use herbicides and pesticides to control weeds and pests, respectively. We also rely on God favourable weather conditions - A group of farmers in *Osun* state, Nigeria.
Although, we can conjure sun using certain plant and invoke rain, this act is not ideal as it could be thunderous and stormy - One participant farmer in Ile-Ife, *Osun* state, Nigeria.
In my own perception of whether or not the mitigation of weather variability is possible, I don't think weather variability can be checked except if we want to deceive ourselves. The old practice of conjuring the rains was common in those days but people suffered for it. For instance in my compound in Ile Ife where people conjured rain, they dare not drink out of it. Also, the wells dug had

no water. People had to go to long distances in search of potable water! Of what use is that then? – A farmer in Ile-Ife, Nigeria
One of the things we do is create water channels as it applies to water-log areas. Also, we combine the planting of certain crops like cassava and maize. We do so in a situation where we have abrupt change in weather conditions which might induce the failure of one crop. We then rely on the second option crop. We also plant banana or plantain alongside cocoa to create shade and prevent water loss - A group of farmers in Ile-Ife, Nigeria.
Source: Field survey (2009)

Much as it is acknowledged that farmers do show resilience in the process of mitigating the vagaries of weather conditions, it is apparent that some negative value orientations came to the fore during the discussions with them [See Box 4]. Some of them exhibit fatalistic disposition affirming that nothing could be done about inclement weather mitigation. That said, farmers identified such approaches as wetting of farmland, fertiliser application, and the use of herbicides and pesticides. Others are the construction of water channels [to serve as conduit for conveying water from marshy area [*Fadama*] to plots where crops are planted; crop intensification; and the planting of shade crops like plantation and banana to prevent water loss. Of interest, however, is crop intensification. Small farmers engage in mixed cropping practices to avert total crop failure; where one crop fails due to its lack of resilience to water or heat stress, other(s) would survive (e.g. Cassava). This has always been an age-long innovative practice that prevents local farmers from food crisis.

Associated problems of mitigating weather variability

In this sub-section, we address the problems that are associated with efforts put in place by local farmers to lessen the effect of weather variability on agricultural production. Responses of participants are provided in Box 5 below:

Box 5: Problems and challenges of small farmers in the process of mitigating weather variability
We have no money to buy irrigation equipment to alleviate problems associated with prolonged dry season. We, as farmers of *Osun* state, don't enjoy provision of irrigation equipment from government. We don't know if they enjoy such in other States but we don't enjoy such here. We need it here. Farmers in the Northern part of the country enjoy the provision of irrigation equipment from government [perhaps due to the extreme dryness experienced there, though]. But then, we feel we also should equally enjoy it here in the South-west – A farmer group in *Osun* state, Nigeria.
If we are compelled to conjure the rains, which of course, are always thunderous, it is not free at all; people pay money to native doctors/wizards who conjure the rains – A farmer in Ile-Ife, Nigeria.
Source: Field survey (2009)

The revelation in Box 5 provides a clue to the vulnerable situation in which the poor farmers presently find themselves. Granted that they have had to contend with weather vagaries for too long, they are becoming more and more prone to the adverse effects of climate change. Combined with other vicious factors, their capacity to cope has been overstretched (Dobie *et al.* 2008: 1). The political economy and ecology of weather variability management have not helped these poor farmers in any way. Consensually acclaimed, treatments given to Northern farmers is not the same as those given to their

Southern counterparts. Agricultural inputs supply has been lopsided. Policy makers and implementers have continued to show failings in the management of the situation. As such, resource poor farmers do not have the wherewithal to forestall the weather shock already confronting them. Left with no alternative, they have continued to rely on rain-fed agricultural practices to do farming business. In a desperate bid to survive, they have resorted to certain traditional approaches, which some of them perceived as not in any way helpful [such rain conjuring]. More importantly, all these issues are a matter of policy debate.

Conclusions

In this paper, we have taken an activist approach to shed some light on the politics involved in knowledge production in our own context [Section 2]. We probed how smallholder farmers discern the vagaries of weather and what exactly constitute weather variability to them (i.e. farmers). We also identify local strategies which smallholder farmers [in south-western Nigeria] use in mitigating weather variability [Section 4]. Small farmers have used various means to read meanings and predict weather conditions within their locality in a particular farming year. They have used crop intensification and other innovative local strategies to mitigate the adverse effect of weather variability.

That said, it is becoming worrisome that farmers' capacity to withstand weather shock is waning by the day. Combined with other unfavourable socio-economic and political factors, these resource poor farmers are constantly being overwhelmed by the current challenges. While research agencies efforts [in devising innovations favourable for farmer survival] are acknowledged, working with farmers to devise low input technologies for this purpose is essential. Also, policy issues that situate farmers within the agenda of weather variability mitigation are crucial for improved agricultural production now and in the future (See also Kolawole 2009). Thus, research agenda and policy formulation need to be in tandem with proven and observable knowledges of the grassroots.

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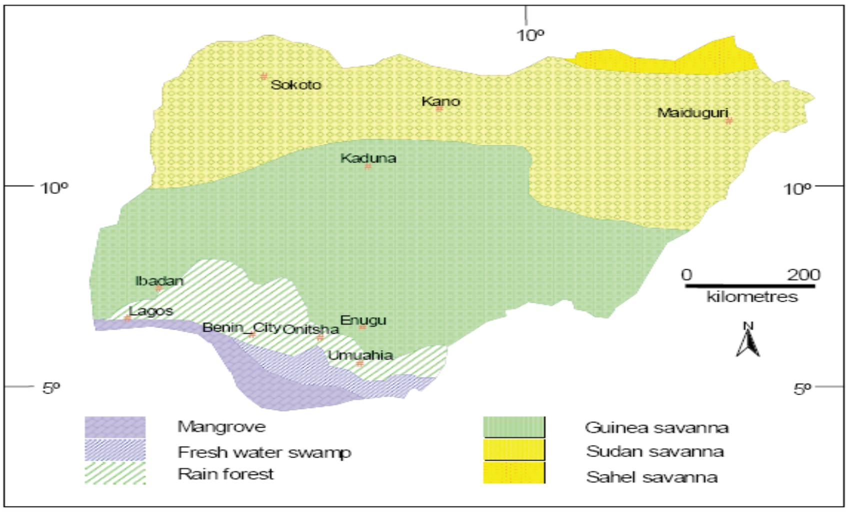
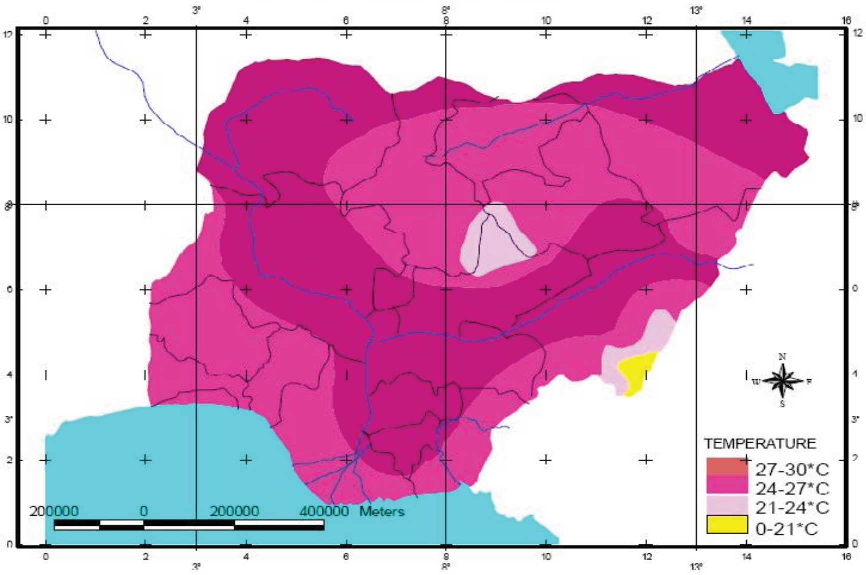
Appendix 1

VEGETATION OF NIGERIA
Source: Ministry of Environment, Nigeria, 2003.



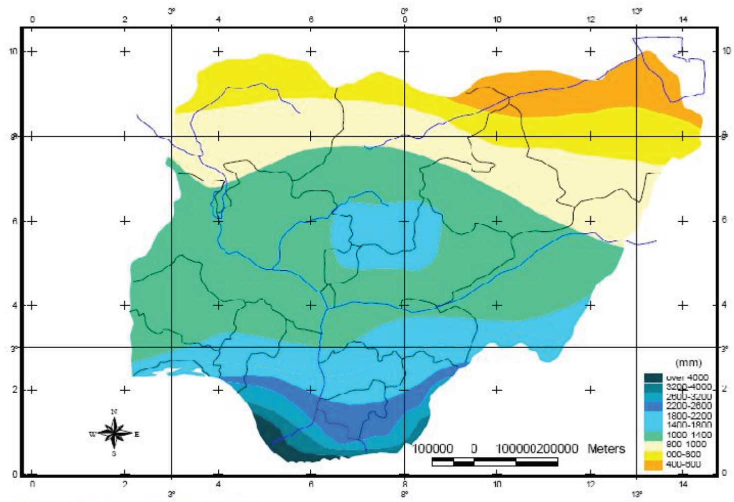
Appendix 2

Spatial Variation of Mean Annual Temperature in Nigeria
Source: Ministry of Environment, Nigeria, 2003.



Appendix 3

SPATIAL VARIATION OF ANNUAL RAINFALL IN NIGERIA



Source: Ministry of Environment, Nigeria, 2003.

APPLICATION OF PROBIOTICS IN AQUACULTURE: ALTERNATIVE TO USE OF ANTIBIOTICS: A REVIEW

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Abstract

Application of biotechnology to aquaculture development is sustainable, but has modified the aquaculture environment in some cases depending on the intensity of usage. Antibiotics have been widely used in aquaculture in sterilization of equipments and in treatment of fish diseases, and control of bacteria infections in fish hatcheries. However, the negative effects of the use of antibiotics such as development of resistant bacteria (modification of microbial ecology) which constitute potential hazard to the environment and the people have encouraged the use of probiotics. Probiotics are live harmless bacteria that help the well being of the host animal and contribute directly or indirectly to protect the host animal against harmful bacteria pathogens. The paper reviewed and discussed the types of natural and synthetic/commercial probiotics available for aquaculture; the selection criteria for probiotics; some techniques or parameters used in the assessment of the performance of probiotics and specific effects of some probiotics on aquaculture. The findings showed that probiotics are useful in reducing anti-nutritional factors (tannin, phytic acid, mimosine) in non-conventional fish feed ingredients; in improving water quality and the growth of fishes and in immune stimulation in fishes. They also help to increase the population of native non-pathogenic bacteria and digestive enzyme activities; and in inhibition of pathogenic organisms and reduction in incidence of diseases. Probiotics are also environmentally friendly therefore their use in aquaculture is indispensable.

Keywords: Antibiotics, probiotics, aquaculture

INTRODUCTION

What are probiotics

Probiotics are simply described as harmless bacteria that help the well being of the host animal and contribute, directly or indirectly to protect the host animal against harmful bacteria pathogens. Fuller (1989) defined probiotics as live microbial feed supplements which beneficially affects the host animal by improving its intestinal microbial balance. Tannock (1997) also explained probiotics as living microbial cells administered as dietary supplements with the aim of improving health. WHO (2001) similarly described probiotics as live microorganisms which when administered in adequate amounts confer a healthy benefit on the host. A beneficial effect by application of certain beneficial bacteria in human, pig, cattle and poultry nutrition has been well documented (Gilliland, 1979; Conway, 1989; Jong, 1993). But the use of such probiotics in aquaculture is a relatively new concept (Kozasa, 1986). Presently the interest and awareness is growing daily. Most probiotics are supplied as live supplements in food, which must have the ability to survive passage through the intestinal tract (Fuller, 1992). The benefit to host may arise as a nutritional effect, whereby the bacteria are able to break down the toxic or otherwise nutritious components of the diet, which the host can then digest

(Smoragiewicz et al 1993). Alternatively, the probiotics may prevent the potential pathogens from colonizing the gut by production of antimicrobial compounds, or by out competing them for nutrients or mucosal space (Smoragiewicz et al, 1993). Gatesoupe (1997) stated that probiotic microorganisms should be non-pathogenic and non-toxic in order to avoid undesirable side effects when administered to fish.

Why probiotics

Prevention of fish diseases is essential to the success of any large-scale, intensive production of fish in culture. Bacterial infections, the major causes of mortality in fish hatcheries and adult fish production systems (Austin and Stobie 1992) are controlled prophylactically, and therapeutically based on oral administration of antibiotics. Such treatment may cause the development of resistant bacteria (Aoki et al 1985) and can lead to potential hazard to the public health and the environment. Besides, the normal beneficial microbial flora in the digestive tract of fish may also be killed or inhibited (Sugita et al. 1991). Amabile-Cuevas et al. (1995) stated that vaccines are also being developed, but cannot also be a universal disease control measure in aquaculture. A new approach that is gaining acceptance within aquaculture industry is the use of probiotic bacteria to improve disease resistance, water quality and/or growth of cultured fishes (Verschuere et al 2000). Probiotics are defined as live microbial feed additive, which gives a good effect on the host animal by improving the microflora of their gastrointestinal tract (Fuller 1989) via the production of nutrients enhancing immune responses and improving the water quality. In order to make aquaculture products safe for human consumption, it is very important to develop an alternative to the use of antibiotics by using living microbial cells as additives in fish feed, to control pathogens and to ensure improved growth and immunity of the fishes. Probiotics enhancement of the natural flora in the gut of organisms will enable the natural intestinal flora to participate in a more war-like activity, and actively produce substances that may inhibit or kill the pathogens (Sugita et al., 1996).

Types of probiotics

Two types of probiotics are natural and synthetic or commercial probiotics. Probiotic bacteria can be isolated from the gastrointestinal tract (GIT) of a fish. That is from the intestines, stomach, gill, kidney and the gonads. They can also be isolated from the internal organs of other animals. After isolation, depending on requirement, the target ones can then be cultured or multiplied. And these groups constitute the natural sources. On the other hand, the commercial sources consist of those already synthesized and are available on the shelf for immediate use. The most frequently used probiotic bacteria are those from Lactobacillus or Bifidobacterium species. Some of the commercially available probiotics are listed below.

Lactobacillus species	**Bifidobacterium species**
Lactobacillus acidophilus	*Bifidobacterium bifidum*
Lactobacillus casei	*Bifidobacterium breve*
Lactobacillus fermentum	*Bifidobacterium lactis*
Lactobacillus gasseri	*Bifidobacterium longum*
Lactobacillus lactis	Streptococcus species
Lactobacillus plantarum	Streptococcus thermophilus
Lactobacillus salivarius	Saccharromyces species
Lactobacillus rhamnosus	*Saccharromyces boulardii*
Lactobacillus johnsonii	*Streptococcus cremoris*
Lactobacillus paracasei	Bacterial mixture (Add-B)
Lactobacillus reuteri	
Lactobacillus helveticus	
Lactobacillus bugaricus	

Selecttion criteria for probiotics

The purpose of probiotics is maintenance or re-establishment of favourable relationships between friendly and pathogenic microorganisms that constitute the flora of intestinal or skin mucus of a fish. Sucessful probiotics are expected to have certain qualities as mentioned below.

Antagonism to pathogens with signs of producing anti-microbial substances like organic acids, hydrogen peroxide (Ringo and Gatessoupe, 1998) or siderophores (Gram and Mel-Chiorsen, 1996). In order to have a beneficial effect on the form of growth promotion or to protect fish against bacteria pathogens, the strains should also have the ability to colonize the fish by adhesion (Olsson et al 1992), and to produce important substances, like vitamins.

Adhesion is one of the most important selection criteria for probiotic bacteria, because it is considered a pre-requisite for colonization (Beachey, 1981). Therefore the microorganisms must be viable for long periods under storage and in field conditions (Fuller 1989), although non-viable bacteria are able to adhere to tissue culture cells indicating adhesion without viability (Hood et al 1988, Coconier et al 1993).

Probiotic microorganisms must have to be non-pathogenic and non-toxic to avoid undesirable side-effects when administered to fish. Tests of antagonism, adhesion and challenge tests in vitro are essential to select among the probiotic species. Challenge experiments where fish treated with friendly bacteria are subjected to pathogens are also needed (Gatesoupe, 1999).

They must also have the ability to produce vitamins for example, the bacterial strain *Rhodospirillum rubrum* produces considerable amount of vitamin B_{12} (Hirayama and Katsuta, 1988). Vitamin B_{12} is an important vitamin for several functions involved in digestion in fish (Sugita et al. 1991). Besides, many probiotics appear to improve the activity of beneficial bacteria species already present in the digestive tract of fish.

Methods of administration of probiotics

Probiotics can be administered orally or as additive in animal feeds or added in water used in culturing fishes. When orally administered with diet or supplied to rearing water, they could attach themselves to the surface of gastrointestinal tract and colonize it. Also when added to the rearing water, they can enter fish gastrointestinal tract and colonize it. They can also be incorporated in live fish feeds.

Mechanism/benefits of probiotics

There are several mechanisms by which probiotics may protect the host from intestinal disorders. In general, the processes by which bacteria inhibit colonization by other strains is called colonization resistance. The mechanisms on how probiotic bacteria may protect the host against intestinal diseases are given as follows. Probiotic bacteria produce a variety of substances that are inhibitory to both gram-positive and gram-negative bacteria. These inhibitory substances include organic acids, such as acetic, lactic acids, hydrogen peroxide and bacteriocins. These compounds may reduce not only the number of viable cells but may also affect bacterial mechanism or toxin production. For instance, *Lactobacillus acidophilus* has been used to produce substances between the molecular weights of 200 and 6,200, some of which are sensitive proteases that can inhibit Staphylococcus, Streptococcus, *Escherichia coli* and Salmonella species. *Lactobacillus rhamnosum* strain GG (LGG) produces a broad spectrum of low molecular weight centimicrobial peptide which is plasmid mediated and has activity against Staphylococcus, Streptococcus, *Escherichia coli*, Mycobacterium, Clostridium and Listeria species. The benefits of probiotics are described interalia.

Blocking of adhesion sites

Competitive inhibition for bacterial adhesion sites on intestinal epithelial layers is a mechanism of action of probiotics. Consequently some bacteria strains are selected for their ability to adhere to epithelial cells. Studies have shown that Lactobacillus can prevent adherence of *Escherichia coli*, Klebsiella species and *Pseudomonas aeruginosa* to intestinal cells.

Competition for nutrients

In competing for nutrients, probiotics can out-compete the pathogens by consuming the nutrients that would otherwise been consumed by pathogenic microorganisms. This mechanism would limit the existence of the pathogens in the intestinal cells because without nutrients the organisms can not survive. .

Degradation of toxin receptor

The mechanism by which *Saccharomyces boulardii* protects animals against *Clostriodum difficile* intestinal disease is through degradation of the toxin receptor on the intestinal mucosa. By this process the toxins does not accumulate on the cells, so there will be no means of pathogenic activities.

Stimulation of immunity

Stimulation of specific and non-specific immunity may be another mechanism by which probiotics can protect against intestinal diseases. The underlying mechanisms of immune stimulation are not well understood but specific cell wall components or cell layers may act as adjuvant and increase humoral immune response.

Some techniques and parameters used in assessment of probiotic performance

As probiotics are expected to contribute to intestinal microbial balance and assist the body's naturally occurring gut flora to reestablish themselves; that is improving the micro-flora of their gastrointestinal tracts. They are also expected to serve as antagonism to the pathogens among other qualities. There are techniques usually applied to test for the qualities or potentials of probiotics. Some of these are described interalia.

Adherence test

Usually *in vitro* examinations are performed to detect the potential of the probioant to adhere to intestinal organs of the host as way of colonizing the environment, supplying needed nutrients or for stability in out-competing the pathogens. A good method for determining the adhesion was described by Ouwehand et al. (1995).

Non specific immune systems

Total immunoglobulin: This could be determined following the methods of Siwicki and Anderson (1993). Briefly, the plasma sample will be diluted 100 times with 0.85% NaCl and the Biuret method will be employed for determining the protein content, the BSA (standard) and other reagents will be sourced. Or 0.1 ml of each plasma sample will be mixed with an equal volume of 12% solution of polyethylene glycol (10,000 MW, Sigma) and incubated for 2 h. The supernatant will be diluted 50 times with 0.85% of NaCl and

Protein concentration of the samples will be determined according to the method of Lowry et al. (1951). The differences between the protein values of the untreated and PEG treated sample corresponds to the total 1g content and is expressed as mg ml^{-1}.

***Lysozyme activity*:** Lysozyme activity in serum may be determined after the method of Demers and Bayne (1997) based on the lysis of the lysozyme sensitive Gram positive bacterium micrococcus lysodeikticus (Sigma) as the standard. The standard egg lysozyme and undiluted serum sample (25µl) will be placed in triplicate into wells of 96-well plate, followed by 175µl of the bacterial suspension. Thereafter, the change in turbidity will be measured every 30 s for 5 min at 450nm using a microplate reader (Multiskan). The equivalent unit of activity of the sample as compared to the standard will be determined using computer application software like Delta SOFT 3; biometalics, NJ, USA) and expressed as µg ml^{-1} serum.

Alternative complement activity: This could be determined according to methods of Yano (1992) based on the hemolysis of rabbit red blood cells (RaRBC). Briefly, the RaRBC will be washed three times in ethylene glycol tetraacetic acid-magnesium-gelatin veronal buffer. At first, the 100% lysis value will be obtained by exposing 100µl of the above RaRBC stock to 3.4-ml distilled water. The hemolysate will be centrifuged and the optical density (OD) of the supernatant will be determined at 414nm using a spectrophotometer. Following this, the test sera will be diluted (x100), different volumes ranging from 100 to 250 µl (total volume will be adjusted to 250µl with the buffer) will be allowed to react with 100µl of RaRBC in small test tubes. This mixture will be incubated at 20^{o}C for 90 min with intermittent mixing, following which 3.15 ml of 0.85% NaCl solution will be added and the tubes will be centrifuged and the OD of the supernatant will be measured as above. A lysis curve will be obtained by plotting the percentage of haemolysis against the volume of serum added on a log-log graph. The volume yielding 50% haemolysis will be used for determining the complement activity of the sample as follows:

ACH50 value (units ml^{-1}) = 1/k x (reciprocal of the serum dilution) x 0.5.

Where k is the amount of serum (ml) giving 50% lysis and 0.5 is the correction factor since the assay will be performed on half scale of the original method.

Phagocytosis: Phagocytic activity of leucocytes may be determined according to methods of Puangkaew et al. (2004). Briefly, a 300-µl volume of the leucocyte suspension in L-15 medium (Sigma-Aldrich) containing $2x10^{6}$ cells will be seeded into a chamber slide (Lab-Tek Nalge nunc International, IL, USA) and incubated at 15^{o}C for 2h after which the non-adherent cells will be removed. They will be incubated further for 1 h after adding opsonized fluorescent latex beads (2µm; Sigma) to each chamber to maintain the cells to beads ratio of 1:10. The latex beads which must have been opsonized earlier by incubating $2x10^{7}$ beads/ml with the serum of very same fish from which the cell sample originated at 15^{o}C for 1 h. After washing and fixation, the slides will be stained with Diff Quick solution. The phagocytic activity (PA) will be expressed as the percentage of phagocytic cells quantified from 300 adherent cells under microscope. The phagocytic index (PI) will be expressed as the average number of particle beads ingested by each phagocytic cell.

Superoxide anion production: The superoxide anion production ($O2^{-}$) by the head kidney leucocytes could be determined based on the reduction of nitroblue tetrazolium (NBT) as described by Puangkaew et al. (2004). Briefly, 15 µl of $2x10^{7}$ cell ml^{-1} isolated leucocytes will be mixed with an equal volume of L-15 containing NBT (solution of NBT in L-15 at 1 mg ml^{-1}) or zymosan solution (zymosan Sigma) in NBT solution at 5 mg ml-1). After incubation for 1 h, 400 µl of N, N-dimethyformamide will be added and centrifuged at 3000xg. The optical density of the supernatant will be measured at 540 nm with a micro plate reader like (Multiskan; Labsystems Oy, Helsinki, Finland).

Digestive enzyme analyses

Amylase assay: Amylase activity may be determined according to methods of Ribeiro et al. (2000). Briefly, prepared crude enzyme solution (350 µl) will be added to equal volume of 20 mM phosphate buffer containing 10mM NaCl (pH 6.9) and potato starch (1% w/v in buffer) and incubated at 25^{o}C for 30 min. Disnitrosalicylic acid solution (750µl) containing 30% potassium sodium tatrate (w/v) will be added and the reducing sugars will be determined by measuring the changes in absorbance at 546nm. The specific activity will be the difference in the absorbance between the crude enzyme extract and blank mixtures per 1 mg protein of the crude enzyme extract.

Trypsin assay: Trypsin activity may be determined according to the method of Gaulicka et al. (2000). Briefly, Prepared crude enzyme solution (200µl) will be added to 800µl of 25mM ammonium bicarbonate buffer (pH 7.8) containing a substrate, 1 mM BAPNA (N-α- benzoyl-L-arginine p nitroanilide hydrochloride) and incubated at 25^{o}C for 30 min. The increase in absorbance at 405 nm will be measured. The specific activity will be difference in the absorbance between the crude enzyme extract and blank mixtures per 1 mg protein of the crude enzyme extract.

Challenge test

Challenge test is performed to determine the ability of the probiotics to confer immunity to the host organism when challenged with pathogens. During the test, a bacterium for example, *Aeromonas hydrophila* may be introduced into the experimental tanks or injected into the fish muscle previously fortified with a probioant to monitor the effects on fish mortality, non-specific immune systems of the fish, histomorphology of the intestines and digestive enzyme activities. The techniques for the determination of these parameters have been described in the text.

SPECIFIC EFFECTS OF PROBIOTICS ON AQUACULTURE

The use of probiotics in aquaculture is a recent event because of the environmental health problems associated with the use of antibiotics. Studies have concentrated on the use of probiotics in fish juveniles, but more attention is now on larvae of fish, shell fish production and on live food organisms. The overview of literature reports on probiotics as biological agents in aquaculture is compiled in tabular form by the author and is presented as in Table 1.

Table 1. Effects of probiotics on aquaculture production

Probiotics	Application	Administration method	Observations	Mode of action	References
Rhodospirillum &Rhodopseudo-Monas	Polluted	Culture water	Improvement		Kamal et al. (1990)
Vibrio-alginalyticus	Atlantic salmon		Reduce diseases	Antagonism	Austin et al. (1995)

Bacteria strains of turbot	Turbot *Scophthalmus maximus*		Suppress growth of pathogen *Vibrio anguillarum*	Antagonism	Olsson et al. (1992)
Streptococcus faecium	Israeli carp	Added to feed	Improved growth and feed efficiency	Improved nutritional value	Noh et al. (1994) Bogut et al. (1988)
Bacillus spp	Channel catfish	Added to rearing water	Increased survival and production		Queiroz and Boyd (1998)
Lactic *ac*id bacteria (LAB)	Rainbow trout	Added to feed	Higher immunoglobulin	Immune stimulation	Panigrahi et al. (2004)
Lactobacillus rhamnosus	Rainbow trout	Added to feed	Elevated lysozyme activity	Immune stimulation	Panigrahi et al. (2004)
Lactobacillus plantarum	Halibut larvae	Added to culture water	Increase in survival of Halibut larvae	Immune stimulation	Olafsen (1998)
Probiotics	Application	Administration method	Observations	Mode of action	References
Lactobacillus sp	Turbot larvae	Enrichment of rotifers & Artemia	Increase in survival of Turbot larvae	Immune stimulation	Gatesoupe (1994)
Lactobacillus sp	Pacific oyster (*Crassostrea gigas*) larvae	Addition to feed	Improved in survival & production	Nutrient enrichment & Antagonism	Douillet & Langdon (1994)
Vibrio alginalyticus	*Artemia nauplii*	Addition to culture water	Increased survival	Immune stimulation	Gomez et al. (1998)
Bacillus subtilis	Channel catfish	Addition to pond water	Increased survival and net production	Immune stimulation & nutrient enrichment	Queiroz & Boyd (1998)
Vibrio alginolyticus	Atlantic salmon	Bathing in bacterial suspension	Increased survival	Immune stimulation	Austin et al. (1995)
Fluorescent pseudomonad F19/3	Atlantic salmon	Bathing in bacterial suspension	Increased survival	Antagonism	Smith & Davey (1993)

Camobacterium Strain K1	Atlantic salmon	Intestinal mucus & faecal extract	Growth inhibition of *V. anguilarum* & *A. salmonicida*	Antagonism	Joborn et al. (1997)
Lactic acid bacteria	Atlantic cod (*Gadus morhua*)	Addition to diet	Increased survival & inhibition of (*Vibro anguillarum*)	Antagonism	Gildberg & Mikkelsen (1998)
Microbially matured water	Turbot & Halibut larvae	Added to culture water	Increase in growth rate	Nutrient enrichment	Skjermo et al. (1997)
Carnobacterium sp	Atlantic salmon	Added to diets	Suppression of *Aeromonas hydrophilia*; *A. salmonicida; Streptococcus milleri* etc.	Antagonism	Robertson et al. (2000)
Vibrio alginolyticus	*Penaeus vannameri* larvae		Increased growth & reduction in diseases	Nutrient enrichment & antagonism	Garriques and Arevalo (1995)
Probiotics	Application	Administration method	Observations	Mode of action	References
Carnobacterium sp	Salmonids (Atlantic salmon and rainbow trout)	In vitro	Produced inhibitory compounds in intestinal mucus	Antagonism	Joborn et al. (1997)
Clostridium butyricum	*Miichthys miiuy*	Added to feed	Improved growth performance	Nutrient enrichment	Song et al. (2006)
Clostridium butyricum	*Miichthys miiuy*	Added to feed	Significant improvement in lysozyme serum & skin mucus activity	Immune stimulation	Song et al. (2006)
Clostridium butyricum	*Miichthys miiuy*	Added to feed	Improved total immunoglobulin (IgM) in serum	Antagonism	Song et al. (2006)
Clostridium butyricum	*Miichthys* miiuy	Added to feed	Significant improvement in serum acid phosphatase activity	Antagonism	Song et al. (2006)
Bacillus subtilis	Leucaena leaf meal	Innoculated in leucaena leaf meal	Significant reduction in anti-nutritional factors (tannin, phytic acid, mimosine)	Nutrient enrichment	Bairagi et al. (2004)

Bacillus subtilis	Rohu carp (*Labeo rohita*)	Added to feed	Sig. increase in growth performance, protein digestibility, α-amylase activity	Nutrient enrichment	Bairagi et al. (2004)
Live yeast *Debaryomyces hansenii* CBS 8339	Leopard grouper (Mycteroperca rosacea) & Gilthead sea bream (*Sparus aurata*)	Added to feed	Enhancement of growth	Nutrient enrichment, antagonism against (*Amyloodinium ocellatum* & (*Aeromonas hydrophila*	Bacerril et al. (2008)
Probiotics	Application	Administration method	Observations	Mode of action	References
Bacillus subtilis	Sea cucumber	Added to feed	Increased survival, growth & intestinal microflora	Nutrient enrichment, immune stimulation & antagonism against *Vibrio splendidus*	Mai et al. (2008)
Live yeast isolated from red claw crayfish gut	Red claw Crayfish (*Cherax quadricarinatus)*	Added to feed	Increased survival & growth rate	Nutrient enrichment & immune stimulation	Olvera-Novoa et al. (2008a)
Lactic acid bacteria isolated from Nile tilapia intestinal microflora	Nile tilapia	Added to feed	Increased growth performance at the same level with antibiotic (Oxytetracycline)	Nutrient enrichment	Olvera-Novoa et al. (2008b)

Source: (Present review)

SUMMARY

The accelerated growth of aquaculture industry has been accompanied by severe outbreaks of diseases caused by wide range of pathogens (Olvera-Novoa et al. (2008b). Gatlin et al. (2008) reported that inspite of expansion in the production of hybrid striped bass, *Morone chrysops* x *M. saxatilis* in the United States, that pathogenic organisms such as *Streptococcus iniae* have resulted in economical losses of several millions dollars annually. Application of accurate, enough, target and safe dosage of probiotics could be a saving grace to most of the disease problems in aquaculture. More so, that probiotics are environmentally friendly and could eliminate the disease resistant problems in the environment and people associated with the use of antibiotics. Besides, as probiotics can improve the quality of non-conventional feed ingredients by denaturing their anti-nutritional factors to liberate the bound nutrients and make them more digestible, it can be applied in the development of low-cost fish feeds. Successful application of probiotics in fish larval rearing and development has been reported. Yufera et al (2003) described that microcapsules including probiotics can be used as a vehicle to administer specific substances that offer positive responses in larval growth and development. This may form a break through to massive production of marine fish larvae as very high mortality is usually recorded at that stage of development. That will also invariably lead to reduction in the cost of marine fish production.

Also as the probiotic bacteria can be isolated from the GIT of the particular animals concerned, it could reduce the cost of aquaculture management in terms of animal growth enhancement and disease preventions. Therefore there is a need for detailed economic study on the use of both natural and synthetic probiotics as this would help the end users in decision making.

CONCLUSION

Aquaculture is the fastest food growing industry in the world (FAO 2006). In year 2003, the total world aquaculture production was 54,786,000 tonnes (FAO 2006). FAO (2006) had also predicted that the sector would supply a total of 80 million tonnes of fish by year 2050 based on the current level of fish production and consumption. Consequently, the incidence of bacterial and disease infections in aquaculture systems would increase. Therefore the use of probiotics in aquaculture operations would also increase. Then, for effective use of probiotics in aquaculture, more researches are needed to determine and characterize the dosage level, activity and mode of action of probioants that would be in application. This is because the functionality of probioants is dependent on the proper/accurate dose application. Further studies should also focus on the determination of specific probiotics that would have the strongest antagonistic activities on specific pathogenic organisms. This will lead to characterization and standardization of the probioants and eventually massive commercial production to make the prices affordable to fish farmers.

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THE IMPACT OF CLIMATE CHANGE ON HUMAN SECURITY: A CASE STUDY OF NIGERIA

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Abstract

As the world's climate changes, largely due to the spade of industrial "progress" and increase in human number, the emission of Green House gases into the atmosphere has grave implications on human security globally, Within this context, 'third world' countries, including Nigeria are the worst hit by the immediate impact of climate change, even though they contribute least to the cause of the problem - emission of Green House gases, in comparison with their counterparts in the global North. This paper contends that climate change affects human security in Nigeria and attempts a critical analysis of the roles of both developed and developing countries in contributing to the problem.

The paper submits that for the effects of climate change to be effectively mitigated or managed in Nigeria and indeed globally, there should be, among other things, a sustained commitment on the part of the developed economies towards assisting developing countries in tackling the problem; mustering of political will at both local and international levels to addressing the problem; attitudinal change and reorientation on the part of the populace towards environmental security and green-friendly initiatives.

MOTIVATION FOR THE PAPER

- Desire to contribute to efforts towards creating awareness on the effects of climate change on Human Security.
- To make a case for developing economies who contribute least to the problem but whom are most affected by its dire consequences in the immediate term
- Desire to join numerous other experts in proffering solution to the negative effects of climate change on Human Security.
- To give some inputs to research and policy framework in the build up to Copenhagen 2009

METHODOLOGY/SOURCE OF DATA

A descriptive Research method was used with frequencies and percentages. It compared, contrasted and analyzed secondary data drawn from institutions such as the NPC/PRB, UNDP, WMO, NASA, NBS, UNFAO, the IPCC and other technical reports. A spatial and temporal comparative analysis of phenomena relating to climate change and its corollary, were carried out to point the direction of the cause and effect of climate change, and its attendant consequences in Nigeria.

SAMPLING/SAMPLE FRAME

Such data of cause/effects as provided by authoritative organizations committed to development programs and the fight against climate change were randomly categorized along the divides of industrialization –or the global North-South dichotomy. By this, a contrast of cause/effect was underscored, against the scale of human security- a paradox that raised moral questions and made a case for the so called ‘third’ world.

INTRODUCTION AND BACKGROUND TO THE PROBLEM

From one epoch to another, the human world has been known for one problem or another. In the 1930s, it was the Great Depression and the ascendency of fascist regimes; from the mid 1940s, it was the Cold War; in the 1950s, racism and Apartheid philosophy occasioned the Civil Right Movement in the glare of a nuclear threat; the 1960s was characterized by nationalist struggles in most parts of the ‘Third world’ and their attendant consequences of martyrdom ; the 1970s and 80s witnessed in large proportions, the arms race (though with some relief brought about by the *Green Revolution)* ; from the 1990s to the dawn of the 21st Century, a dual catastrophes faces humanity- Terrorism and The Global Financial Meltdown. Yet Climate Change poses a threat that is second to none of these. Climate Change is indeed the most potent catastrophic challenge that humanity faces in the contemporary world. The reality of change is evidenced nowhere else than in our climate.

At the twilight of the 20th century and the dawn of the 21st, we are confronted with the “fierce urgency” of a crisis that links today and tomorrow. For many years global warming was portrayed in the media as an issue with two sides, with some scientists arguing that global warming is occurring and others arguing that it is not. However, this portrayal was an oversimplification of the scientific debate. In 1988 the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC). The panel comprises thousands of the top climate scientists from around the world and releases a report every six years describing the state of scientific knowledge on global warming. The IPCC’s Fourth Assessment Report (2007) offered the strongest scientific consensus to date on global warming. The panel concluded that it is “very likely” (more than 90 percent probability) that human activities are responsible for most of the warming since the mid-20th century; that it is “extremely unlikely” (less than 5 percent probability) that the warming is due to natural variability; and that it is “very likely” the warming is not due to natural causes alone. While the behavior of the climate system and the processes that cause global warming are well understood and grounded in basic scientific principles, scientists are still working to understand certain details of the climate system and its response to increasing greenhouse gases. Scientific uncertainty is inevitable with a system as complex as Earth’s climate. However, advancements in measuring, analyzing, and modeling techniques have helped clarify many uncertainties in recent years. Climate Change may reverse progress made in the last 100 years hence it is now a scientifically established fact.

Prior to 1800s, average surface temperature of the earth was about 15 degrees centigrade. 100 years later, it has risen by about 0.7 degrees centigrade. The IPCC, in its 2007 Fourth Assessment Report predicted a further warming of 2.4 to 6.4 degrees Celsius by the year 2100 given present and future emissions of GHGs. Today however, most recent studies by Judith Lean of the US Naval Research Lab, and David Rind, of NASA's Goddard Institute for Space Studies show that temperatures will shoot up at 150% of the rate predicted by the UN's IPCC by 2014 (*Daily Trust,* 2009:45). The consequences are manifest around us. Warming temperatures are already causing significant changes to mountain glaciers around the world, ice sheets in Greenland and the Antarctic, and polar sea ice in the Arctic. From Europe to Africa to Asia to North America, mountain glaciers have receded over the 20th century, and melting is becoming more rapid. The large-scale melting of ice may accelerate the pace of global warming in what is known as *a feedback process*. Because ice reflects sunlight back out to space, it has a cooling effect. Water and land, which are darker than ice, absorb and retain more heat. Glaciers on Kilimanjaro-the highest mountain in Africa for instance, are said to have lost 82 percent of their ice since 1912 (the year that Titanic Sank). This trend has dare consequences on Human Security. "Global warming impacts everyone regardless of national borders", so says UN Secretary-General Ban Ki-moon, at the United Nations Climate Change Conference in Bali, Indonesia, he charged delegates to overcome differences and agree on a road map to tackling the issue.

CONCEPTUALIZATION OF CLIMATE CHANGE

In their article "*Global Warming*", Mastrandrea, M. and Schneider H. (2008), have defined both Global Warming and Climate Change as the measurable increases in the average temperature of Earth's atmosphere, oceans, and landmasses due to increase in heat-trapping gases called Greenhouse gases. It is however contended herein that although Climate Change and Global Warming are often used interchangeably the two terms differ slightly.

Global Warming is the measurable increases in the average temperature of Earth's atmosphere, oceans, and landmasses due to increase in heat-trapping gases called Green house gases(GHGs) including Water vapor, CO2, Methane, Nitrous Oxide, and synthetic chemicals . Global Warming is unidirectional in that it focuses only on *increase*.

On the other hand, Climate Change encompasses Global Warming and other reversal changes that may imply the antithesis of warming, i.e. a cooling world. Climate Change may be seen as a two-tailed phenomenon. In this context however, we may operationalised the phrase *Climate Change* to mean warming of the planet since it is better understood as such. Moreover, it is important to add from the onset of this paper that GHGs do not represent everything that is negative. But for them, the earth would have been too cold for existence. Their excess however may be moving the earth to a state of becoming less inhabitable. Greenhouse gases were part of the Intelligent Design of our planet safe for the human-induced quantity added to the natural and finite supply. Greenhouse gases occur naturally, and without them the planet would be too cold to sustain life as we know it. Since the beginning of the Industrial Revolution in the mid-1700s, however, human activities have added more and more of these gases into the atmosphere. For example, levels of carbon dioxide, a powerful greenhouse gas, have risen by 35 percent since 1750, largely from the burning of fossil fuels such as coal, oil, and natural gas.

THE CONCEPT OF HUMAN SECURITY

The UNDP Human Development Report (1994) captures the concept of Human Security in unequivocal terms even though the term had been in circulation earlier. Human Security is a departure from the traditional concept of a state-centred security, to a people-centered one. The intent of human security was to bridge the freedom from want and freedom from fear, freedoms that lay at the heart of the United Nations. The phrase 'freedom from fear' is intended to indicate freedom from violence, and the phrase 'freedom from want', freedom from poverty. In the final analysis, human security is a child who did not die, a disease that did not spread, a job that was not cut, an ethnic tension that did not explode in violence, a dissident who was not silenced. Human security is not concerned with weapons – it is a concern with human life and dignity (Alkire, 2003:13).

The report identified the following four essential characteristics of human security:

- Human security is a universal concern. It is relevant to people everywhere, in rich nations and poor.
- The components of human security are interdependent.
- Human security is easier to ensure through early prevention than later intervention. It is less costly to meet these threats upstream than downstream.
- Human security is people-oriented. It is concerned with how people live and breathe in a society, how freely they exercise their many choices, how much access they have to market and social opportunities – and whether they live in conflict or in peace (*Human Development Report* 1994:23)

Human Security is centered on Freedom from fear and – violent conflicts, aggression etc. Freedom from want – poverty, food insecurity, disease, ignorance etc. According to Anan, (2000), Human security in its broadest sense, embraces far more than the absence of violent conflict. It encompasses human rights, good governance, access to education and health care and ensuring that each individual has opportunities and choices to fulfill his/her potentials. Every step in this direction is also a step towards reducing poverty, achieving economic growth and preventing conflict. Freedom from want, freedom from fear and the freedom of future generations to inherit a healthy natural environment – these are the interrelated building blocks of human – and therefore national security. Human Security embraces social, political and economic justice, all of which are already being affected by climate change. All development is ultimately about expanding human potential and enlarging human freedom. It is about people developing the capabilities that empower them to make choices and to lead lives that they value. Climate change threatens to erode human freedoms and limit choice. It calls into question the Enlightenment principle that human progress will make the future look better than the past. The early warning signs are already visible.

CAUSES OF CLIMATE CHANGE

The causes of Climate Change may be classified into Natural and Human/Biological

Natural causes (less than 10%):

Massive Volcanic eruptions; gives rise to CO2 and other GHGs

- ➢ Changes in the intensity of energy emitted by the sun; and
- ➢ Milankovitch cycles -Variations in the earth's position relative to the sun, both in its orbit and the inclination of its spin axis, combined to produce cyclical changes in the global climate. Added to this is the period of such change (41,000-year), as well as variations in how far out of round the Earth's orbit is. Predictions based on these cycles forecast at least 100,000 years without an ice age in our future.

Human and biological causes (over 90%):

- ➢ Burning of fossil fuel due to industrialization and rapid population explosion;
- ➢ Deforestation;
- ➢ Excess consumption and poor disposal of organic waste products from such animals as the ruminants(that chew the cud); and
- ➢ Excess human chemical activities that react with the atmosphere

The UNDP Human Development Report (2008) remarked that Global warming is evidence that we are overloading the carrying capacity of the earth's atmosphere. The earth is often said to have six continents and seven seas but it has only one atmosphere- a thin layer of air that lies directly above the land and oceans, we depend on this one and only atmosphere for our survival. Humans are significantly increasing the amount of carbon dioxide released to the atmosphere through the burning of fossil fuels (such as coal, oil, and natural gas), solid wastes, and wood and wood products to heat buildings, drive vehicles, and generate electricity. The extreme activities of market driven economies through their agents-the multinational cooperation, have largely contributed to the problem we face in climate change today. This they have done in pursuant to material success, often at the expense of the world's 'poor' and future generations. Such precarious situation raises moral questions. Soros (2002:31) submits that all other things being equal, international trade benefits all parties, in practice though, other things are rarely equal. In particular, the gainers from international trade rarely compensate the losers. This is a time that calls for responsibility beyond nationalism. In a globalized world, human security ought to be viewed through the lens of Collective Security and a universal moral code. Soros (2002: 163) notes sadly that we have been so put off by the perversion of morality that we are trying to do without morality. He added that we have gone wrong, as according to him, no society can exist without morality. (Soros 2002: 164). He contends that the distinguishing feature of both market fundamentalism and geopolitical realism is that they are amoral. The attendant consequences of climate change put us at the risk of loosing the gains of a century and possibly reversing human progress. This confirms Fisher (1936) that progress is not a law of nature, the grounds gained by one generation may be lost by the next. Climate change brings us close to this point until something urgent is done. The other side of the coin is the surge in human number as seen in the developing countries. At the same time, the number of trees available to absorb carbon dioxide through photosynthesis has been greatly reduced by deforestation. The 1992 United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, was unique in uniting the countries of the world through global conventions on biodiversity and climate change. Above all, a plan of action for promoting, environmentally sustainable development, known as "*Agenda 2 1*" was adopted. Agenda 2 1*,* designed for implementation during the last decade of the 20th century and the first decade of the twenty-first century, is a blueprint for economic development without environmental destruction. The growing number of ethnic and economic conflicts indicates that development, even if environmentally insensitive, will not be socially sustainable if it ignores equity. In other words, a better common present is essential for a better common future. This fact raises moral questions on the major industrial nations who are principally responsible for climate change.

CULPABILITY OF DEVELOPED VERSUS DEVELOPING COUNTRIES

Studies have established a relationship between Climate Change and the beginning of the Industrial Revolution. Before the Industrial Revolution began in the mid-1700s, there were about 280 molecules of carbon dioxide per million molecules of air (abbreviated as parts per million, or ppm. By 2007 it has gone up to 379ppm (IPCC, 2007). This is in addition to methane which is emitted into the atmosphere during the mining of coal and the production and transport of natural gas and oil. Methane also comes from rotting organic matter in landfills, rice paddies, and wetlands, as well as from animals that chew the cud, especially cows, as a byproduct of digestion. Live plants also emit small amounts of methane. Since the beginning of the Industrial Revolution, the amount of methane in the atmosphere has more than doubled. Methane traps nearly 30 times more heat than the same amount of carbon dioxide. Compared to carbon dioxide, methane appears in lower concentrations in the atmosphere and remains in the atmosphere for a shorter time. In total, methane contributes about a third as much as carbon dioxide to global warming.

To stabilize atmospheric concentrations of carbon dioxide, global emissions would need to be cut significantly—on the order of 70 to 80 percent. If efforts are not made to reduce greenhouse gas emissions, carbon dioxide is projected to reach concentrations more than double or even triple the level prior to the Industrial Revolution by 2100. In a higher-emissions scenario carbon dioxide is projected to reach 970 ppm by 2100, more than tripling preindustrial concentrations. In a lower-emissions scenario, carbon dioxide is projected to reach 540 ppm by 2100, still almost doubling preindustrial concentrations (IPCC, 2007). The same source cautioned that even if greenhouse gas concentrations in the atmosphere ceases growing, the climate would continue to warm for an extended period as a result of past emissions, and with more dramatic effects than were observed during the 20th century. If greenhouse gas emissions continue to increase, scientists project severe climate changes.

In October 2007 a study published in the *Proceedings of the National Academy of Sciences* warned that climate models used to project future global warming may have been overly optimistic. The study found that atmospheric carbon dioxide levels had increased 35 percent from 1990 to 2006, a rate of increase far higher than most climate models had assumed. The researchers reported that the average rate of growth in carbon dioxide levels was 1.3 percent during the period from 1990 to 1999, but 3.3 percent from 2000 to 2006. In 2000 an estimated 7 billion metric tons of carbon were released into the atmosphere from burning fossil fuels; by 2006 that number had grown to 8.4 billion metric tons, according to the study. Scientists pointed to the unexpectedly rapid melting of sea ice in the Arctic Ocean during the summer of 2007 as evidence that climate models were failing to predict how quickly the climate was changing. In terms of contribution to emission of GHGs, which is the major cause of Global Warming, developed countries of the North are fingered as the principal culprits, compared to developing countries of the south. Mingst, (2004:289) noted the Per capita emission of CO_2 (the major GHG) in thousands of metric tons as at 1998 shows:

- developed countries – 10.8
- Developing countries – 1.9

Current statistics shows that this gap has widened due to rapid growth of industrialization.

- Africa which accounts for 14% of the world population is only responsible for 3.5% of the most serious global climate changing gases.

The area covered by sea ice during summer has declined by 15 to 20 percent in the last 30 years, and is projected to disappear almost completely late in the 21st century (NASA 2008). Many species, including polar bears, seals, and walrus, depend on sea ice for their survival. The rapid loss of Alaskan glaciers represents almost half of the total loss of ice in glaciers worldwide, and makes a significant contribution to observed sea level rise. Melting of the Greenland ice sheet, which could raise sea level by 7 m (23 ft) if it melted completely, is also accelerating. The area that is experiencing at least some melting increased by 16 percent from 1979 to 2002, and scientists estimate that warming of more than a few degrees Celsius could cause widespread and possibly unstoppable melting, leading to significant sea level rise.

As the atmosphere warms, the surface layer of the ocean warms as well, expanding in volume and thus raising sea level. The melting of glaciers and ice sheets, especially around Greenland, further swells the sea. Sea level rose 10 to 25 cm (4 to 10 in) during the 20th century. (The range is due to measurement uncertainties and regional variation.) By the end of the 21st century, sea level is projected to rise another 28 to 58 cm (11 to 23 in) if greenhouse gas emissions continue to increase significantly. The projection is somewhat less—a rise of 19 to 37 cm (8 to 15 in)—for a scenario in which greenhouse gas emissions peak around the year 2050 and then decrease. These projections do not incorporate possible large-scale melting of the Greenland or Antarctic ice sheets, which could begin in the 21st century with warming of a few degrees Celsius. Rising sea level will complicate life in many island and coastal regions. Storm surges, in which winds locally pile up water and raise the sea, will become more frequent and damaging. Erosion of cliffs, beaches, and dunes will increase. As the sea invades the mouths of rivers, flooding from runoff will also increase upstream.

Plants and animals will find it difficult to escape from or adjust to the effects of global warming. Scientists have already observed shifts in the lifecycles of many plants and animals, such as flowers blooming earlier and birds hatching earlier in the spring. Many species have begun shifting where they live or their annual migration patterns due to warmer temperatures. With further warming, animals will tend to migrate toward the poles and up mountainsides toward higher elevations. Plants will also attempt to shift their ranges, seeking new areas as old habitats grow too warm. This point underscore the threat to food security in the regions of the tropics(including Africa and Nigeria in particular) In many places, however, human development will prevent these shifts. Species that find cities or farmland blocking their way north or south may become extinct. Species living in unique ecosystems, such as those found in polar and mountaintop regions are especially at risk because migration to new habitats is not possible. For example, polar bears and marine mammals in the Arctic are already threatened by dwindling sea ice but have nowhere farther north to go. In a warmer world, experts predict that more people will get sick or die from heat stress, due not only to hotter days but more importantly to warmer nights (giving the sufferers less relief). More frequent and intense heat waves will further contribute to this trend. At the same time, there will be some decreases in the number of cold-related deaths. Diseases such as malaria, now found in the tropics and transmitted by mosquitoes and other animal hosts, are projected to widen their range as these animal hosts move into regions formerly too cold for them. Other tropical diseases such as yellow fever, and encephalitis may increase their spread. Scientists also project rising incidence of allergies and respiratory diseases as warmer air grows more charged with pollutants, mold spores, and pollens. Responding to the challenge of controlling global warming will require fundamental changes in energy production, transportation, industry, government policies, and development strategies around the world. These changes take time. The challenge today is managing the impacts that cannot be avoided while taking steps to prevent more severe impacts in the future.

Responding to the challenge of controlling Climate change will require fundamental changes in energy production, transportation, industry, government policies, and development strategies around the world. These changes take time. The challenge today is managing the impacts that cannot be avoided while taking steps to prevent more severe impacts in the future.

Reducing emissions of greenhouse gases, also called greenhouse gas mitigation, is a necessary strategy for controlling global warming. There are two major approaches to slowing the buildup of greenhouse gases. One is to reduce the consumption of fossil fuels, thereby reducing greenhouse gas emissions. The other is to keep carbon dioxide out of the atmosphere by storing the gas or its carbon component somewhere else, a strategy known as carbon sequestration or carbon capture.

One way to keep carbon dioxide emissions from reaching the atmosphere is to preserve and plant more trees. Trees, especially young and fast-growing ones, soak up a great deal of carbon dioxide from the atmosphere and store carbon atoms in new wood. Worldwide, forests are being cleared at an alarming rate, particularly in the tropics. In many areas, there is little re-growth as land loses fertility or is changed to other uses, such as farming or housing developments. In addition, when trees are burned to clear land, they release stored carbon back into the atmosphere as carbon dioxide. Slowing the rate of deforestation and planting new trees can help counteract the buildup of greenhouse gases. The total worldwide consumption of fossil fuels is increasing by several percent per year. However, energy use around the world is slowly shifting away from fuels that release a great deal of carbon dioxide toward fuels that release somewhat less of these heat-trapping gases. Wood was the first major source of energy used by humans. With the advent of the Industrial Revolution in the mid-1700s, coal became the dominant energy source. By the mid-1800s oil had replaced coal in dominance, fueling the internal combustion engines that were eventually used in automobiles. By the 1900s, natural gas began to be used worldwide for heating and lighting. In this progression, combustion of natural gas releases less carbon dioxide than oil, which in turn releases less of the gas than do either coal or wood. Significant reductions in carbon dioxide emissions can only be achieved by switching away from fossil-fuel energy sources. Nuclear power plants release no carbon dioxide at all, but nuclear energy is controversial for reasons of safety, security, and the high costs of nuclear waste management. Solar power, wind power, and hydrogen fuel cells also emit no greenhouse gases. These energy sources can be practical, low-pollution alternatives to fossil fuels. Other alternatives include fuels made from plants, such as biodiesel (made from used and new vegetable oil) and ethanol (a plant-based gasoline additive). Use of these fuels can help reduce total carbon dioxide emissions from automobiles.

THE INCIDENCE/CAUSE-EFFECT OF CLIMATE CHANGE IN NIGERIA

Nigeria is particularly vulnerable to the effects of climate change for the following reasons:

- ➢ Its high dependence on climate-sensitive resources both as source of energy and foreign exchange earner.
- The primary activity in Nigeria that adds to climate change is the release of harmful substances into the atmosphere from the oil and gas extraction sector, mainly from gas flaring throughout the Niger Delta and off shore.
- The secondary activity is the cutting of trees, the loss of forests from logging and the use of trees as firewood and for wood product. It has been reported that Nigeria destroys close to 600,000 hectares of her forests annually in feeding these industries.
- ➢ Rapid Population Explosion: The Population Reference Bureau says world's population is now 6.7 billion people and is projected to reach 8 billion by the year 2025. The world's population grows by more than 90million each year (Green, 1992). Each of these people needs a portion of the earth's resources for food, shelter, energy, and water. In just 33years, by 2025, human numbers may be 50% more than they are today- the largest population growth ever seen in so short a time. By the end of this decade, more than half of the developing countries may be unable to feed their populations from their own lands. Nearly half of the world's people will lack sufficient fuel wood. Within two decades few large stands of tropical forest will remain. Within two decades carbon dioxide emissions from energy use in developing countries could triple. Within about four decades readily accessible

supplies of oil will be exhausted. Global warming could raise the oceans by one meter, flooding coasts and displacing millions.

The signs of environmental stress grow as the world's population increases: worn-out farmlands, eroded hillsides, polluted water, parched grasslands, smoke-laden air, depleted ozone, and treeless ranges. Each year about 17 million hectares of tropical forest vanishes- an area the size of Tunisia or Uruguay. Fish catches are leveling off. Cities are clogged with refuse, thereby making water and air, instead of sustaining life, to cause diseases (Hinrichsen & Robey, 1997). This has implication on carbon and other greenhouse gas emissions. This is a reminder of the Malthusian hypothesis. At the instance of the International Conference on Population and Development (ICPD) in Cairo Swaminathan (1994:2) cited Malthus in his "*Essay on the Principle of Population as It Affects the Future Improvement of Society*"(1798) that Food and safe drinking water are first among the hierarchical needs of human beings. One wonders if Malthus thought of the need for clean air as first in the hierarchical ladder to both water and food. Yet we know today that a rapid growing population has implication on per capita emission of GHG. Ultimately though, the inadequacies of air food and water could undermine human and therefore national security. The UNFAO in 2008 submitted that a third of the worlds people (over two billion persons) fall short of food security. Yet the indices of Human Security and the Human Development Index begin with food in the midst of other things. The current population size of Nigeria (over 140Million) is not as alarming as its growth rate which stands at almost 4%P.A, giving a doubling period of less than 24 years. More than 200 years ago Malthus raised the question: "How many people can the world carry?" Today, we are compelled to contextualize that question in Nigeria and indeed Africa as a whole. Similarly, Gandhi had coined a dictum over 60 years ago, he was said to have asked: "..How many planets will be required if India were to follow Britain's pattern of industrialization?" Only recently the UNDP Human Development Report (2008) gave a posthumous answer and much more, to the question; it estimates that nine times our planet will be required if all people were to consume/emits as high as does Western Europe and the U.S. The connection between population growth and the environment has been established in many studies.

Each additional person adds an increment to the demand on the environment, making the situation a little worse. Each person's demand is multiplied to varying degrees by the person's affluence and by the environmental impact of technologies involved in production and consumption. The high population density of large cities, resulting partly from high birthrates, overwhelms energy demands (carbon foot print) sanitation, and waste disposal systems. Describing the unsustainable patterns of production and consumption, Green (1992) wondered if we were not Stealing from our children. People have long worried that nonrenewable resource such as oil will run out. Today a new concern has arisen: renewable resources-clean air and water, forest, and soil, for example- are threatened by overuse and population. Their capacity to renew themselves can be damaged irrevocably. The next decade is crucial. Action must be taken now on both environmental and population-related problems. If current trends continue, it could take decades, even centuries, to restore lost forest, depleted topsoil, and polluted waterways and to return to today's climate. Some damages, such as groundwater pollution and the extinction of species, further depletion of the Ozone Layer is irreversible in this decade. Green observed that population policies will determine whether world population stops growing at less than 9 billion or pass 19billion by 2100. He added that urgently needed actions including resource and energy conservation, pollution control, farsighted economic and social policy reforms, protection of high-risk areas, and support for family planning programs ought to be taken. As the world's population and per capita consumption grows however, the human race is using resources and generating waste faster and faster. Thus we are now beginning to see nature's limits. Pollution of the air and water, destruction of forests, and loss of fertile soil are becoming critical problems, with serious consequences for health, food production, productivity, and perhaps even the ability of the earth to support life. When used by so many people, the technologies that have raised living standards which have began to threaten even life itself.

- The concept of *Ecological Interdependence* Ecological interdependence Climate change is different from other problems facing humanity—and it challenges us to think differently at many levels. Above all, it challenges us to think about what it means to live as part of an ecologically interdependent human community. *Ecological interdependence* is not an abstract concept. We live today in a world that is divided at many levels. People are separated by vast gulfs in wealth and opportunity. In many regions, rival nationalisms are a source of conflict. All too oft en, religious, cultural and ethnic identities are treated as sources of division and difference from others. In the face of all these differences, climate change provides a potent reminder of the one thing that we share in common. It is called *planet Earth*. All nations and all people share the same atmosphere. And we only have one habitable earth. Global warming is evidence that we are overloading the carrying capacity of the Earth's atmosphere Plants and animals and their various species; peoples of various races and nation-states with our regional peculiarities and resource-advantages makes us share the same planet with its various endowments which have temporal and spatial differences. But the consequences of our activities affect the earth as an entity. This presupposes that *when* people in an American city turn on their air conditioning or people in Europe drive their cars, their actions have consequences to rural communities in Bangladesh, farmers in Ethiopia and slum dwellers in Lagos. Whereas the world has six continents and seven oceans, it has only one atmosphere. Added to this is the natural tendency of gases to diffuse beyond state sovereignties. All these are pointers to the vulnerability of Nigeria and other developing countries to climate change even if their own carbon footprint is not yet consequential.

- Worse still, is the economic shock that may befall the nation in years to come as the industrialized economies shift away from fossil fuel to cut down carbon emissions. A precarious economic climate looms if the nation does not diversify its monolithic oil-dependent economy. This too will undermine human security in a number of ways. Climate change presents significant threats to the attainment of the UN Millennium Development Goals, especially those related to eliminating poverty/hunger and promoting environmental sustainability. The impact of Climate Change includes floods, landslides, drought and famine among other problems. As weather becomes fiercer and storms increase in frequency and intensity, serious socio-economic consequences result. Malnutrition and disease become common occurrences. Climate Change has a cumulative effect on natural resources and the balance of nature. Its effects are already visible in Nigeria. It paints a gloomy picture. Among the effects of Climate Change on Human Security, are the following:

- Impact on agriculture – crop failures leading to food insecurity;
- Impact on human health – spread of diseases such as malaria, cancer, respiratory disorders, sleeping sickness, and other related (parasitic diseases) are now common in various parts of the country. Climate Change causes higher temperatures and humidity, a thriving situation to pests and diseases especially within the tropics.
- Impact on the environment – environmental insecurity (floods, submergence of coastal settlements on one hand and acute draught/desertification in the northern fringes of the country, on the other). All of these have dire consequences on human security.

THE MORAL QUESTIONS AND THE PARADOX OF CAUSE/EFFECT

The world is moving towards sound moral codes, paradigms are shifting towards a more collective response to global challenges. The time is long overdue for the industrialized nations to begin to redeem pledges made at international conferences where conventions were drawn. Nations who owe from the average global carbon footprint must begin to think of the cost, on those other citizens of the globe, for whom such carbon balance was meant. Commitments in proportion to carbon footprint of nations, may point the world to a more just and workable approach in fighting the scourge. In a globalized world, human security ought to be viewed through the lens of Collective Security. We must admit that every extravagant living in the wealthy nations have dire consequences on the world's poor and future generations. The world's poor will suffer the earliest and most damaging impacts. Rich nations and their citizens' account for the overwhelming bulk of the greenhouse gases locked in the Earth's atmosphere. But, poor countries and their citizens will pay the highest price for climate change. The inverse relationship between responsibility for climate change and vulnerability to its impacts leaves much to be desired.

How the world deals with climate change today will have a direct bearing on the human development prospects of a large section of humanity. Failure will consign the poorest 40 percent of the world's population—some 2.6 billion people—to a future of diminished opportunity. It will further worsen problems of inequalities between and within nations. And it will undermine efforts to building a more inclusive pattern of democracies and globalization, reinforcing the vast disparities between the 'haves' and the 'have nots'. Although it is the world's poor who are bearing the brunt of climate change today. Tomorrow, it will be humanity as a whole that faces the risks that come with global warming. As stated earlier, human security cannot be exhaustive without food security. To ensure food security, an adequate diet must include not only calories but the full range of nutrients that humans need. Of particular importance is protein, which is essential for muscles, bones, the antibodies that prevent infection, and the many enzymes that regulate all of the body's systems. Grains, beans, and seeds are common sources of protein in developing countries, while meat, milk, cheese, and eggs are more likely to be consumed in industrialized countries, and by the elites in developing countries. The demand for these products is high, despite the inefficient use of land required to produce them.

To ensure food security in times of low crop yields, natural disasters, or famine, nations must use stored foods. Global cereal reserves, also known as *world carryover stocks*, are an indicator of world food security. Grain stores reached a historic high in 1988, sufficient to feed the world for 100 days. By the beginning of the 21st century, however, stores had dropped to their lowest level in 20 years. The decrease in grain stores resulted from cutbacks in grain production in Europe and the United States, lower yields due to regional weather problems, and soil erosion resulting from poor farming practices. As yields have decreased, many countries have dipped deeper into carryover stocks to feed their growing populations. People in different regions of the world have vastly different food supplies and nutritional states. Much of this difference is caused by poverty, the availability and condition of natural resources for food production, corruption, the political system, and national economic policies—including international trade arrangements which also affect the number of people suffering from under nutrition in each region. Furthermore, a variety of historical and contemporary forces prevent many African countries from attaining food security. The slave trade, for example, which lasted from the 15th century to the early 19th century, profoundly disrupted many African societies. Also, the political, economic, and social domination, or colonization, by other countries significantly altered traditional agricultural systems throughout Africa. Colonialists replaced the most fertile peasant farms with plantations designed to provide sugar, coffee, cocoa, tea, peanuts, rubber, cotton, and other commodities for export to their own countries. The rich farmlands of Ghana, for example, once the site of abundant yam production, were transformed into cocoa plantations. (Rodney 2008) Africa still has European-owned plantations and farms, where a variety of products are grown for export. When plantations were established, many peasant farmers were displaced to farmlands where poor soil or steep terrain made survival by traditional farming methods difficult to achieve. More worrisome is the protection measures through subsidies on agricultural commodities as practiced by the industrialized nations. This is the major killer of agriculture and food security in the developing countries African leaders who replaced the colonial administrations did not always institute necessary reforms, further hobbling the ability of their countries to achieve food security.

Today, these forces, combined with inefficient agricultural techniques, droughts, and civil wars, make food supply very precarious in Africa, the only continent where food production has not kept pace with population. The number of chronically undernourished people in sub-Saharan Africa more than doubled between 1970 and 1990. By the beginning of the 21st century, 25 African countries, including Eritrea, Ethiopia, Democratic Republic of Congo, and Zimbabwe, had acute food shortages requiring emergency assistance. The Consultative Group on International Agricultural Research (CGIAR 2008).

Climatic catastrophes displace populations and can indirectly lead to conflict and civil unrest Adekanye, (2008: 71) posits that all the conflict cases in Africa past and present stemmed essentially from stresses of environmental cum demographic insecurity have become accentuated since the mid-1980s and the pressures from the regimes of debt and adjustment, and the result has been to intensify human insecurity within and across state boundaries everywhere, fuel inter group conflicts and wars, and produce massive refugee movements. The deterioration of land as the natural resource base resulting from these problems, coupled with demographic pressure and chronic poverty, has meant that the little available arable land has become subject to intense disputes and life-and-death struggles (Ibid 2008: 70) This underscores a point that connects scarcity to conflict or better still, that establishes the concept of *environmental resource scarcity*. Yet it is all too certain that conflict produces scarcity in no less way than scarcity leads to further conflict. The fragile public health infrastructure erodes if resources are diverted to disaster recovery and conflict management. Communities and government are burdened with clean-up costs, emergency response, repairs, and support to displaced and unemployed communities. Nigerians already suffer from nutritional imbalances. Climate Change will further aggravate the situation if serious actions are not taken. As well, the location of some diseases caused by pests, such as malaria (mosquitoes) and sleeping sickness (tsetse fly), will shift with the patterns of rainfall and temperature, especially where flooding is a problem. Studies have shown that Malaria and cholera increase with flooding and higher temperatures, cerebrospinal meningitis is linked to higher temperatures and low humidity.) Skin cancer, from direct ultra-violet radiation, could become more common, as could increase incidences of heatstroke and heart and lung disorders.

It is herein submitted that the Nigerian state and indeed the international community must rise to the occasion. Land reforms are crucial for mechanized and sustainable farming practices. Widespread poverty induces heavy and total dependence on the immediate environment for livelihoods. Lack of information (awareness) and knowledge (education) about Climate Change also means that many Nigerians are reluctant, or skeptical to accepting the reality of Climate Change. Moreover, there is a lack of public policy, weak political will and ill commitment to promoting Climate Change adaptation strategies in this country. There is a dearth of data to guide public policies that target adaptation, and those that do exist are inadequate or deviate from best practices. Certainly, a lack of dedicated research institutions makes it difficult to study comprehensively, the growing negative effects of Climate Change in Nigeria. The health impacts of Climate Change on the Nigerian population will be far ranging. Water resources will be extremely vulnerable. It is certain that water quality will suffer, as will the human and animal populations that depend on them. Human health will be vulnerable when food production, livestock, agriculture, etc. are all affected as a result. It is obvious that Climate Change will have a significant effect on all aspects of Nigerian society, affecting each and every socioeconomic sector. This will, in the long run translate into the antithesis of human security. Health sciences and related disciplines must provide new and better methods for studying the relationship of population health to natural Climate Changes and to human-induced Climate Change (i.e. pollution).

Yet the present level of research and knowledge on Climate Change in Nigeria has hardly began, neither has efforts of adaptation.

We know the danger. We know it is growing with every day of inaction. In reality, the world is a heterogeneous place: people have unequal incomes and wealth and climate change will affect regions very differently. This should be the basis for immediate action. Climate change is already starting to affect some of the poorest and most vulnerable communities around the world. A worldwide average 3° centigrade increase (compared to preindustrial temperatures) over the coming decades would result in a range of localized increases that could reach twice as high in some locations. The effect that increased droughts, extreme weather events, tropical storms and sea level rises will have on large parts of Africa, on many small island states and coastal zones will be inflicted in our lifetimes. In terms of aggregate world GDP, these short term effects may not be large. But for some of the world's poorest people, the consequences could be apocalyptic. In the long run climate change is a massive threat to human development and in some places it is already undermining the international community's efforts to reduce extreme poverty and the attainment of the MDGs in 2015. The UNDP (2008) in its *Human Development Report* remarked that what we do today about climate change has consequences that will last a century or more. It adds that the part of that change that is due to greenhouse gas emissions is not reversible in the foreseeable future. The heat trapping gases we send into the atmosphere in 2008 will stay there until 2108 and beyond. (Ibid) We are therefore making choices today that will affect our own lives, but even more so, the lives of our children and their children. This makes climate change different and more difficult than other policy challenges.

RECOMMENDATION FOR DEVELOPED/INDUSTRIALIZED COUNTRIES

✓ Respect and Immediately implement treaties of deep emission cuts in the Kyoto Protocol and its successor treaty later in Copenhagen;

✓ Extreme consumers/emitters should be conscious of other members of our planet and extravagance be avoided.

✓ Meet their aid commitments to attaining the MDGs;

✓ Provide additional aid for adaptation/mitigation measures in the developing countries with special focus on genetic research aimed at developing draught/heat resistant plants and animals for the avoidance of extinction and tropical drifts. By the same token, existing research institutes like the IITA should be well funded in order to consolidate on the gains of the past within the sub-region.

✓ Share and transfer existing technology and new adaptation measures with the developing world;

✓ Create an enabling environment for poor countries to limit their emissions while safeguarding their rights to development; and

✓ Support developing economies in policies aimed at reducing rapid population growth, enhancing good governance and fighting corruption.

RECOMMENDATION FOR EMERGING/DEVELOPING ECONOMIES

- ✓ Ensure rights to land, water, energy and livelihood for the poorest people in sustainable manner;
- ✓ Formulate and implement to the later, sustainable population policies to slow down population growth rate and buy time for economic growth;
- ✓ Integrate climate change initiatives with early warning systems into national MDGs to ensure sustainable development;
- ✓ Explore/Prioritize renewable energy sources while being conscious of comparative advantages;
- ✓ Increase the vegetal cover of territorial land by deliberate reforestation;
- ✓ Diversify national economies with less dependence on fossil fuel and
- ✓ Include emerging economies such as China, India, and the Republic of South Africa (in subsequent (GHG) emission cuts at the expiration of the Kyoto Protocol in 2012.

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"WHAT ROLE CAN BIOTECHNOLOGY PLAY IN MITIGATING THE ADVERSE EFFECTS OF CLIMATE CHANGE ON CROP PRODUCTION?"

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Abstract

Domesticated plants are known as crops. They are cultivated to meet the diverse needs of man for food, clothing, shelter, aesthetics, landscaping, horticultural therapy, human health and raw materials to feed different kinds of industries. Crop growth and yield depend on complex interactions between the crop and the several factors and conditions in the environment whether in the air (atmospheric) or below the ground (edaphic). Climate plays a significant role in crop production and survival. Elements of climate like rainfall, temperature, intensity and duration of sunshine, wind, atmospheric humidity required by crops must be available in sufficient quantities. They determine having a bumper harvest or total crop failure. These climatic variables also determine the preponderance or otherwise of biotic variables like pests and diseases. A change of climate triggers on a lot of ripples that affect and threaten the survival and productivity of crops. Biotechnology or genetic engineering has been employed to augment the efforts of the plant breeder in the development of crops for high yield in terms of quality and quantity as well as in optimum performance even in adverse production environments. The significant roles which Biotechnology has played in addressing the menace of global warming on crop production are fully discussed with pertinent examples.

Keywords: Climate change, global warming, crop production, biotechnology, plant breeding,

INTRODUCTION

There are some 350,000 known species of plants in the world but relatively few of these have been used for food by people (Ezedinma, 1999). Although cultivated plants are known as crops, the classification is unsatisfactory because some plants which may occur wild in some areas may be cultivated in other areas. Furthermore, many plants which occur in the wild are still harvested for food or for other uses, especially for medicinal purposes. Those plants which have been identified, domesticated and cultivated are usually known as crops. Cultivated plants (crops) have been classified in many ways using criteria like duration of growth (annuals, biennials and perennials), use of the crop(food, feed, cash, industrial) , mode of production(field, forage, horticultural , plantation), geographical location(temperate, tropical, sub tropical, Mediterranean etc.). Classification criteria are so many that a stage is reached when there is a pronounced overlap between members of a group. These groups describe the desirability of crop plants among the human race. Crop production is carried to meet human diverse needs for food (including soil conservation), clothing, shelter, aesthetics, landscaping, horticultural therapy, human health, raw materials to feed different kinds of industries (Ferrini, 2003).

Crop growth and yield depend on complex interactions between the crop and the several factors and conditions in the environment (biotic and abiotic) whether in the air (atmospheric) or below the ground (edaphic).

Soil depth and structure, soil moisture, soil air, soil slope and stoniness, soil reaction (pH), atmospheric and soil temperature, intensity and duration of sunshine, wind, rainfall and atmospheric humidity have a domineering influence on crop performance.

Limiting factors and concepts in crop production:

Yield is a product of the genetic constitution of the crop and the environment. The environment influences the expression of the genotype. Many environmental factors limit crop growth and yield. Some of these (weeds; pests e.g. insects, rodents, birds; diseases e.g. fungi, bacteria, viruses, nematodes) directly reduce yield irrespective of the potential yield level in a given environment. Others (soil, nutrients, stand or population density, spacing, leaf orientation) may add or subtract from the yielding ability of a crop in any environment. Most agronomic practices are aimed at balancing these variable factors to achieve optimum yields.

CLIMATE

Climate encompasses the temperatures, humidity, atmospheric pressure, winds, rainfall, atmospheric particle count and numerous other meteorological elements in a given region over long periods of time, as opposed to the term weather, which refers to current activity of these same elements. The climate of a location is affected by its latitude, terrain, altitude, persistent ice or snow cover, as well as nearby oceans and their currents. Climates can be classified using parameters such as temperature and rainfall to define specific climate types. The most commonly used classification scheme is the one originally developed by Wladimir Köppen. The Thornthwaite system in use since 1948 incorporates evapotranspiration in addition to temperature and precipitation information and is used in studying animal species diversity and potential impacts of climate changes. The Köppen classification includes climate regimes such as rain forest, monsoon, tropical savanna, humid subtropical, humid continental, oceanic climate, Mediterranean climate, steppe, subarctic climate, tundra, polar ice cap, and desert(Wikipedia, 2009; free encyclopedia) .Climate is a cardinal factor in crop production. They determine having a bumper harvest or total crop failure.

Climate change

Climate change refers to the variation in the Earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities (Wikipedia, 2009). In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming.

Carbon dioxide CO2 and other green house gases have been implicated by scientists for climatic change / global warming (Arrhenius, 1896, Mathew, 2008). Green house gases are trace gases in the atmosphere which maintain the Earth’s temperature at the average level that we have today. The most important ones that may be influenced directly by human activity are carbon dioxide, methane, nitrous oxide, and the CFC's- chlorinated fluorocarbons such as Freon (Mathew, 2008; Omowole, 2008). All these constituents are distributed in the atmosphere from the surface to high altitudes. The Inter-governmental Panel on Climatic Change (IPCC, 2007) has reported a warming of approximately 0.77^0C over most of the African region during the 20^{th} century(Badejo *et al*. 2009) . The warming occurred at the at the rate of about 0.05^0 per decade and a temperature rise of about 0.1^0 per decade is expected for the next two decades , even if greenhouse gases and aerosol concentrations are kept at year 2000 levels (Osman –Elasha, 2009). The second assessment report of studies conducted by IPCC established a positive correlation between increase in temperature and the concentration of greenhouse gases in the atmosphere and that human activity greatly increases the amount of these greenhouse gases.

Results of a new study released by scientists of the Consultative Group on International Agricultural Research showed that climate change threatens wild relatives of key crops. Wild relatives of crops such as potato, cowpea and groundnut are at risk of extinction, threatening a valuable source of genes that are needed to boost the ability of crops to resist pests and tolerate drought. The study specifically found that in the next 50 years as many as 61% of the 51 wild groundnut species analysed and 12% of the 108 wild potato species analysed could become extinct as a result of climate change. Most of the wild potato and groundnut species that remained would be confined to much smaller areas further eroding their capacity to survive (Geneflow, 2007). There is an urgent need to collect and store the seed of wild relatives in crop diversity collections before they disappear. They remarked that extinction of crop wild relatives threatens food production because plants contain genes for traits such as pest resistance and drought tolerance that breeders use to improve the performance of cultivated varieties either by conventional plant breeding or biotechnology. It was aptly reported in the study that Plant Breeders tend to dip back into the gene pool of the robust wild relatives in search of traits that will enable domesticated varieties to overcome any threat(disease, pest, drought) that my spring up.

The vulnerability of a wild plant to climate change can depend on its ability to adapt by, for example, extending its range of adaptation as its native region becomes too hot. One reason wild groundnut plants appear to be so vulnerable to climate change is they are largely found in flat lands and would have to migrate a long way to reach cooler climates, a predicament made worse by the fact that groundnuts burry their seeds underground, a meter or less from the parent plant. That limits the speed at which seeds can move into more favourable climates. In contrast, plants in mountainous locations could theoretically survive by extending their range slightly up a slope, even only by a few meters, to find a cool weather.

The irony is that plant breeders will rely on wild relatives more than ever as they work to develop domesticated crops that can adapt to changing climatic conditions. Yet because of climate change, we could end up loosing a significant amount of these critical resources at precisely the time they are most needed to maintain agricultural production.

Results of Geneflow (2008) study shows that climate change will have an impact on what we grow and where we grow it. Overall, the area suitable for crop cultivation is projected to increase. For example, the model predicts increases in the area of land suited to pearl millet (31%), sunflower (18%), common millet (16%0, chickpea (15%), and soybean (15%0. The problem is that many of the gains occur in regions where these crops are not currently important for food security. Specifically, the study predicted an increase of more than 10% in the area suitable for pearl millet in Europe and the Caribbean, where hardly anyone eats the crop, but not in Africa, where pearl millet is widely cultivated. Geneflow (2008) study under reference supports the recent call by the IPCC to invest in solutions that will allow countries to adapt to the impacts of climate change. It will be crucial, for example to develop new varieties of crops with resistance to a range of stresses, such as greater tolerance of drought, flooding and extreme temperatures. Such new varieties would allow cultivation to continue in areas that would otherwise become unsuitable for a particular crop to be grown in new and previously inhospitable areas thus via biotech and bioremediation, flood plains, heavy metal sites can be reclaimed for safe cultivation of crops.

The IPCC Fourth Assessment Report of 2007 predicts that many mid-latitude regions, such as Mediterranean Europe, will experience decreased rainfall and an increased risk of drought, which in turn would allow forest fires to occur on larger scale, and more regularly. This releases more stored carbon into the atmosphere than the carbon cycle can naturally re-absorb, as well as reducing the overall forest area on the planet, creating a positive feedback loop. Part of that feedback loop is more rapid growth of replacement forests and a northward migration of forests as northern latitudes become more suitable climates for sustaining forests. (Wikipedia, March 2009). A team headed by a Finnish researcher concludes that stronger winds caused by global warming may be dispersing seeds and pollen over longer distances. An increase in temperature of only a couple of degrees may increase the dispersal of plants in Northern forests and the spread of plant species into forest clearings after logging or forest fires.(Thomas, 2009).

Overt adverse effects of global warming include increased evaporation, drought, flooding, genetic erosion, diseases, insect pests, reduction in water volume, drying up of rivers and lakes, sea level rise, desertification, air quality problems especially the thinning out of ozone layer which exposes man to the damaging effects of the ultraviolent radiation (UV) from the sun. Wikipedia (2009) opined that rising atmospheric temperatures, longer droughts and side-effects of both, such as higher levels of ground-level ozone gas, are likely to bring about a substantial reduction in crop yields in the coming decades. The region likely to be worst affected is Africa, both because its geography makes it particularly vulnerable, and because seventy per cent of the population rely on rain-fed agriculture for their livelihoods. Sea level rise is projected to increase salt-water intrusion into groundwater in some regions, affecting drinking water and agriculture in coastal zones. Furthermore, increased evaporation will reduce the effectiveness of reservoirs.

Global warming is already taking its toll on water volume reserve of Lake Chad in Nigeria. The water volume is drying up at an alarming rate to the extent that the human population around the lake who derive their livelihood from fishing are gradually being thrown out of job as the fishes are at the verge of extinction. Between 1989 when the author first visited the Lake and now 2009, the water volume had receded precariously that livelihood and activities around the lake portrays a sorry state of a lake and its habitat at the verge of extinction. Government urgent intervention (Nigeria and Chad) is needed!

BIOTECHNOLOGY

The plant biotechnology - plant breeding bridge

Breeding involves screening large numbers of different lines, selecting those individuals with agriculturally important traits, quantifying the responsible genes and incorporating those genes into elite breeding material through several generations of crossing and backcrossing to elite lines. DNA technology assists in the selection process by improved pedigree analysis or gene mining for improved genetic variants and also in tagging desirable genes in a crossing programme through marker assisted breeding (Lande and Thompson, 1990). Plant biotechnology can increase productivity by raising, either directly through increased photosynthetic efficiency, or by redirecting photosynthate into preferred structures/sinks such as seed or tubers.

Biotechnology is a scientific discipline with focus on the exploitation of metabolic properties of living organisms for the production of valuable products of a very different structural and organizational level for the benefit of men. The products can be the organisms themselves (i.e., biomass or parts of the organismic body), products of cellular or organismic metabolism (i.e., enzymes, metabolites), or products formed from endogenous or exogenous substrates with the help of single enzymes or complex metabolic routes. The organisms under question vary from microbes (bacteria, fungi) to animals and plants. In addition to intact organisms, isolated cells or enzyme preparations are employed in biotechnology. The products of biotechnology are of importance for medicine, pharmaceutical sciences, agriculture [crops, livestock -including fishery, soil], food production, chemistry, and numerous other disciplines (Barz and Oksman-Caldentey, 2002). Genetic engineering and biotechnology are providing new tools for genetic improvement of crops. Biotechnology has made possible the techniques of cell and tissue culture, molecular genome analysis, plant genetic transformation, molecular plant disease diagnosis and germplasm cryo-conservation in plant improvement.

Tissue culture was developed in the 1950s and became popular in the 1960s. Today, micropropagation and in vitro conservation are standard techniques in most important crops, especially those dealing with vegetative propagation. Tissue culture is seen as a main technology for developing countries for the production of disease-free, high-quality planting material. Tissue culture includes micropropagation; embryo rescue; plant regeneration from callus and cell suspension; and protoplast, anther and microspore culture. These techniques are being used particularly for large-scale plant multiplication. Plant regeneration from callus and cell suspension has also constituted an avenue for creating variability in vitro through somaclonal variation. Micropropagation has proved especially useful in producing high quality, disease-free planting material of a wide range of crops and also for virus indexing (Ogunbodede, 1995).

Molecular DNA markers are some of the tools which can be used in various fields of breeding and germplasm management (Thottappilly *et al*., 2000). They are useful for determination of phylogenetic relationships in related species and construction of genetic maps. A genetic map is a collection of genetic markers that have been grouped according to their linkage. Molecular markers serve as a means for unifying basic and applied genetics. Plant breeders will or would have to change their modus operandi with the development of objective marker-assisted introgression and selection methods. Backcross breeding will be shortened by eliminating undesired chromosome segments (also known as linkage drags) of the donor parent or selecting for more chromosome regions of the recurrent parent. Parents of elite crosses may be chosen based on a combination of DNA markers and phenotypic assessment in a selection index, such as best linear unbiased predictors. Molecular markers in various forms can be used to construct linkage maps of different species so as to locate particular genes. The mapped markers are used for speeding up selection in conventional breeding procedures. Allozymes were available as the first biochemical genetic markers in the 1960s. Population geneticists took advantage of such marker system for their early research. Since then, marker-aided analysis based on PCR has become routine in plant genetic research and marker systems have shown their potential in plant breeding. Furthermore, new single nucleotide polymorphic markers based on high density DNA arrays, a technique known as 'gene chips' (Nill, 2002) have recently been developed. With 'gene chips', DNA belonging to thousand of genes can be arranged in small matrices (or chips) and probed with labeled cDNA from a tissue of choice. Ortiz (1998) opined that to achieve success in these endeavours, cheap, easy, decentralised, and rapid diagnostic marker procedures are required. Although molecular markers provide a mechanism for applying linkage genetic techniques to complex inheritance problems that almost reduces them to the level of studying single gene trait (Hlentjaris, 1993), he cautioned that, both experimental design and phenotypic measurements are much more critical in making this realizable.

Breeders can use DNA maps to carry out marker assisted selection. It enhances cloning of genes for crop improvement. In cowpea a genome map based on mainly on RFLP markers have been developed (Fatokun *et al.,* 1997). Using the map, quantitative trait loci (QTLs) for seed weight, pod length, and aphid resistance have been identified. Abdulai (2001) also identified QTLs in maize controlling days from planting to flowering, ear and plant heights as well as total number of leaves at flowering.

Some of the most useful molecular markers for DNA fingerprinting are the polymerase chain reaction (**PCR**)-molecular genome mapping and diagnosis of plant pathogens. Restriction Fragment Length Polymorphisms (**RFLPs**), Random Amplified Polymorphic DNAs (**RAPDs**) and Amplified Fragment Length polymorphism (**AFLP**). Restriction fragment length polymorphisms (RFLPs) (Bostein *et al*., 1980) provided researchers with a tool that in many ways supersedes the limitations of isozymes. Microsatellites are highly polymorphic, randomly distributed in the genome and easily analysed by the PCR technique. Microsatellites are regarded as general and novel source of genetic markers and they are being used to construct high resolution genetic maps. Transposable elements was first described by McClintock in 1957 .They are genes which move from one chromosome location to another and they are also called transpoons (Briggs, 1993). Most transposons contain inverted repeats at their ends and encode a transposase enzyme that recognizes these inverted repeats. The transposase cuts at the borders between the transposon and adjacent genomic DNA and it also helps the excised transposon integrate at a new site (Morakinyo *et al.,* 2008). Transpoons may inhibit, suppress or modify gene action and may also induce point or mutations. Fawole (2008) reported that the activities of transposable elements cause turbulent heredity in cowpea and that Transposable elements transfer mutability to otherwise stable loci and they may be used to generate genetic variability for plant breeding and genetic analysis.

DNA-based techniques include isolation, amplification, modification and recombination of DNA; genetic engineering to obtain Genetically Modified Organisms (GMOs); use of markers and probes in gene mapping and in functional and structural genomics; and unambiguous identification of genotypes through DNA fingerprinting.

Recombinant DNA techniques are succinctly outlined by Morakinyo *et al.,* 2008. The techniques are used for the production of transgenic individuals, which involves DNA extraction, gene cloning, gene construct/design, transformation and backcross breeding all of which facilitate the recombination and reinsertion of genetic material by various techniques. The best available method of gene transformation is based upon the ability of the bacterium *Agrobacterium tumefaciens* to transfer and integrate the T-DNA region of its Ti plasmid into the recipient genome (Old and Primose, 1994; Morakinyo *et al.* 2009). Physical methods of protoplast transformation include electroporation, chemically mediated uptake, mechanical introduction of DNA into cells by microinjection, use of high velocity microprojectiles/biolistics (Old and Primrose, 1994). Several transgenic cultivars of major food crops have been released incorporating genes for resistance to herbicides and insects.(Monti, 1992, Dale *et al.*, 1993). Development of an efficient transformation protocol in cowpea (*Vigna unguiculata* (L.) Walp) had being a herculean task (Kononowicz *et al.* (1997). Raji *et al*. (2008) described an efficient transformation system for this crop which had been hither to very recalcitrant to transformation. This discovery now places cowpea on a new research highway for rapid improvement of the crop. The area planted with transgenic crops in the world went from 2.8 million ha in 1996 to 28 million ha in 1999 (FAO, 1999). There are 4.4 million ha of transgenic corn (14% of total acreage), 5 million ha of transgenic soybean (20%), and 1.6 million ha of transgenic canola (42%) grown only in North America (Moore, 1998). Argentina is the leading developing country with an excess of 4 million ha of transgenic herbicide-resistant soybean. Trees are the next target in the agenda of genetic engineering (Ortiz, 1998). Plans are on going for the introduction of Genetically Modified crops in Nigeria. The Nigerian priority crops include Bt-Cotton, Cowpea, Cassava and Bt-corn (Solomon *et al.,*2008).

Cryopreservation is the storage of biological material at ultra-low temperature, usually that of liquid nitrogen (-196^{0}C), is the only currently available to ensure the safe and cost-effective long term storage of genetic resources of species that have recalcitrant seeds or are vegetatively propagated. Cryopreservation is applicable in the preservation of ornamental, horticultural, fruit, wild relatives of cultivated crops and other endangered species. Different parts of the plant e.g. pollen, zygotic embryos, shoot apices, meristems, whole seeds etc. can be cryopreserved. Cryopreservation techniques could be Classical or Vitrification in nature. **Classica**l technique is freeze-induced dehydration e.g. undifferentiated culture systems like cell suspensions and calluses while **Vitrification** technique can take various forms: encapsulation-dehydration, vitrification, encapsulation-vitrification, desication, pregrowth and pregrowth desication. In all vitrification –based procedures, cell dehydration is performed prior to freezing by exposure of samples to concentrated cryoprotective media and/or air desiccation. (Engelmann, 2000).

The full realisation of the agricultural biotechnology revolution depends on both continued successful and innovative research and development activities and on a favourable regulatory climate and public acceptance. Biotechnology should be fully integrated with classical physiology and breeding to fulfill the following tasks: (1) as an aid to classical breeding, (2) for generation of engineered organisms, (3) for integration of micro-organisms into agricultural production systems.

Biotechnology will, by the production of genetic modified plants, impact the agricultural and plant scene in three major areas: (1) growth and development control (vegetative, generative and reproduction/propagation), (2) protecting plants against the ever-increasing threats of abiotic and biotic stress, (3) expanding the horizons by producing specialty foods, biochemicals and pharmaceuticals (Altman, 1999).

Likewise, research advances in gene regulation, especially those processes concerning plant development patterns, will help breeders to fit genotypes in specific environments. Photoperiod insensitivity, flowering initiation, vernalization, cold acclimation, heat tolerance, host response to parasites and predators, are some of the characteristics in which advanced knowledge may be acquired by combining molecular biology, plant physiology and anatomy, crop protection, and genomics. Multidisciplinary co-operation among researchers will provide the required holistic approach to facilitate research progress in these subjects.

Plant biotechnology requires both human resources and infrastructure. Governments of developing countries must provide these because technical constrains in terms of scarcity of human resources, limitation in technology development and use, infrastructure and lack of information/data banks on plant biotechnology usually undermine major biotechnological breakthroughs.

OPPORTUNITIES PROVIDED BY THE NEW BIOTECHNOLOGY TOOLS

Augumentation of traditional breeding

Breeding involves screening large numbers of different lines, selecting those individuals with agriculturally important traits , quantifying the responsible genes and incorporating those genes into elite breeding material through several generations of crossing and backcrossing to elite lines. DNA technology can assist in the selection process by improved pedigree analysis or gene mining for improved genetic variants and also in tagging desirable genes in a crossing programme through marker assisted breeding (Lande and Thompson, 1990).

Advances in crop productivity

Agricultural biotechnology can increase productivity by raising yield, either directly through increased photosynthetic efficiency, or by redirecting photosynthate into preferred structures/sinks such as seed or tubers. Alternately, yield increases can be achieved by minimizing losses to pest and diseases. Specifically, plants can be strengthened with genes resistant to insects, nematodes, fungus, parasitic weeds, bacteria or virus. Similarly, transformation with stress tolerant genes can alleviate losses due to abiotic factors such as drought, high salt or aluminum toxicity.

MEA (2005) categorized agricultural interventions to reduce hunger into (a) increasing yield (and also nutrient fortification), (b) increasing area in agriculture/ number of animals and (c) reducing past harvest losses (through measures such as crop protection, value addition and provision of appropriate and adequate storage facilities). Biotechnology is involved in each of the three categories above.

Improved health and nutrition

Biotechnology advances can be found that tackle areas not solely related to improving crop productivity, but also address the broader issues of health and nutritional needs (Keese *et al.,* 2002; Ferrini, 2003). Transgenic crops with insect or pathogen resistance genes can have a significant indirect benefit on health by reducing the need for potentially dangerous chemical sprays.

Fine-tuning plant responses to distinct environments mitigates effect of climate change and also enhances crop productivity.

It will be crucial, for example to develop new varieties of crops with resistance to a range of stresses, such as greater tolerance of drought, flooding and extreme temperatures. Such new varieties would allow cultivation to continue in areas that would otherwise become unsuitable for a particular crop to be grown in new and previously inhospitable areas thus via biotechnology and bioremediation, flood plains, heavy metal sites can be reclaimed for safe cultivation of crops. Plant Biotechnolgy has made the production of the following crop ideotypes possible:

A. Engineered plants for salt tolerance.

Engineered plants for salt tolerance are able to cope with the problem of fresh water pollution arising from rising levels of ocean in coastal water lands. In some countries, such as Israel where this work was pioneered, fresh water supplies are already stretched to the point that farmers are forced to use a proportion of salty water for irrigation and it is anticipated that this usage will continue to grow in the future. If encroaching desertification is to be avoided under these circumstances, then the development of salt-resistant crops and trees becomes essential.

B. Engineered plants for drought tolerance.

Such plants (trees) are used in aforestation programmes and they also help to arrest desertification. Drought resistant annual crop varieties make production possible where it would have been impossible especially in the dry ecologies of the region. Early maturing crop varieties e.g. maize and cowpea increase the number of cropping within a given period of time at a particular location.

C. Engineered plants for resistance to insect pests and diseases.

Plants have an inbuilt defence mechanism protecting them from attack by insects but the damage caused by the pests may still be sufficient to reduce the commercial potential of the crop. The usual procedure is to spray the crop with insecticides but in an effort to reduce the amount of chemical insecticides being used, plants are being engineered to have an increased self-defence against pests. Attack by insects not only causes damage to the plant but also provides a route for bacterial or fungal infection in addition to the role played in the spread of plant viruses. With a view to increasing resistance to sustained attack, the genes coding for the *δ-endotoxin* of the bacterium, *Bacillus thuringiensis* (Bt), have been transferred into plants. Examples are of synthetic *B. thuringiensis δ-endotoxin* genes transferred, in the first case, by *A. umefaciens* into Chinese cabbage (Cho *et al*. 2001) and in the second, by biolistic bombardment into maize (Koziel *et al*. 1993). In both cases, the transgenic plants showed greatly improved resistance to pest infestation. Insects are able to develop resistance to Bt products which is a problem addressed by insertion of *δ- endotoxin* genes into the chloroplast genome rather than into that of the plant's nucleus, with promising early results (Kota *et al*. 1999).

Attempts to improve virus resistance have led to the introduction, by *A. tumefaciens*, of the genes expressing antibodies to the coat protein of Tobacco Mosaic Virus (TMV). Expression of these in the plant led to complete immunity against TMV (Bajrovic *et al*. 2001).

Farmers of vegetatively –propagated root and tuber crops in developing countries suffer significant yield losses induced by pests and diseases and conventional resistance breeding has shown only limited successes. Recombinant techniques bring about new opportunities to develop high yielding, virus resistant varieties through the introgression of viral coat protein or replicate genes into the plant genome. Collaborative projects to advance non conventional virus resistance in sweet potatoes i.e. transgenic potatoes in Kenya and Mexico have been undertaken. The project between Kenya Agricultural Research Institute (KARI) and Monsanto (USA) on one part and between the center for Research and Advanced studies in Mexico and the same Monsanto (USA) on the other made transgenic virus resistant potatoes available to Kenyan and Mexican farmers (Solomon *et al.,* 2008). Such transgenic crops with insect or pathogen resistance genes show improved resistance to pest and diseases and they also have a significant indirect benefit on health by reducing the need for potentially dangerous chemical sprays.

D. Engineered plants for resistance to herbicides.

'Glyphosate', one of the most widely used herbicides, is an analogue of phosphoenol pyruvate and shows herbicidal activity because it inhibits the enzyme *5-enolpyruvylshikimate-3-phosphate synthase*. The gene coding for this enzyme has been identified, isolated and inserted into a number of plants including

Genetic Manipulation 227 petunias. In this case, the gene was expressed behind a CaMV promoter and

introduced using *A. tumefaciens*, leading to very high levels of enzyme expression. As a consequence, the recombinant plants showed significant resistance to the effects of glyphosate (Shah *et al*. 1986). Developments in this strategy include the formation of a chimaeric *synthase* enzyme, the analysis of which should lead to improved herbicide resistance in transgenic crops using this strategy (He, 2001). Argentina is the leading developing country with an excess of 4 million ha of transgenic herbicide-resistant soybean. (Ortiz, 1998).

E. Engineered plants for Phytoremediation i.e. (Photodegradation, Rhizodegradation and Phytovolatization)

A wide variety of organic chemicals are commonly encountered as environmental pollutants including many types of pesticides, solvents and lubricants. The most ubiquitous of these across the world, for obvious reasons, are petrol and diesel oil. These hydrocarbons are not especially mobile, tend to adhere closely to the soil particles themselves and are generally localised within 2metres of the surface. Accordingly, since they are effectively in direct contact with the rhizosphere, they are a good example of ideal candidates for phytoremediation. Phytoremediation biotechnology generally relies on the transpiration pull of fast-growing trees, which accelerates the uptake of the pollutants in groundwater solution, which are then released through the leaves. The genetic modification of a poplar specie to enable mercury to be removed from the soil and converted to a form able to be released to the atmosphere is widely used in phytoremediation. This process is termed 'phytovolatilisation' (Rugh *et al*. 1998). The transgenic yellow poplar plantlets were found to exhibit tolerance to mercury and to volatalise it at 10 times the rate observed in untransformed yellow poplar plantlets. . This confers the ability to tolerate higher mercury concentrations and to convert the metal's ionic form to the elemental and allows the plant to withstand mecury toxicity (Bizily *et al*., 2000). This study demonstrated the possibility that trees can be modified to become useful tools in the detoxification of soil contaminated with mercury.

This innovation can be used for phytoremediation of dump sites and flood plains to void them of heavy metals (Pb, Cu,Zn,Cd). Flood plains/river banks are largely used for vegetables (fruits, leaves , roots) production especially in the dry season,{Akinola and Ekiyoyo, 2006; Oyedele *et al.* 2008;

Awotoye *et al.* 2008}. Vegetables translocate these heavy metals especially Pb into their edible portions. Such sites will be suitable for production of vegetables safe for human consumption after phytoremediation.

Biotechnology for better yield and nutritional qualities

- A. Tissue culture bananas with average bunch weights of 40kg compared to the usual average of 15-30kg have been developed (Jones, 2007).
- B. Mushrooms for mycoremediation- application of fungi in remediation of polluted soil and aqueous effluents have been documented (Adenipekun, 2006).
- C. Cultivated edible mushrooms : Contains 19-40% high quality protein with all the 9 EAAs., low fat content(1-8% dry wt), little sugar, no starch and with a richer supply of minerals than meats and double the amount found in most vegetables (Fasisdi, 2006).
- D. New Rice for Africa -NERICAs Rice- This biofortified variety was produced by African Rice Center (WARDA) in Cote d'Ivoire from an interspecific hybrid (*Oryza glaberrima* x *Oryza sativa)* accompanied by embryo –rescue to produce fertile plants which eventually passed through several backcrosses to the *O. sativa* parent to produce progeny with robust fertility (Jones, 2007). The attributes of the NERICAs include the following: Early maturity -90-100 days instead of 120-140 days for *O. sativa.* ;drought tolerance, lodging and shattering resistance; resistance to African rice gall midge, the region's most devastating insect pest and resistance to rice yellow mottle virus, a major disease in lowland rice; resistance to blast disease; possession of taste, aroma and other grain qualities favoured by farmers and higher % protein (10.5%) vs 8% of *O. sativa.v*ariety.

Engineered plants for aesthetics, horticultural therapy and human health

- The first references to the use of plant cultivation as therapy for disabled people were found in an Irish monastery dating back to 1300(Ferrini, 2003). Several definitions of horticultural therapy have been given. This term is used for numerous matters that range from the obtainable benefits form social gardening flower cultivation, the program of environmental education of children at kindergarten and elementary school up to proper programs of support and rehabilitation for individuals with learning difficulties, physical and mental handicaps or problems related to drug and alcohol abuse, periods of incarceration or with ageing (Relf and Dorn, 1995; Stoneham *et al.,* 1995). The simplest definition of horticultural therapy is perhaps "rehabilitation through contact with Nature" (Anonymous, 1995). Biotechnology has been employed to create novel morphological and vegetative mutants in cowpea. Mutant cowpea plants with yellow and variegated leaves sort out in a myriad of ways producing different beautiful plants that can be used as ornamental/potted plants for decoration (Fawole, 2008; Obisesan, 2008). These cowpea vegetative mutants enrich the ornamental industry. Generally, clonal propagation of fast growing horticultural and ornamental (horticultural therapy) species are very apt for horticultural therapy. Ferrini (2003) opined "For most of us simply being in a garden makes us feel better. Strolling through a park or botanical garden soothes our nerves, gives us a break from day to day problems and puts us back in touch with the rhythms". Neuberberger (1992) reported that horticultural therapy is prescribed by ward physicians of psychologists for rehabilitative reasons (22%) or simply to restructure the patient's daily routine(78%).

Engineered plants for afforestation programmes

Clonal propagation of fast growing tree species produced by Forestry Research Institute of Nigeria(FRIN) e. g. *Ttriplochiton scleroxylon* (Obeche), *Terminalia superba* (White afara) and *Terminalia ivorenses* (Black afara) have become available (Ladipo *et al.,* 1999) and are currently used in national afforestation programmes in Nigeria (Badejo *et al.,* 2008).

Biotechnology in conservation of plant genetic resources

- Andean "orphan" food crops as arracacha *(Arracacia xanthorrhiza),* achira (*Canna edulis*), yacon (*Polymnia sonchifolia*), mashua (*Tropaeolum tuberosum*), oca (*Oxalis tuberosa*), ulluco (*Ullucus tuberosus*), quinoa (*Chenopodium quinoa*), amaranto o kiwicha (*Amaranthus caudatus*), popping beans -"nuñas" (*Phaseolus vulgaris*), tarwi (*Lupinus mutabilis*), goldenberry-"capuli" (*Physalis peruviana*), cherimoya (*Annona cherimola*) and passion -fruit (*Passiflora sp*.) are highly under-utilised and face the need to strengthen modern plant biotechnology for the conservation and sustainable agricultural use of those essential genetic resources. For these purposes, biotechnologies as cell and tissue culture, molecular genome analysis, plant genetic transformation, molecular plant disease diagnosis and germplasm cryo-conservation coupled with plant breeding and physiological integrated crop management, can be successfully used to cope with genetic erosion, to reinforce *ex-situ* collections and in *in-situ* conservation in the mountain lands (Izquierdo and Roca, 1998). In vitro conservation and cryopreservation of germplasm (cultivated, wild relatives, endangered species) is also appropriate. Geneflow (2007) reported that wild relatives of crops such as potato, cowpea and groundnut are at the verge of extinction .There is an urgent need to collect and store the seed of wild relatives in crop diversity collections before they disappear. The extinction of crop wild relatives threatens food production because plants contain genes for traits such as pest resistance and drought tolerance that breeders use to improve the performance of cultivated varieties either by conventional plant breeding or biotechnology. Plant breeders tend to dip back into the gene pool of the robust wild relatives in search of traits that will enable domesticated varieties to overcome any threat(disease, pest, drought) that my spring up.
- There are many Genetic Resources Centers across the globe. Mandate crops for each center are as indicated. [IITA in Nigeria: cowpea, cassava, banana, plantain, sweet potato, yam ; CIMMYT in Mexico: maize, wheat triticale; ICRISAT in India: sorghum, pearl millet, chickpea, pigeon pea, peanut/groundnut ; CIAT in Columbia: dry bean, cassava, tropical forages ; AVRDC in Taiwan: mungbean, soybean, tomato, Chinese cabbage, pepper ; CIP in Peru: potato, sweet potato ; ICARDA in Syria: wheat, barley, broad bean, lentils ; IRRI in Philippines: rice].

- The Nigerian Government established the National Center for Genetic Resources and Biotechnology in 1986 with the mandate to use biotechnology tools for the conservation of the nations genetic resources, established Biotechnology Advanced Laboratory (BAL) at Sheda Science and Technology Complex (SHETSCO) in 1993 with the mandate to provide a center of excellence for research and training in biotechnology and genetic engineering. The country also put in place a National Biotechnology Policy (NBP) and the National Biotechnology Development Agency in April and November 2001 respectively (Solomon *et al*.,2008).

Biotechnology in Greenhouse Farming

Large scale production of fruits and vegetables is practiced in Israel inside the greenhouse. It is also practiced in Florida state of USA as well as in Belgium and many other European countries. Vegetables are sustained by nutrient solutions supplied in sufficient quantities and in appropriate proportions in the greenhouse (with controlled environment). This innovation makes the production of vegetables possible irrespective of the environmental conditions outside the greenhouse.

CONCLUSION

Climate change and its attendant global warming is taking its toll on soil and crop production that grows on it. It appears that global warming is determined to strip man and its environment bare as a first step towards man's extinction. The overt adverse effects of global warming include increased evaporation, drought, flooding, genetic erosion of plant and animal resources, diseases, insect pests, reduction in water volume, drying up of rivers and lakes, sea level rise, desertification, air quality problems especially the thinning out of ozone layer which exposes man to the damaging effects of the ultraviolent radiation (UV) from the sun. Biotechnology has been of tremendous advantage in mitigating adverse effects of global warming by ameliorating soil conditions for crop growth/productivity by phytoremediation, by augmenting the efforts of plant breeders to develop an array of high yielding crop varieties (including Genetically Modified Crops) to meet different needs and with adaptation to different hostile production environments (diseases, insect pests, herbicides, drought, salinity, flood) as well as long term storage of threatened crop species and their wild relatives via conservation in seed gene banks or as tissue cultures. Biotechnology has also opened the door of profitable greenhouse farming. Governments of developing countries in particular must regularly and faithfully provide the human capacity development atmosphere and infrastructural frame work which biotechnology requires to make significant breakthroughs.

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CLIMATE VARIABILITY FOR SUSTAINABLE FOOD CROP PRODUCTION: IMPLICATIONS FOR AGRICULTURAL EXTENSION DELIVERY IN NIGERIA.

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Abstract

The relative decline in food crop production in Nigeria has been attributed largely to changing weather conditions. Scientists have indicated that global warming will place millions of people at greater risk of food and water shortages particularly in sub-Saharan Africa. Yet, the impact of changes in agro-climatic conditions on food crop production has received little attention in agricultural research in Nigeria. This study therefore examined the effect of agro-climatic variables on food crop production in Nigeria. Time Series data covering four decades (1965-2004) were obtained for output and prices of Tuber crops (yam, cassava and potato), from Food and Agricultural Organization and Central Bank of Nigeria. Agro-climatic variables (relative humidity, temperature, rainfall, sunshine, solar radiation, wind speed, and evaporation.) were obtained from Meteorological Centre, Nigeria. Data were analysed using descriptive statistics and Error Correction Model (ECM).There was a wide gap in minimal and maximal values of each of the agro-climatic variables, which affected crop output. ECM indicated that rainfall had significant effect on the output of all crops considered ($P<0.05$). Windspeed had significant effect on all the crop outputs ($P<0.05$) but had inverse relationship for yam and cassava outputs in the long run. Sunshine hour had significant effect on yam and cassava outputs. The coefficient of ECM was negative and significant ($P<0.01$) for all the crops, confirming the existence of long- run equilibrium relationship between the crops and the weather variables and also the presence of significant short-run dynamics. Agro-climatic variables significantly influenced the output of all the crops considered. The relationship between food crop output and agro-climatic variables if carefully monitored will increase total output of each of the crops considered. Hence the need for farmers' education and proper monitoring of climatic conditions in the country as this will help stabilize and sustain food crop production.

Keywords: Agro-climatic variables, Food crop outputs, sustainability, Error Correction Model.

INTRODUCTION

Planet earth is increasingly being consumed by unprecedented and dramatic changes in weather conditions. Global warming, El-Nino/ tsunamis and high powered hurricanes are becoming important and critical influences on human lives and soon will be on land economy, land use and eventually on food production. Scientists continue to show evidence that global warming will soon place millions of people at greater risk of food and water shortages particularly in sub-Saharan Africa. Climate change is rapidly emerging as one of the most serious threats that humanity will face. In recent times, there have been changes in the climate across the globe due to the effect of global warming arising from various human activities. Rosenzweig (2001) had predicted that "in a most fundamental way, climate change will bring change to agriculture wherever it is practiced." The highest damage from climate change, has however been predicted to be in the agricultural sector in sub-Saharan Africa

(Kurukulasuriya and Mendelsohn, 2008). Because it is linked so closely to natural resources and climate conditions, agriculture will keenly feel the effect of climate change through changes in both temperature and precipitation. Given Africa's high dependence on agriculture as highest provider of labour, the effect of climate change could put millions of people at risk of poverty and hunger. Africa is particularly vulnerable to climate change because of the high incidence of low-input, rain-fed agriculture, compared with Asia or Latin America.

The climatic changes attributable as they are to global warming and green house effects recorded in many parts of the globe including sub-Saharan Africa (SSA) suggest that a sustainable growth in agricultural production from an increasingly fragile ecosystem requires new and innovative management strategies. Although considerable progress has been made in evaluating the potential effects of climate change on global agriculture, significant uncertainties remain at regional levels and since existing evidence indicates that global effects are manageable, concern is increasingly shifting to regional effects (Reilly, 1999). This flows from the fact that the climate of an area is found to be highly correlated to the vegetation and by extension the type of crop in that area. The quality and character of weather are thus a central determinant of what can be produced, how it is produced, as well as the expectation of achievable results. For example, it has been observed that in spite of qualitative seed selection, subtle management and varietals selection, unusually bad weather can bring about significant output losses (Knerpp and McRae, 1999).

The effect of climate change on agricultural productivity demands greater attention given that agriculture is the single most important occupation and second largest export earner after petroleum in Nigeria. Because of Nigeria's heavy dependence on agriculture, the negative effects of climate change on productive croplands can impact directly on the welfare of the population and the economic development of the country (Mendelsohn and Dinar, 1999). Agriculture in sub-Saharan Africa, vis-à-vis Nigeria has been found to thrive under extreme heat and low precipitation and it relies on relatively basic tools and technologies (McCarthy et. al. 2001).

In spite of the above difficulties, the impact of changes in climatic conditions on agricultural production has received little attention and the development, testing and practical application of methods of agro-climatic analysis have not benefited much from priority areas in agricultural research in Nigeria. For example, relatively limited information is available on the effect of climate on agriculture, Mendelsohn and Dinar (1999) observed that most empirical works, whose results have been extrapolated world wide focused on the industrialized nations, thereby excluding developing nations that are more vulnerable in the face of changing climates. The situation is even more critical for Nigeria, which was excluded from a cooperative research effort among some African countries (Kurukulasuriya and Mendelsohn, 2008). The omission has created a big gap in the knowledge about climate change and its effect on agriculture in Nigeria and the significance for the validity of Africa results thus far.

Nigeria has a land area of 983 000 km^2 which is about 4 percent of the total land area of the sub-Saharan Africa. Nigeria had a CO_2 emission per unit of GDP of 0.9 as opposed to 0.6 for Sub-Saharan

Africa. (Little Green Data Book 2001). Furthermore, Nigeria is the most populous black nation with an estimated population of 140 million (Census, 2006); a fact considered critical to the African continent in the fight against poverty and food insecurity that might arise as a result of the negative impact changing climate may have on agricultural productivity. In the circumstance, there is need for a better understanding of the Nigerian situation.

Food shortages caused by natural and human- caused disasters continue to affect many countries in all regions of the world due to lack of knowledge and understanding of crops, its yield, vis-à-vis agro-climatic variables. Fluctuations in crop outputs over the years have been due mainly to fluctuations in weather and climate. To provide output stability therefore, there is the need for a study that would examine the effect of climate change on staple food crop production in Nigeria. Such a study would also provide a long-term forecast of these climatic factors to be able to predict what the trend in staple food crop production would be and consequently adaptability of agriculture to changing climatic conditions. This study intends to assess the trends in both agro-climatic variables and food crop outputs with a view to examining the effect of climate change on agricultural productivity and implications for agricultural extension delivery in Nigeria.

CONCEPTUAL FRAMEWORK/LITERATURE REVIEW

Conceptual Framework

Sustainable food crop production

There is a growing realization that the optimization of food production goes beyond the question of availability of improved production technologies (Oyekale 2000).It is observed that climate plays a vital role both directly and indirectly in crop growth, development and output and nearly every item of standard meteorological data has some relevance to crop production. It has also been observed that in spite of qualitative seed selection, subtle management and varietals selection, unusually bad weather will amount to significant output losses (Knerpp and Mc Rae, 1999).

Trend analysis in crop production has been known to have relevance for both microeconomic and macroeconomic decision making. At the farm level for example, the pattern of crop output and rainfall distribution can have important consequences on farmers' income and risk management. Considering an aggregate perspective, the growth of crop output and their variability have raminifications for food security programmes of a country, particularly for development of new technologies (Offut *et al.,*1987). For instance, the threat of increasing length of dry season in Nigeria and some other African countries have shifted the attention of agricultural development planners towards expanded irrigation networks while consideration is being given to the establishment of mini-dams for intensive crop production even in the rainfall belt of the country. One major attribute of agricultural production is that output varies from period to period mainly due to changes in policy, biophysical and socioeconomic and agro-climatic environments.

The alarming food deficit projected for sub-Saharan African from recent production figures make it mandatory that no effort be spared in reversing the trend of declining yield. Developing better understanding of such climate related constraints as inadequate or excessive rainfall, high levels of intensity storms, temperatures, evaporation demands and errodability of soils will result in measures that can overcome or mitigate these constraints to crop production and facilitate sustainability. Sustainability has been variously defined; Conway (1985) defines it as the ability of a system to maintain productivity even in the face of a major disturbance. Similarly Lynam and Herdt (1988), stated that a sustainable system must have non-negative trends in total factor productivity .At farm and village levels, the essential concern is that the production system should not collapse under pressure from adverse weather conditions in the foreseeable future .In other words, a sustainable agricultural production system is expected to be both productive and resilient.

A way of achieving sustainable agricultural development is to raise the productivity of the farms by optimizing efficiency within the limits of the existing resource base and available technology. The factor productivity growth of input-output relations and enterprise shows that small-scale farmers operate on the frontiers of the production function (Udoh and Akintola 2001).

Farrell (1957) developed the concept of technical efficiency based on input/output relationship. He suggested a method of measuring technical efficiency by estimating the production function of firms, which are fully efficient. However, according to Udoh and Akintola (2001), a farm is said to be technically inefficient when actual observed output from a given input mix is less than the maximum possible. Efficient use of various inputs, which could be agro-climatic variables, is an important part of sustainability [Harwood, 1987], which implies either fewer input to produce the same level of output or higher output at the same level of inputs.

Methodological Concept

Co integration and Error Correction Modeling (ECM)

In the last decade, co-integration methodology has become a widely used technique for the analysis of economic time series. It has assumed increased importance in analyses that purport to describe long-run or equilibrium relationship Goodwin and Schroeder (1991) and Alexander and Wyeth (1992) employed it to study market integration. Hallam *et al* (1992) used it to establish the determinants of land prices, while Adams (1992) applied the concept of co-integration to estimate the demand for money in Kenya. Other studies that have employed the concept include: estimating agricultural export supply in Cameroon (Tambi, 1999), cocoa export supply in Nigeria (Tijani, 1999) and Chete (1998) in estimating the determinants of direct investment in Nigeria. These studies validated theoretical and antidotal priors, and agreed to the fact that most time series variables are non-stationary at their level but attain stationarity at different levels of differencing, thus, questioning the predictive reliability on empirical results based on Ordinary Least Square (OLS) specification. The above inform our conviction in the application of co-integration and error correction specification as appropriate and plausible in modeling the effect of exogenous variables on sustainable food crops production in

Nigeria. A prerequisite of the ECM estimation is the determination of the characteristics of the time series variables in the model as to whether they are stationary or non-stationary. Co-integration theory Felix and Welch (1998), Goodwin and Schroeder (1991) examined the time series characteristics of data with a view to overcome the problems of spurious correlation often associated with nonstationary time series data and simultaneously generate long-run equilibrium relationship (Engle and Granger,1987). Co-integration means that time series variables [one, two or more] may be regarded as defining a long-run equilibrium relationship if they move closely together in the longrun, even though they may drift apart in the short-run. This long-run relationship is referred to as a co-integrating vector because there is a long-run relationship between the variables. Regression containing all the variables of a co-integration vector will have a stationary error term, even if none of the variables, taken alone is stationary (Campbell and Shiller (1988).

The use of ECM is facilitated when variables are first differenced stationary and co-integrated. An equilibrium relationship exists when variables in the model are co-integrated. A necessary condition for the integration, however, is that the data series for each variable involved exhibit similar statistical properties, that is, be integrated to the same order with evidence of some linear combination of the integrated series. A variable is integrated of order I (0) when it is stationary in level form. A stationary series Xt for example has a mean, variance and autocorrelation that are constant over time (Tambi, 1999). However, most economic series tend to exhibit non-stationary stochastic processes of the form.

$$X1 = \alpha + \beta Xt\text{-}1 + et$$

Where;

α = constant drift

β = regression coefficient and is equal to 1,

et = an error term.

If et has zero mean, constant variance and zero covariance, then Xt is a random walk and said to be integrated of order I(1). Then series Xt is integrated because it is sum of its base value X0 and the differences in X up to time t. Since β is unity, X is said to have unit root. If Xt is non-stationary, the variances may become infinite and any stochastic shock may not return to a proper mean level. As shown by Engle and Granger (1987), such a non-stationary series has no error-correction representation. A non-stationary series requires differencing to become stationary. Xt is integrated of order Dx or Xt ~ I (Dx) if it is differenced Dx times to achieve stationary. Engle and Granger (1987) provide appropriate tests for stationary of the individual series as the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics. These tests are based on t-statistics on δ obtained from estimates of the following OLS regression applied to each of the series.

$\Delta X\text{t} = \alpha + \delta X\ \text{t-1} + e\text{t}$ *(for the DF test)*

$\Delta X\text{t} = \alpha + \delta X\ \text{t-1} + \Sigma t\text{-}1$

$k\ \beta\Delta X\ t\text{-}1\ 1 + e\text{t}$ (for the ADF test)

Where the lag length k chosen for ADF ensures that et is empirical white noise. The null hypothesis holds that X is I(1) as against the alternative being I(0). The null hypothesis is rejected if the statistics on δ is negative and statistically significant when compared to appropriate critical values established for stationary tests. These critical values have been established for stationary by a number of studies from Monte Carlo simulations (Fuller. 1976; Dickey and Fuller. 1981; Engle and Granger, 1987). Most of the critical values are appropriate or large samples.

Once the stationary properties of the individual series are established, linear combinations of the integrated series are tested for co-integration. If a set of these series (e.g Xt ~ I (Dx), Yt ~ I (Dy) and Zt ~ I(D2) are integrated of the same order I(P), then they form a co-integrating set. Should a linear combination of individual non-stationary series produce a stationary data series, then the variables are co-integrated and unless they co-integrate, they cannot describe equilibrium relationships. If they do not co-integrate, regression of one I(1) variable to another become spurious. As shown by Granger and Newbold (1974) such regressions produce high coefficients of determination and t-ratio that are biased towards rejecting the null hypothesis of no relationship between the variables Estimates obtained from linear combination of individual series that are properly co-integrated are reliable and consistent and are fit for describing the steady-state relationships Studies on co-integration methodology along with tests for evaluating the co-integration properties of a pair of non-stationary series include Engle and Granger (1987), Johansen (1988) and Juselius (1990).

Johansen (1988) and Juselius (1990) presented a co-integration estimation methodology that overcomes most of the problems of the two-step approach. This is based on maximum likelihood estimates of all the co-integrating vectors in a given set of variables and provides two likelihood ratio tests for the number of co-integrating vectors. The risks associated with climate change lie in the interaction of several systems with many variables that must be collectively considered. Agriculture (including crop agriculture, animal husbandry, forestry and fisheries) can be defined as one of the systems, and climate the other (Sombroek and Gommes, 1995). If these systems are treated independently, this would lead to an approach which is too fragmentary. The issue is more global. It is now held as likely that human activities can affect climate, one of the components of the environment. Climate in turn affects agriculture, the source of all food consumed by human beings and domestic animals. It must be further considered that not only climate may be changing, but that human societies and agriculture develop trends and constraints of their own which climate change impact studies must take into consideration.

Literature Review

Climate constitutes a complex of inter-related variables. On average, through a set of regulatory mechanisms, a smooth change in one variable triggers smooth changes in others. With the exception of possible qualitative and abrupt variations, which will be mentioned below, such inter-relations are independent of atmospheric carbon dioxide (CO_2). The latter and other greenhouse gases play a part largely through their effect on the radiation balance of the atmosphere. There is only a weak link between such factors as cloudiness and wind. Temperature, evaporation and rain are strongly correlated. Combined with the projected pressure on land and water use, competition for land and water will certainly become a key social and political issue. Climate variability, therefore, is likely to increase under global warming both in absolute and in relative terms. The rate of change itself is extremely important. Agro-climatic variables have been considered to be of great importance in food crop production, given that all crops and livestock have specific climate or weather required for their survival. Climates are those environmental factors which interact and affect cultivated plant and livestock (Mcmtosh, 1963).The climate of a place is the average weather condition over a long period of time say 35 years. Weather however is described as the real atmospheric conditions experienced in a particular time Ettson (1986). Climate is often associated with the type and geographical extent in which crops can be grown. Weather is however associated with variation in output at particular times. Characterizing climatic conditions are fixed and known ranges of thermal, light and moisture conditions determining animal and plant life. Weather conditions reflect variations in these parameters. Climate and weather can be proclaimed as the most important determinant factors both for plant growth and crop productivity. They both influence most of the processes such as solar radiation which is responsible for energy required for soil warmth, air for metabolic activities, rainfall and its characteristics in terms of amount, distribution and intensity for dilution of soil nutrients which determine quality and quantity of crop production. Also, Oguntoyibo *et al*, 1983) revealed that on an annual basis in Nigeria, there is a general increase in the sunshine hours from the Atlantic to the interior and ranging from a minimum of 1300 hours in the Niger Delta to over 3200 hours in the extreme North-East. The rate of increase is however not constant. Akoroda (1998) has observed that the maximum possible hour of sunshine in a location is very important in determining the amount of photosynthesis that can occur in a growing crop this is referred to as photoperiod. It varies slightly away from the expected 12 hours a day and 12 hours dark period. The variation may be small but it is this small variation that affects crops to the extent that some will flower and others would not except the required amount of photoperiod is available. This confirms the statement made by Wittier (1995) that photoperiod or the length of daylight, while relating to location perhaps more than one climate, has a significant impact on the responses of many, if not all the crops. From the foregoing, there is therefore no gainsaying the fact climate variability directly or indirectly affect food crop production hence the need for the study.

RESEARCH METHODOLOGY

Study Area

The study was carried out in Nigeria. It covered all the ecological regions and agriculturally cultivable land zones in the country. Nigeria is divided into six main ecological zones. This ecological zoning is based on agro-climate variation, which is latitudinal across the country spanning the humid through the sub-humid to the semi-arid zones as one proceeds from the south to the north. The climate is equatorial and semi-equatorial in nature. There are two seasons in Nigeria, the wet (rainy) and the dry (harmattan). The wet season lasts from April to October while the dry season lasts from November to March. The wet and dry seasons are associated with the prevalence of the moist tropical air mass from the Atlantic in the northwest and dry tropical continental air mass from the Sahara in the north. During the year, the boundary between these two air masses, the inter tropical discontinuity (ITD) is gradually pushed to the north and reaches its northernmost position between latitude 19^oN- 20^oN in early September.

Rainfall varies widely over short distances and from year to year. Niger Delta, where the rainy season is year round, receives more than 4,000mm (160in) of rain each year. Most of the county's middle belt, where the rainy season starts in April or May and runs through September or October receives from 1,000 to 1,500mm (40 to 60in) within this region. The Jos plateau receives somewhat more rain due to its higher elevation. In the dry savanna regions, rainfall is especially variable over distance and time. The regions along Nigeria's northeastern border receives less than 500mm (20in) of rain per year, and the rainy season lasts barely three months. Temperatures are high throughout the year, averaging from 25oc to 28oc. In the higher elevations of the Jos plateau temperatures average 22^oC.

Sources and Methods of Data Collection

Secondary data were used. Data were collected from the Department of Meteorological Services, the National Bureau of Statistics, Central Bank of Nigeria statistical bulletins and FAOSTAT.

Data were collected on:

(i) Annual outputs of three tuber crops

(ii) Average temperature, rainfall, wind speed, radiation, sunshine hours, evaporation and relative humidity during the growing periods of each of the crops (1965- 2004)

Analytical Techniques

A number of analytical tools were employed in the study and these include;

Descriptive Statistics: This involves the use of tables, averages and frequencies.

Growth rate: These were used to describe the trend in food crop production and agro-climatic variables over the study period and to predict future values of food crops.

Growth Rate: $$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}}$$

Where:

Y_{it} = crop yield in year t

Y_{it-1} = crop yield in the previous year (i.e year t -1)

Co-integration and Error Correction Model: Error Correction Modeling (ECM): In order to achieve long-run equilibrium relationship the second step of Dickey-Fuller (Augmented Dickey-Fuller – ADF) was applied. Residuals from equilibrium co-integrating regressions were used as an error correcting regressor (Ec+1, lagged one period) in a dynamic model (Chete, 1998) as shown in the equation below:

$$\Delta Xt = \alpha 0 + \alpha 1Yt\text{-}1 + \alpha 2ut\text{-}1 + et$$

Where;

$Yt-1$ = one period lagged independent variable

$ut-1$ = one period lagged value from residual (i.e. ect-1)

Regression analysis based on co-integration and error correction modeling was used to determine the long run equilibrium relationship between agro-climatic variables and food crops outputs in Nigeria. The general form of the model is specified as follows:

$$\Delta Yt=Xo+X1\Delta X1t-1+X2\Delta X2t-1+X3\Delta X3t-1+X4\Delta X4t-1+X5\Delta X5t-1+X6\Delta X6t-1+X7\Delta X7t-1 +ecmt-1 + \mu$$

Where;

Yt = Average output of crop i in year t (million metric tones)

X1t = Total rainfall during the growing period in year t (mm)

X2t = Average temperature during the growing period in year t (oC)

X3t =Average relative humidity during the growing period in year t (%)

X4t = Average solar radiation during the growing period in year t (Mj/m2/day)

X5t =Average windspeed during the growing period in year t (kl/hr)

X6t = Average sunshine during the growing period in year t (hr)

X7t = Evaporation during the growing period in year t (mm)

ecmt-1 = Regressor to capture the short-run dynamics

μ = Error term

In analyzing the data, an Econometric View package (E-View) was used. Augmented Dickey Fuller (ADF) statistics was used to test for stationarity for both individual time series and residuals from Ordinary Least Square regressions.

RESULTS AND DISCUSSION

Figure 1 shows there is a wide gap in minimal and maximal values of all agro climatic variables. The pattern of trend over the observed periods showed fluctuations in the mean values, which indicated instability.This has a lot of implications for crop yields and could be responsible for the high incidence of pest especially in the Southern Nigeria and cloud cover as a result of harmattan dust in the North. These invariable leads to reduction in the rate of photosynthesis and low yields in crops.

Table 1 show that cassava production had the highest production values while potato had the lowest. The low production values of potato could be as a result of the limitation in the area of production. Cassava is grown all over Nigeria and would thrive in any area with limited supply of rainfall and could also be grown all year round. However, potato could only be grown in very few parts of Nigeria where conditions are favourable for its production and it is also seasonal.The growth rates in all the crops considered except potato were positive. However, they all indicate positive trends which show the adaptability of each of the crops to its production zones the negative growth rate indicates that any innovation and/or improvements in the technology of production of potato have not resulted in any dramatically significant increase in outputs.

Table 2 shows the result of co-integration tests for tuber crops. Most of the variables were non stationary [{1}] at their levels but attained stationarity at their first levels of difference and/or second levels of difference, the variables can then be determined directly as to whether or not they are co-integrated. The results using Johansen test are presented for the dependent variables. The table revealed that the different food crops had varying numbers of co-integrating vectors. This is an indication that there was a long-run relationship between the dependent variables and the weather variables.

Table 3 revealed that relative humidity, rainfall, sunshine and windspeed are all significant weather variables for cassava yield, significant at10% except windspeed which is at 1%. Also the coefficient of windspeed is negative indicating an inverse relationship. Windspeed, evaporation, relative humidity, sunshine and rainfall are the significant weather variables for yam yield. They are significant at 10%, 5% and 10% respectively. However windspeed and relative humidity both have negative coefficients which suggest an inverse relationship. Windspeed, relative humidity and rainfall were significant at 1%, 5% and 10% levels respectively for potato yield. Population growth and acreage expansion were highly significant in the yield of all the crops. All other variables are not significant. The error correction (ECM) variable was rightly signed (negative sign) and highly significant for all the crops. This is an indication of the existence of long-run equilibrium relationship between the yield of each crop and the weather variables

CONCLUSION AND RECOMMENDATIONS

The observations registered by this study is that average outputs of all crops covered could be increased if the relationship between yield and ideal weather conditions is better understood and built into agricultural policies.

A number of areas of action recommend themselves and will include among others:

- Establishment of agro-climatic data centres
- Early warning system
- Improvement in farmers' decision making process (resource allocation etc)
- Insurance/protection against flood/drought, Weather-Crop failure
- Storage strategies
- Credit, price support & price stabilization.
- Extension agencies should be informed.

In line with the above, it is therefore recommended that:

(i) A national record of movements and trends in agro-climatic variables and crop outputs should be established for continued collection, analysis and timely dissemination of data (to farmers).

(ii) Control/management measures for these agro climatic variables are necessary for ideal crop outputs since there is a wide gap in minimal and maximal values of all agro climatic variables.

(iii) Appropriate relevant policies (such as flood, drought yield insurance and extension) should be applied for sustaining and improving the growth rates of those crops with positive growth rates such as yam and cassava.

(iv) It is necessary that particular attention be paid to the multi ranged climatic template of Nigerian agriculture for creating and managing sustainable food production and security.

(v) Agricultural extension agencies should include information on climate change in their education to farmers.

(vi) Agricultural extension agencies should develop new calendar of work for arable crop farmers, based on change in climate for sustainable and profitable agricultural production.

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STRATEGIC FEEDING OF WEST AFRICAN DWARF (WAD) SHEEP WITH FAT – SUPPLEMENTED CONCENTRATE DIETS AS MEANS OF REDUCING NITROGEN EMISSION

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Abstract

The possibility of reducing livestock green house gas emission was studied using nine growing West African Dwarf sheep to investigate the effect of fat supplementation on the digestibility and nitrogen utilization of a typical ruminant concentrate diet. Sheep were allotted to diets containing two fat sources at the inclusion rate of 50g/kg in a completely randomized design. Three concentrate diets were formulated to include supplementation with fat source as Diets A (concentrate with coconut oil) and B (concentrate with palm kernel oil) while Diet C is the control (concentrate without any fat supplementation). Highest ($P < 0.05$) dry matter digestibility (66.97 g/100g DM) was observed for sheep fed concentrate with coconut oil supplementation (diet A) followed by sheep on diet B (63.78g/100g DM)while sheep on concentrate diet without fat supplementation (diet C) recorded the least value of 59.93 g/100g DM. Values for Digestible Nitrogen ranged ($P < 0.05$) from 9.52 g/day in diet C to 12.63g/day in diet A. Nitrogen utilization was best ($P < 0.05$) in sheep on diet A, having 62.53 % retention, followed by 58.14 % in diet B and least for sheep on diet C with 46.39 %. Strategic supplementation with coconut and palm kernel oils may mitigate greenhouse effect by reducing nitrogen emission.

Keywords: Concentrate diets, Dry matter digestibility, Fat sources, Green house effect, Nitrogen digestibility.

INTRODUCTION

The earth is currently facing a period of rapid warming brought on by rising levels of heat-trapping gases, known as greenhouse gases, in the atmosphere. Greenhouse gases (GHGs) occur naturally, and without them the planet would be too cold to sustain life as we know it, but since the beginning of the Industrial Revolution in the mid-1700s, human activities have added more and more of these gases into the atmosphere (Mastrandrea and Schneider, 2009) therefore resulting in a thickening blanket of these gases covering the atmosphere and trapping more heat. Of the GHGs, carbon dioxide, methane and nitrous oxide are the most critical and their contributions from agricultural systems are significant enough to attract attention.

Agriculture remains the most important sector in the economies of most non-oil exporting African countries as it constitutes approximately 30% of Africa's GDP and contributes about 50% of the total export value, with 70% of the continent's population depending on the sector for their livelihood (CEEPA, 2002). Ruminant livestock systems are a significant source of GHGs. Methane (CH_4) and nitrous oxide (N_2O) are potential greenhouse gases produced from animal production system. Methane emission from ruminants account for about 16% of total methane emission from the earth and nitrous oxide emission from animal waste is 6% of total nitrous oxide emission (IPCC, 1995). The major impact of ruminant livestock contribution to global warming has largely been viewed from the perspective of methane production, but nitrous oxide emission, which is an indirect product of their manure, still portends serious implication especially as nitrous oxide has a global warming potential of about 300 times that of carbon dioxide while that of methane is just about 30 times more than the same amount of carbon dioxide and more so that the concentration of nitrous oxide in the atmosphere has reportedly increased by 18 percent over preindustrial levels (Spedding, 2009; Mastrandrea and Schneider, 2009).

Nitrous oxide emissions associated with agricultural management, and ruminant production in particular, can be linked to nitrogen inputs and recycled dietary nitrogen and the major factor determining total N excretion as manure (faeces and urine) has been linked to total dietary N intake (Castillo *et al*., 2000; Yan *et al*., 2006). Various nutritional strategies aimed at manipulating ruminant dietary nitrogen and nitrogenous compounds towards improved utilization and efficiency would therefore go a long way in mitigating the impact of the ruminant livestock production on the environment. It has been reported by some authors that nutritional management of ruminants for improved utilization of absorbed nitrogenous compounds will reduce not only the amount of manure N excreted, but also the portion excreted as more volatile urinary urea N (Frank *et al*., 2002; Reynolds and Kristensen, 2008). Sutton *et al*. (1983) reported that a supplementation of linseed or coconut oil did not alter apparent total tract N digestibility but rather increased the efficiency of rumen microbial protein synthesis despite suppressing ruminal organic matter and fibre digestion.

Coconut oil has been reported to influence nitrogen utilization in sheep (Machmüller *et al*., 2006). About 64% of coconut oil consists of medium chain fatty acids, containing 8, 10, or 12 carbons (Armstrong, 2005). Information on the use of palm kernel oil as fat supplement for ruminant feed is scarce. Palm-kernel oil has been reported to resemble coconut oil in its physical content (Redmond, 2008).Coconut and palm kernel oils were reported to contain same levels of energy (3607 KJ) and total lipids (100) per 100g edible portion (USDA, 2004) and similar fatty acid compositions with the major difference being in their oleic acid composition where coconut oil has 6g /100g and palm kernel oil has 15g /100g (Zamora, 2005).

The objective of the present study was to assess the effect of palm kernel oil in the feed of WAD sheep, as substitute or complement to coconut oil, being a possible nutritional management strategy in reducing nitrogen emission.

MATERIALS AND METHODS

Nine growing WAD sheep with a mean weight of 10.33 ± 0.33 kg were subjected to three dietary treatments in a completely randomized design. Diet A contains Coconut oil – supplemented concentrate, while Diet B contains Palm kernel oil – supplemented concentrate and Diet C contains concentrate without any fat supplementation. Feeding of the animals was done at 5% body weight, comprising 2% Concentrate feed and 3% *Panicum maximum* (basal diet). Sheep were adapted for a 14 – day period before the commencement of the experiment, to enable the animals adjust to the new diet. The animals were housed in separate wooden metabolic cages of 60 × 12 cm^2 dimension. Coconut and palm kernel oils were included in the concentrate diet at 50g/ kg. The duration of the experiment was 14 days. Parameters measured during the feeding trial included feed intake, faecal and urine outputs.

Collection of refusals was done 24 hours after feeding and faecal and urine samples collection was done every morning before feeding, from where representative samples were taken and stored in the refrigerator until the end of the experiment for laboratory analysis. Faecal samples were dried to constant weights in a force – draught oven, at 60ºC for 96 hours. At the end of the study, proximate analysis of the samples was carried out according to the procedure of AOAC (2000). Fibre analysis was done using the method of Van Soest *et al*. (1991) as modified by Nahm (1992).

Digestibility values were obtained by the difference in the Total feed intake and Faecal output divided by the Total feed intake. Nitrogen balance was obtained by subtracting the values of Faecal nitrogen and Urinary nitrogen from the Nitrogen intake, while Nitrogen retention was obtained by dividing Nitrogen balance by Nitrogen intake.

All data generated were subjected to a one –way classification method of SAS (2007), using Duncan's New Multiple Range test of the same package to determine the level of significance.

RESULTS AND DISCUSSION

The gross composition of the concentrate diets is shown in Table 1. All ingredient items for the three diets were similar except for the inclusion of fat sources in Diets A and B which made the wheat offal content of Diet C to increase by almost 17%. The Wheat offal increase was expected to make up for the assumed upsurge in the energy content of Diets A and B due to the fat supplementation (USDA, 2004; Zamora 2005; Redmond, 2008) but the chemical analysis of the diets' composition (Table 2) showed Diet C to contain the least ($P < 0.05$) ether extract of 3.1% although the difference between the ether extract values of Diets B and C was not significant ($P > 0.05$). Expectedly, the fat supplementation did not alter ($P > 0.05$) the protein content of the three diets significantly.

Table 1: Gross composition (g/ 100g) of the concentrate diets

Feed ingredients	Diet A	Diet B	Diet C
Maize	10.00	10.00	10.00
Soybean joff	24.75	24.75	24.75
Wheat offal	30.00	30.00	35.00
Brewers'dry grain	20.00	20.00	20.00
Coconut oil	5.00	-	-
Palm kernel oil	-	5.00	-
Cassava peel	10.00	10.00	10.00
Salt	0.25	0.25	0.25

Diet A = Coconut oil supplementation; Diet B = palm kernel oil supplementation; Diet C = No oil supplementation

Table 2: Chemical composition (g/ 100 g) of the concentrate diets

Parameter	Diet A	Diet B	Diet C	SEM
Dry matter	73.62b	73.99b	86.61a	2.14
Crude protein	23.01a	22.87a	22.58a	0.26
Ether extract	3.80a	3.34b	3.10b	0.11
Ash	14.39b	12.51c	18.55a	0.90
NDF	41.95c	46.79a	43.42b	0.73
ADF	16.69b	20.90a	15.32c	0.85

Diet A = Coconut oil supplementation; Diet B = palm kernel oil supplementation; Diet C = No oil supplementation

Inclusion of the fat sources was observed to influence the dietary consumption of the sheep as reflected in their total feed intake (Table 3). The reason for this increased intake could be deduced from the physical appearance as well as the fat composition of the fat – supplemented diets (Zamora, 2005; Redmond, 2008). Addition of the oils conferred a distinct aromatic influence on diets A and B which could be said to have stimulated the sheep appetite to consume more feed than their counterpart on Diet C. The total feed intake of the animals on diets A and B were similar ($P > 0.05$) notwithstanding the slight variation in their grass intake.

Sheep on the fat – supplemented diets recorded better ($P < 0.05$) digestibility values compared to the concentrate diet without any fat supplementation (Diet C) but of the two fat sources, diet A containing coconut oil was better (66.97 g/100g DM). The better digestibility of the fat – supplemented diets might be as a result of their fatty acid composition which are mostly Medium chain (MCFAs) and these have been reportedly to be rapidly metabolized on consumption (Armstrong, 2005; Zamora, 2005) while the difference in the digestibility of Diets A and B could only be traced to their Oleic acid contents, which is a monounsaturated fat.

Table 3: Digestibility of the concentrate diets by WAD sheep

Parameter	Diet A	Diet B	Diet C	SEM
Concentrate intake (g/day)	248.89a	245.14a	231.67b	2.66
Grass intake (g/day)	362.94b	367.22a	295.70c	11.59
Total feed intake (g/day)	611.83a	612.36a	527.37b	14.13
Faecal output (g/day)	202.09c	221.80a	211.31b	2.89
Urine output (ml/day)	244.00b	261.07ab	279.43a	5.63
Digestibility (g/100g DM)	66.97a	63.78b	59.93c	1.03

Diet A = Coconut oil supplementation; Diet B = palm kernel oil supplementation; Diet C = No oil supplementation

Table 4: Nitrogen utilization of the concentrate diets WAD sheep fed

Parameter	Diet A	Diet B	Diet C	SEM
Concentrate Nitrogen intake (g/day)	9.16a	8.97a	8.36b	0.26
Grass Nitrogen intake (g/day)	6.24a	6.32a	5.09b	0.29
Total Nitrogen intake (g/day)	15.40a	15.29a	13.62b	0.30
Urinary nitrogen (g/day)	2.73b	2.27c	3.18a	0.13
Faecal nitrogen (g/day)	3.04b	4.12a	3.93a	0.17
Digestible Nitrogen (g/day)	12.63a	11.17b	9.52c	0.45
Nitrogen balance (g/day)	9.63a	8.89b	6.24c	0.52
Nitrogen utilization (%)	62.53a	58.14b	46.39c	2.41

Diet A = Coconut oil supplementation; Diet B = palm kernel oil supplementation; Diet C = No oil supplementation

Table 4 presents the result of the nitrogen utilization of the concentrate diets by the WAD sheep. Nitrogen intakes of the animals on fat – supplemented diets (Diets A and B) were higher than those on Diet C. Urinary and Faecal nitrogen outputs were least ($P < 0.05$) in animals on Diet A (2.73 g/day and 3.04 g/day respectively). Digestible nitrogen increased ($P < 0.05$) from 9.52 g/day in Diet C to 12.63 g/day. Nitrogen balance and Nitrogen utilization followed similar pattern, being least in Diet C and highest in Diet A.

Result of the present study was contrary to the earlier report on fat supplementation that suggested fat to be associated with a reduction in ruminal fibre degradation and sometimes organic matter degradation due to the fact that fat is not fermentable (Macmüller *et al*., 1998; Fievez *et al*., 2003) but Armstrong (2005) had reported that Medium chain fatty acids are largely broken down by saliva upon ingestion. Coconut oil and Palm kernel oil are mostly made of MCFAs. The better nitrogen utilization of the fat – supplemented diets also agreed with the work of Sutton *et al*., (1983) who reported a supplementation of linseed and coconut oil to increase the efficiency of rumen microbial protein synthesis.

The better results obtained for the coconut oil – supplemented diet may be as a result of their unsaturated: saturated fatty acid ratio which is 0.1 in coconut oil and 0.2 palm kernel oil (Zamora, 2005).

CONCLUSION

The present study compares the effect of palm kernel oil to that of coconut oil in reducing nitrogen emission in the context of faecal and urine output, while as well influencing the feed intake of WAD sheep. Fat supplementation in the feed of the WAD sheep improved the digestibility of the animal's feed and also nitrogen utilization by the WAD sheep feed. Inclusion of coconut oil in the concentrate of the WAD sheep resulted in better performance than palm kernel oil.

Improved nitrogen utilization translates to a reduction in nitrogen emission which would slow down the rate of nitrous oxide build up, thus resulting in the mitigation of greenhouse gases.

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GENETIC FINGERPRINTING OF NIGERIAN POPULATION OF *XANTHOMONAS AXONOPODIS* PV *MANIHOTIS* USING AMPLIFIED FRAGMENT LENGTH POLYMORPHISM

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Abstract

Xanthomonas axonopodis pv *manihotis* (*Xam*) is the causal agent of cassava bacterial blight (CBB) in all cassava growing areas of the world. To develop an efficient disease management strategy, the genetic diversity of the pathogen's population ought to be known. Information is scarce on the genetic diversity of *Xanthomonas axonopodis* pv *manihotis* population in Nigeria.

We characterized the bacterial population in Nigeria with Amplified Fragment Length Polymophism. A total of 74 bacterial strains were characterized which include sixty eight (68) *Xanthomonas axonopodis* pv *manihotis* (*Xam*), four (4) *Xanthomonas axonopodis* pv *cassavae* (*Xac*, a yellow variant of the bacteria) and two (2) reference strains of *Xanthomonas campestris* pv *malvacearum.* The results obtained showed a significant variation in the pathogen population structure with this molecular marker technique. Ten clusters were identified at 60% similarity coefficient on the dendrogram separating the yellow variants from the non-pigmented strains. The Principal Component Analysis results grouped the bacterial population into 5 clusters, separating the yellow variant also in cluster 4. The diversities observed were not regionally influence or agro-ecologically determined. The diversity observed in this study revealed the secret behind the usual breakdown of resistant to CBB in suggested resistant cassava cultivars. Therefore, monitoring the bacterial population through regular diagnostic surveys of all ecological zones in the country is proposed for effective surveillance of the disease for proper control measures.

Keywords: Genetic diversity, DNA, Agro-ecological zones, AFLP and bacteria

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a major staple food for more than 500 million people living in Africa, South America, and Asia. Sub-Saharan Africa is the largest cassava producer in the world with over 82 million tonnes /annum (Fauquet and Fargette, 1990; FAO, 1996). Cassava is important in the world yet a major biotic constraint to its production is cassava bacterial blight caused by *Xanthomonas axonopodis* pv *manihotis*. It is estimated that the disease can cause 80% losses in root and aerial products of the plant in susceptible varieties (Dixon *et al.*, 2002 Lozano, 1986).

The characterization of pathovars of *X. campestris* is currently based on host and symptom specificity and remains difficult, particularly when the host plant of a *Xanthomonas* is not known and also with the non-pathogenic *Xanthomonas*, which occur epiphytically on healthy or diseased plants (Hilderbrand *et al.*, 1990; Vauterin *et al.*, 1990; Ogunjobi 2005). An illustration is given by the Xanthomonadin-producing strains of *X. campestris* that have been isolated from cassava leaves in Colombia. On the basis of different analyses, these Colombian isolates were found to be related to *X.*

campestris pv *cassavae* (Elango *et al.*, 1981), *X. campestris* pv *manihotis* (Kimura and Dianese, 1983; Dos Santos and Dianese, 1985) and *X. campestris* pv *peinsethicola* (Van den Mooter *et al*., 1987).

In the past decade, various methods have been developed for the identification and typing of prokaryotic and eukaryotic organisms at the DNA level. These methods differ in their taxonomic range, discriminatory power, reproducibility, and ease of interpretation and standardization (Maslow *et al*., 1993; Van Belkum, 1994; Morel, 1997). Molecular approaches based on DNA polymorphisms have been developed for the taxonomic study of plant-pathogenic bacteria. Rapid methods based on specific PCR amplification have been used recently for the detection and identification of *Xanthomonas* species (Pan *et al.,* 1997). Restriction Fragment Length Polymorphism (RFLP) analysis is a highly discriminative method currently used to describe the pathogen population structure (Verdier *et al.,* 1994). Different probes could be used to detect and differentiate restriction polymorphisms in the pathogen genome. Also, rRNA genes have highly conserved sequences, and their potential usefulness in the identification and phylogenetic studies of bacteria has been demonstrated (Grimont *et al.*, 1989; Berthier *et al.*, 1993). Specific sequences from genomic or plasmid DNA, such as repetitive elements and insertion sequences have provided useful probes for the assessment of genetic diversity and also allowed a better understanding of the pathogen population structure (Gabriel *et al.*, 1988; Cook *et al.*, 1991; Qhobela and Clafflin, 1992; Berthier *et al.*, 1994). Both ribotyping and RFLP analysis with the use of different DNA probes have facilitated the study of the population structure of *X. campestris* pv *manihotis* (Verdier *et al.*, 1993). However, recent genetic diversity of *X. campestris* pv *manihotis* was mainly characterized by RFLP analysis, using the pathogenicity gene (pth B) as the RFLP probe (Restrepo and Verdier, 1997; Verdier *et al.*, 1993). This technique is more precise and discriminative than those of RFLP analyses using genomic probes (pBS6 and pBS8) or ribotyping (Verdier *et al.*, 1993; Restrepo and Verdier, 1997).

The genetic variability studies on *X. campestris* pv *manihotis* with RFLP revealed that the African strains are homogeneous whereas in South America the pathogen is highly diverse (Verdier *et al.*, 1994). This is to be expected since the *manihot* genus originates from South and Central America where the centers of diversity are in Brazil and Mexico (Rogers and Appan, 1973). Nevertheless, recent RFLP analysis of African strains with a plasmid probe (pth B) did distinguish different haplotypes (Assigbetsé *et al.*, 1998). The appearance of new RFLP types of *X. campestris* pv *manihotis* in Africa may explain the observed breakdown of resistance in some improved cassava cultivars (Assigbetsé *et al.*, 1998). Moreover, the sequence with which the pathogenicity gene (pth B) hybridizes has the major disadvantage of representing a minute portion of the genome containing genes that are subject to strong natural selection (Leung *et al.*, 1993). To avoid possible bias, the population structure should be inferred from neutral markers that are distributed randomly throughout the genome (Janssen and Dijkshoorn, 1996). The ideal genotyping method produces results that are invariable from laboratory to laboratory and allows unambiguous comparative analyses and the establishment of reliable databases.

One of the newest and most promising methods is Amplified Fragment Length Polymorphism (AFLP) analysis (Vos *et al.*, 1995), developed by Keygene BV, Wageningen, The Netherlands. This method combines universal applicability with high powers of discrimination and reproducibility (Janssen *et al.,* 1996). An increasing number of reports describe the use of AFLP analysis for plant and animal genetic mapping, medical diagnostics, phylogenetic studies, and microbial typing.

Amplified Fragment Length Polymorphism (AFLP) is a recently developed technique for the fingerprinting of plant, bacterial, fungal and nematode genomes (O'Neil *et al.*, 1997; Folskerstma *et al.*, 1996; Lin *et al.*, 1996; Vos *et al.*, 1995). The advantages of this technique in characterising a microbial population are the extensive coverage of the genome under study (Jansen *et al.*, 1996) and the fact that the complexity of the AFLP fingerprint can be advantageously managed by adding selective bases to the primers during PCR amplifications (Vos *et al.*, 1995). For the bacterial genome, the AFLP method has been evaluated in microbial taxonomy (Vaneechoutte, 1996), in diversity studies of human pathogenic bacteria (Picardeau *et al.*, 1997), and in characterising plant pathogenic bacteria at the pathovar level (Bragard *et al.*, 1997). Janssen *et al.* (1996) also demonstrated the high resolution of AFLP in characterising bacterial strains at the sub-generic level. However, until now, only a few molecular analyses have been conducted on this species of *Xanthomonas* in Africa. Restriction Fragment Length Polymorphism (RFLP) and Random Amplified Polymorphic DNA (RAPD) were used to evaluate the genetic diversity among *Xanthomonas axonopodis* pv *manihotis* from Africa (Assigbetsé *et al.*, 1998). Amplified Fragment Length Polymorphism has not been applied to the African population of *Xam* and the genetic variability of the Nigerian population of the causal agent of cassava bacterial blight has not been studied extensively.

We know that a durable resistance-breeding program requires that the pathogen's population structure should be well known. To verify the genetic homogeneity of the African population, we needed a molecular technique that can detect smaller sequence variations than the RFLP technique. This study thus focuses on characterising *Xanthomonas axonopodis* pv *manihotis* population from Nigeria, the largest cassava producing country globally (FAO, 2000), with AFLP.

MATERIALS AND METHODS

Bacterial Strains and DNA Isolation: All the *X. axonopodis* strains were obtained from the diseased plants in the survey of all agro-ecological zones of Nigeria conducted in the year 2000 (Ogunjobi *et al*., 2001). Two reference strains from the German Collection of Microorganisms and Cell Cultures (DSMZ) were also included. The bacteria were cultured on yeast extract dextrose peptone agar (YDPA) containing 5g yeast extract, 10g dextrose, 5g peptone and 15g agar per litre of distilled water (pH 7.2).

A total of 74 bacterial strains were characterized which included sixty eight (68) *Xanthomonas axonopodis* pv manihotis (*Xam*), four (4) *Xanthomonas axonopodis* pv cassavae (*Xac*, a yellow variant of the bacteria), and two (2) reference strains of *Xanthomonas campestris* pv *malvacearum.* The bacteria were cultured and maintained on yeast extract dextrose peptone agar (YDPA) containing 5g yeast extract, 10g dextrose, 5g peptone, and 15g agar / L of distilled water (pH 7.2).

Extraction of genomic DNA of bacteria: The cells of the bacteria were harvested from 1.5ml of a suspension of cells by low speed centrifugation at 1200xg for 2 min. The pellet was washed in 1ml of 5M NaCl and once in 1ml TE buffer (10mM Tris-HCl, 1mM EDTA (pH8)). Genomic DNA was extracted by the method of Sambrook *et al.* (1989) The DNA quality was checked on agarose and quantified with DNA fluorometer (model TD-700).

Polymerase Chain Reaction (PCR) amplification: All PCR reactions were performed in a total volume of 25µ using 20-50 ng DNA.

The Genomic DNA was quantified and diluted to 50ng/µl. The AFLP marker was assayed as previously described by Restrepo *et al.* (1999), with some modification. About 15µl of the diluted DNA was digested with EcoR1 and Mse1 restriction endonucleases simultaneously. EcoR1 has a 6-bp recognition site while Mse1 has a 4-bp recognition site. When used together, these enzymes generate small DNA fragments that will amplify well and are in the optimal size range (<1kb) for separation on denaturing polyacrylamide gels. The digested samples were then ligated at 20 ^{0}C for 2 hours to the respective adapters. Ten microlitre of the ligated mixture was added to 90µl TE buffer and mixed well. Five microlitre of the ligation reaction dilution was pre-amplified for 20 cycles at 94 ^{0}C for 30 sec; 56 ^{0}C for 60 sec; 72 ^{0}C for 60 sec and soaked temperature was 4 ^{0}C. In the first reaction, genomic DNA was pre-amplified with AFLP primers with no selective nucleotides (Primers E+0; M+0) [GIBCO BRL products]. The PCR products of the pre-amplification reaction were diluted in ratio 1:50 and 5µl of this was used as the template for the second amplification using two AFLP primers containing either zero, one or two selective nucleotides. This reaction mixture was introduced into PCR machine and run as follows: 23 cycles of 94 ^{0}C for 30 sec; 56 ^{0}C for 30 sec; 72 ^{0}C for 60 sec; soaked temperature was 4 ^{0}C. After the selective amplification, the PCR products were mixed with an equal volume of loading buffer (formamide dye; 98% formamide, 10mM EDTA, bromophenol blue, xylene cyanol). This was heated in the PCR machine to denature DNA at 95 ^{0}C for 3 min. and immediately placed on ice to chill.

Six percent polyacrylamide gel (20: 1 acrylamide: bis; 7.5 M Urea; 0.5X TBE buffer) with 0.4 mm spacers and sharks-tooth combs was prepared on a glass plate gel. The gel was pre-electrophoresed at constant power (Bio RAD, Model: 3000Xi computer controlled electrophoresis power supply) for between 20 and 30 min. About 5µl of each sample were loaded on the gel and electrophoresed at constant power of 60 W until xylene cyanol (a slower dye) was two-thirds down the length of the gel. The takes about two hours. Thereafter, the gel was stained in silver staining solution and de-stained in double distilled H_2O. The plates were left to dry at room temperature overnight. The gel was scored for polymorphism on fluorescent light pack and scanned for record purposes.

RESULTS

Analysis of 68 *Xanthomonas axonopodis* pv *manihotis,* 4 *Xanthomonas axonopodis* pv *cassavae* and 2 *Xanthomonas campestris* pv *malvacearum* strains showed a total of 405 AFLP bands from the eight primer combinations, (only clearly recognized and visible bands were considered). Bands obtained / strain on a glass plate polyacrylamide gel were between 30 and 70 fragments, ranging from 30 to 360 bp (Plate 1). However, a high number of bands / primer combinations were monomorphic and therefore were not considered in the analysis. Only 211 bands (52 %) that were polymorphic fragments were considered for the Principal Component and phylogenetic tree analysis.

When the 211 polymorphic AFLP bands were used for the cluster analysis using the Un-weighted Pair Group Arithmetic Means Analysis (UPGMA) program of NTSYS-PC (version 2.02j), a high level of polymorphism was shown in the pathogen population. The set of 74 strains was classified into 10 clusters using 60% similarity coefficient as a cut-off point. Cluster 1 is the largest containing 35 strains across different ecological zones in Nigeria (Fig 1). Clusters 1 and 2 contained 47 strains representing 63.5 % of the entire bacterial strains.

The yellow strains isolated in this study were grouped together in cluster 8, having a similarity coefficient of 70 %. Two of the yellow strains (70 and 72) were more closely related than the other two (69 and 71) showing 97 % (data not shown) level of closeness. These four species showed a very distinctive pattern and the level of similarity among them was 68 %. The *Xanthomonas campestris* pv *malvacearum* (*Xcm*) (73 and 74) used as reference organisms were more closely related than the pathogen of cassava, having a similarity coefficient level of 95 %. These reference strains were grouped together with other 10 strains in cluster 2 with a similarity coefficient value of 64 %. The Ten other strains in the cluster 2 were 58, 59, 61, 60, 62, 64, 63, 65, 66, and 67.

The PCA assembly summed up the bacteria into five clusters and one of the strains stood out from the others. Cluster 1 appear to be more identical than others in that there is more overlapping among the strains compared to other clusters (Figure 2) Isolate 2 was separated in the PCA analysis showing a strong variation from other strains of *Xam* isolated in this study. The Principal Component Analysis (PCA) shows a distant relationship of strain 69 from other yellow variants.

Table 1 revealed the regional distribution of the bacteria within the clusters. Cluster 1 of the dendrogram contained isolates from all the agro-ecological zones, indicating that the distribution of the bacteria is not agro-ecologically influenced. Cluster 2 contained ten strains from all the eco-zones except the humid forest; cluster 3 grouped together three strains from the humid forest. Cluster 8 contained the yellow variants that were isolated only from cassava plants in the arid and semiarid agro-ecological areas. Cluster 2 grouped the reference strains together with the *Xam* strains.

DISCUSSION

The results of the AFLP analysis effectively and efficiently provided quantitative estimates of genetic similarities related to the distribution of variability among *Xanthomonas axonopodis* pathovars. A higher level of polymorphisms (52 % polymorphic bands) was shown in the pathogen population structure with this molecular technique. A total of 211 polymorphisms were detected using eight combinations of selective primers. The *Xam* strains were grouped into ten separate clusters in this study at a similarity coefficient level of 60 %. The use of different sets of restriction enzymes or of more and different sets of primer combinations can dramatically increase the number of polymorphisms detected in this *Xam* population (Ogunjobi et al., 2007a; Restrepo 2004). AFLP molecular technique therefore allowed the discrimination of closely related bacterial strains and was able to detect differences of minutia smallness. Bacterial genomes have been shown to be relatively small and, in general, one selective base for both primers yields scoreable banding patterns (Janssen *et al.*, 1996; Ogunjobi 2005). This agreed with the report of Vos *et al*. (1995) that AFLP was an extremely useful and reliable technique for detecting polymorphism in bacterial populations and its reproducibility was very high. A complex and informative fingerprint can become useful by making small changes in the primer sequence. Restrepo *et al.* (1999) confirmed that a suitable choice of restriction enzymes and the number and base composition of selective bases determined the usefulness and applicability of AFLP fingerprints in diversity studies.

Strain 2 was highly heterogeneous in genetic composition compare to other non-pigmented strains, and was observed to be the least virulent among the bacteria in the pathogenicity experiment conducted on the isolates (data not shown) (Ogunjobi 2005). The information provided with this molecular marker technique revealed the ability to distinguish between pathogenic characters within the population of *Xam*

This signifies that the *Xam* population in Nigeria was not homogeneous, as other recent studies have shown (Ogunjobi *et al*., 2006; 2007a) contrary to earlier information by some workers who reported homogeneity in African population of the bacteria and that heterogeneity was limited to South American countries where cassava was said to be indigenous (Ikotun, 1975; Persley, 1980; Verdier, 1988; Restrepo and Verdier, 1997Ogunjobi *et al*., 2007b). However, some workers have reported that different haplotypes of the bacteria have been isolated in Africa (Assigbétsé *et al.*; 1998) where they presumed that the genetic variability observed within *Xam* population might result from the host selection pressure. If characterization of the bacterial population with different methods would yield similar results, it is reasonable to conclude that there are differences in the genetic properties of the pathogen population in Nigeria. Restrepo *et al*. (2004) reported that the population structure of *Xanthomonas axonopodis* pv *manihotis* was unstable due to the observed disappearance of some haplotypes and sudden appearance of other haplotypes and pathotypes in Colombia; the predominant haplotype also changed. The sudden breakdown of resistance in cassava to this disease has been linked to this onset of new, undiscovered haplotypes of the bacteria. Instability in *Xanthomonas axonopodis* pv *manihotis* due to mutation has been reported by Stolp *et al*. (1965) and Restrepo *et al*. (2004). With this background knowledge that the population structure of *Xanthomonas axonopodis* pv *manihotis*, is precarious the observed heterogeneity in the Nigerian population of *Xam* should be expected. AFLP analysis revealed an observable diversity between the genetic structures of *Xanthomonas axonopodis* pv *manihotis* and *Xanthomonas axonopodis* pv *cassavae*. The yellow variant in cluster 8 had a distant relationship of 55 % coefficient level of similarity in the dendrogram with the non-pigmented *Xam* strains. This possibly confirmed that the two bacterial species are not the same pathogenic entity at the molecular level. However, the two pathovars initiate similar infectious symptoms on susceptible cassava plants on the field and in the screen-house experiment (Maraite 1993). The Yellow variants of this bacterial strain were, however, restricted to one agro-ecological zone in Nigeria. Efforts should be made to hinder the spread of this yellow variant of the bacterial strain to other zones of the country. The diversities observed were not regionally influenced or agro-ecologically determined as most of the strains within a cluster were not from the same ecological zone. This precludes the possibility of developing a regional resistance program for all the pathogenic isolates in a region. A strategy for controlling the spread and damaging effect of the pathogen at a country level must be encouraged and embarked on.

If new pathotypes appear in the population, these must be characterised and included in the set of strains used for screening cultivars to be deployed. In other host-pathogen systems, the most widely used method for characterising the pathogen population has been virulence analysis, using a set of differential cultivars of the host. However, pathotyping analysis does not always reflect the complete genetic structure of a population because of dependence on the host genotype used. The analysis of genetic variability through molecular markers can reveal the potential for change and the phylogenetic relationships within the population. A combination of virulence investigation and molecular genetic characterisation is therefore necessary and useful for the evaluation of existing biodiversity among strains of *Xam* in Africa to determine the true knowledge of the state of this pathogen in the continent. Knowledge of pathogen population structure is essential for us in formulating long-term disease management plans. Also information on pathogen diversity can be used in characterising, developing, and deploying resistant germplasm.

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EXTRACTABLE METALS AND PHYSICOCHEMICAL PROPERTIES OF SOME SOUTHWESTERN NIGERIAN SOILS

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Abstract

The study investigated the correlation between the extractable metals and the physico-chemical properties of soils in some parts of Ife-Ijesha area, of southwestern Nigeria. Surface (0-15cm) and sub-soil (15-30cm) samples were analyzed for the extractable metals, the pH, organic matter and the particle size distribution. Results indicated that the physico-chemical properties of the soils varied with soil types, and that the pH ranged from 4.80-7.36, while the organic matter(OM) content for all the soils was less than 5%. The pH and organic matter content of the soils decreased with depth in most cases. The extractable metal concentrations of the soils decreased with soil depth for most of the soils and the mean level of the extractable metals was within the ranges considered “non toxic” to plants. The result of the correlation tests between extractable metal concentrations and selected soil properties, showed that there was no significant correlation between the extractable metals and the soil pH except for Zn-pH (0-15cm) and Mn-pH (15-30cm) in which the correlation was significant at $P \leq 0.05$. In the top soil, only Mg was negatively correlated with sand at $P \leq 0.05$ while at 15-30cm Cu ($P \leq 0.05$), Fe ($P \leq 0.05$), Mg ($P \leq 0.05$) and Al ($P \leq 0.05$) correlated negatively with sand. At both depths, none of the metals correlated significantly with silt. Ni, Cr, Al, Fe, Mg correlated significantly with clay. Cu was also significantly correlated ($P \leq 0.05$) with clay at 15-30cm depth.

Keywords: Extractable metals, Physiochemical properties, Soil, P^H, OM, Nigeria

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INTRODUCTION

The Ife – Ilesa schist belt of southwestern (sw) Nigeria (Fig. 1) forms part of the schist belts of the Nigerian basement complex. Soil is an essential component of terrestrial ecosystems because the growth of plants and biogeochemical cycling of nutrients depend upon it. Of the total area of the world’s land mass (13.07×10^9 ha), only 11.3 % is cultivated for crops; permanent grazing occupies 24.6 %, forest and woodland 34.1 % and ‘ other land’ including urban / industry and roads, account for 31%. From a resource perspective, soil is vitally important for the production of food and fibre crops and timber and it is therefore essential that the total productive capacity (quality and quantity) of the world’s soils is not impaired. Soil pollution can also be a hazard to human health when potentially toxic substances move through the food chain or reach groundwater used for drinking water supplies.

We have earlier carried out a study of gross trace element concentrations of the soils of this area. Our results show that trace element concentrations of most of the soils of Ife / Ijesa area are within normal limits and the fact that the trace element levels in the surface soils is higher than sub – surface soils are attributed to applications of some fungicides and fertilizers for agricultural purposes in the area. The anomalously high trace element concentrations in one of the sample areas are attributed to previous mining activity.

However, previous studies have shown that extractable (available form) metal concentrations of soils and waters are more important than their gross concentrations for plant mineral uptake and general environmental pollution considerations Wagner *et* al (2008). In fact the report of the work done by Wagner *et al* (2008) showed that Mn at the water – sediment interface was found mainly in the available or exchangeable fraction, adsorbed on Fe and Mn oxides. Contrary to Fe, Mn was determined in high concentrations in the available form. In some of these studies, relationships have been established between extractable metal concentrations and soil microbial activity as well as some physico – chemical properties.

It has been suggested that metals become less available when sludge is added to soil. (Logan and Page, 1989; Chang *et al*., 1984).

Nevertheless, the importance of the chemical form of metal on plant uptake or movement in soil was best illustrated in the peer review of standards for the disposal of sewage sludge (Logan and Page, 1989). Trace metals in a form (that is soluble in the soil solution) are much more available for plant uptake and potential toxicity than those held in the sludge organic matrix. Babera (1987) found that the application of compost to agricultural soils increased both the total and the available concentrations of some metals in the soil. In another study, (Korcak, *et al*., 1979), diphenytriamine pentaacetic acid (DTPA) extractable Zn, Ba, Cd, and Ni were monitored throughout a 2, 4-year experiment where compost was added to a sandy soil- Extractable Cd, Zn, and Cu decreased with time, indicating increased retention with time, while soil Ni extractability tended to increase with time. Organomineral interactions were characterized by Vedy *et al*. (1986) by a granulometric fractionation and by chemical extractions for compost enriched with trace metals. The granulometric fractionation indicated that, in general, higher concentration of metals were found in finer particle sizes (< 50μm), while chemical extraction suggested that both Cu and Zn were strongly associated with organic matter (67 to 88% and 66 to 96%, respectively), while organic chelates were scarce. Tackett *et al* (1986) observed that pH can affect leaching rates of metals in some cases. Short-term leaching rates of Cd, Fe, Pb, and Zn from composted sewage sludge were determined over pH range of 2.5 to 7.0 at unit interval of 0.5pH. Only Zn and Cd leached significantly as the pH was lowered, with both showing the greatest relative solubility increase over the pH range of 5.5 to 6.0. Attempts have been made to relate extractable metals to increases in plant uptake rates, and results have varied greatly. Korcak *et al* (1979) found poor correlations between DTPA extractable metals and metal concentrations in pearl millet, red oak or black walnut. Also Barbera (1987) noticed significant uptakes of metals in plant tissues were related to variations of their available fraction in the soil. In particular, a strong linear relationship was found for available Zn fraction in the soil and its uptake in corn silage. In contrast, mineral fertilizers were found to have no effect on the levels of total and available metals in the soil or on the uptake of metals in plant tissues. In a study conducted to determine the effect of toxic metals on soil acid phosphotase and alkaline phosphatase, and enzyme activities in landfill soils (Roy *et al*., 2004). The enzyme activities were consistently higher in the landfill soils than in an uncontaminated alluvial soil. It was also reported that the landfill soils contained higher concentration of metals (Fe, Mn, Cd, Pb, Zn, Cu) than did the alluvial soil. Enzyme activities were negatively correlated with the metals, with inhibition increasing with the bioavailability of the metals. It was then suggested that the metals affected enzyme activities by behaving synergistically or additively with each other. Although the landfill soils had higher enzyme activities than the alluvial soils due to higher organic matter concentrations, the ratios of enzyme activity/organic carbon indicated that inhibition of enzyme synthesis and stability had occurred due to metal stress (Roy *et al.*, 2004). Hamid and Rene (2004) reported that the release of metals as measured by their extractability, into different ultramafic soils from New Caledonia appeared to be related to microbial activity; the link with pH was not clear and the percentage of microorganisms tolerant to Ni was highly correlated to the extractable concentration of this metal in the soil Mitra, *et al*. (2003).

reported that cultivated landfill soils dumped with municipal solid wastes had higher EC, organic C, total N, available phosphorus, carbonate, and total - diphenyltriamine pentaacetic acid (DTPA) and water –soluble heavy metals (Zn, Cu, Pb and Col) including the relative availability (RA), than the normal agricultural alluvia soil. Among the heavy metals studied, the RA of Cu, was more.

The heavy metals species of the landfill soils were negatively correlated with the physico-chemical properties and the coefficients were generally statistically significant, with the bioavailable forms (DTPA and water-soluble) in most cases. Itanna, *et al*. (2003) in their study on the influence of soil type differences on the distribution of DTPA extractable heavy metals in soils irrigated with industrial effluents, found that the Fluvisol was slightly basic on the surface, and had clayey texture throughout the profile; application of the industrial liquid waste modified and increased levels of DTPA metals in the treated soils compared to natural levels in the background soils. The fluvisol had more DTPA extractable Fe, Mn and Zn than the vertisol. Surface Cu, Cd and Ni contents were higher in the vertisol opposed to the fluvisol. They also reported that there was more enrichment of these metals within depth, in the fluvisol. Pb concentrations in the fluvisol were about twice as much as the vertisol throughout the profile. Soils solution pH seems to have the greatest influence for most metals. Surface Cu and Ni of the treated vertisol were more influenced by organic matter, while on the whole CEC had negative influence on metal availability because of competing ions. These metals generally decreased consistently with depth in vertisol, while in the fluvisol the profile distribution was irregular. Leaching due to coarser textural composition and flood plain soil impacted by the contaminated river sediments were responsible for metal redistribution in the fluvisol than in the vertisol. There was thus greater risk of metal uptake by vegetables on the fluvisol than the vertisol.

However, the review of literatures on Ife-Ijesa soils revealed that not much has been known on the extractable metals in the area; hence this study presents the concentration of some trace elements in these soils that can be available for plant extraction. This would serve as useful reference point for future soil studies in the area. In view of the importance of the Ife – Ijesa soils for agricultural and mining activities, we have extended our previous studies of gross elemental concentrations of soils in the area to include a correlation of the extractable metal concentrations with some physico – chemical properties of the soils. The latter constitutes the subject of this paper.

MATERIALS AND METHODS

Sample collection and preparation

The study was carried out within Ife-Ijesa area of southwestern Nigeria. The major soil types in the region were identified using the semi-detailed soil map of central western Nigeria produced by Smith and Montgomery (1962). A total of nine soil series which differ widely in parent material, texture, drainage, topographic position and chemical composition were sampled. Table 1 gives the soil type, the sampling locations, major land use at the sampling locations and general features on the soil

The identified soil types (Table 1) were sampled using Dutch soil auger to collect core samples at 0-15cm and 15-30cm soil depths. For each soil series, ten core samples were composited and homogenized. The homogenized samples were air-dried, crushed and sieved with 2mm sieve. The less-than-2mm fraction of each sample was kept in a polythene bag and labeled. Representative soil samples were taken using the quartering approach, prior to analysis.

10g of each soil sample was put into an acid- washed reagent bottle, and 100ml of 0.05m Na-EDTA solution was added. The bottle was stoppered and shaken for 30mins at room temperature. It was then filtered through No 40 Whatman filter paper and the filtrate was retained for the determination of the extractable metals (Cu, Zn, Fe, Pb, Cr, Mn,Mg,Al)

Table1: Soil type, sampling locations, major land use and brief description of the soils

Soil **series**	Sampling location	Major land use in sampling location	Brief description of the soil	Textural Class
Iwo	O. A. U. Teaching & Research farm, Ile - Ife	Yam & pepper plot	Well drained, coarse textured soils, overlying weathered rock material, Derived from coarse-grained granitic rocks and gneisses	Sandy loam
Ondo	Near Owena town	Cocoa & Kola nut plantations	Well drained, medium to fine textured soil, overlying orange brown, yellow brown and white mottled clay, mainly derived from medium ground granitic rocks and gneisses	Sandy loam
Egbeda	O. A. U. Agricultural Research farm, Ile - Ife	Cocoa, Kolanut,Orange, Plantain/ banana plantations	Well drained fine textured soil, overlying red brown, yellow brown and white mottled clay, mainly derived from fine – ground biotite gneiss and schist.	Sandy clay-loam
Itagunmodi	Near Itagunmodi village	Cocoa farm	Well drained, very fine textured soils of uniform brownish red or dark chocolate brown colour to depth, derived from amphibolites and related basic rocks	Clay
Jago	O. A. U. Teaching & Research farm, Ile - Ife	Sugarcane, bamboo trees banana trees	Soils of various textures in low topographical sites, with drainage affected by seasonally high water table derived from alluvium and local colluviums.	Sandy clay-loam
Oba	O. A. U. Teaching & Research farm, Ile - Ife	Maize and yam plot	Well drained, coarse textured soils, overlying weathered rock material, derived from coarse- grained granitic rocks and gneisses.	Sandy loam
Gambari	O. A. U. Teaching & Research farm, Ile - Ife	Citrus plantation	Sandy and clayey soils either containing very large quantities of ferruginous concretions and fragments of iron stones or overlying massive iron stone pan	Sandy clay-loam
Apomu	O. A. U. Teaching & Research farm, Ile - Ife	Maize farm	Well drained drift soils, pale brown to reddish brown, sandy to fairly clayey soils, with no gravel concretions and quartz grains.	Sandy loam
Efon	Ipetu – Ijesa road	Maize, pepper and yam farm	Well drained drift soils, sandy or fairly clayey, gravel soils merging to rotten rock.	Sandy clay loam

Determination of the Concentration of the Elements in Solution

A Buck Model 200A Atomic Absorption Spectrophotometer (AAS) was used. The AAS was standardized, by using the wavelength for the particular element of interest. Blank determinations were also carried out along with other internal standards for quality control. The difference between the sample reading and blank reading was multiplied by the dilution factors.

The organic matter content of the soils was determined following the procedure of Walkley and Black (1934). The pH of the soils was determined by the electrometric method, using a glass electrode pH meter.

The particle size distribution was determined by the hydrometer method of Bouyoucous (1962).

The standard deviation of extractable concentrations of replicate measurements was determined for each element. For subsequent general evaluation of the data, the mean values were used. The Duncan new multiple range tests was also carried out to separate mean concentrations of elements that were significantly different, while Pearson correlation tests were used to investigate the relationship between the soil parameters.

RESULTS AND DISCUSSION

The results of the extractable elemental concentrations of the surface and sub-surface soil samples are presented in Tables 2 and 3 respectively. From the results of the extractable metal contents of the soils (Tables 2 and 3), the elemental concentrations were generally higher in the top soil (0 -15cm) than sub soils. This may be due to atmospheric deposition, as well as input from fertilizers, agrochemical, phytocycling and other inorganic pollutants. The unusually high concentration value of Cu in Ondo and Itagunmodi surface soils may be due to the effects of copper fungicides being applied to Cocoa growing on the soils. Cocoa is the major crop on these soils and it is usually sprayed with copper fungicides. In most of the soils, the concentration of Zn, Cu, Ni and Mn decreased with depth and this could also be due to the application of copper fungicides and Mn and Zn containing fertilizer to the surface soil. There was no particular trend in the changes in concentration of Pb, and Cr with increasing depth.

Table 2: The Extractable metal content of the soils (ppm) at 0 – 15 cm depth

Soil series	Zn	Cu	Ni	Fe	Pb	Cr	Mn	Mg	Al
Apomu	1.77^{i}	0.90^{i}	0.00^{i}	142^{g}	4.30^{g}	0.00^{f}	181.7^{i}	125.8^{h}	238^{c}
Efon	2.81^{c}	2.90^{d}	2.30^{c}	172^{e}	8.60^{b}	0.30^{d}	517^{d}	216.8^{c}	355^{b}
Egbeda	9.13^{a}	8.4^{c}	4.40^{a}	196^{d}	5.60^{e}	0.30^{d}	794^{b}	248.1^{b}	54^{i}
Gambari	2.38^{e}	1.90^{f}	0.70^{h}	172^{f}	7.20^{c}	0.30^{d}	285^{g}	105.4^{i}	381.0^{a}
Itagunmodi	3.56^{b}	15.30^{a}	4.20^{b}	254^{b}	3.70^{h}	0.90^{a}	810^{a}	349.8^{a}	197^{e}
Iwo	2.17^{g}	1.70^{g}	2.00^{d}	142^{h}	6.80^{d}	0.10^{e}	350.5^{e}	135.9^{f}	231^{d}
Jago	2.20^{f}	1.10^{h}	1.40^{f}	535^{a}	6.80^{d}	0.00^{f}	344.0^{f}	156.2^{d}	132^{h}
Oba	2.73^{d}	2.30^{e}	1.70^{e}	236^{c}	10.70^{a}	0.60^{b}	701^{c}	132.8^{g}	140^{g}
Ondo	1.89^{h}	11.50^{b}	1.0^{g}	119^{i}	4.90^{f}	0.40^{c}	244.6^{h}	137.1^{e}	143^{f}

Means with the same alphabets are not significantly different.

Table 3: The extractable metal content of the soils at 15 – 30cm depth (ppm).

Soil series	Zn	Cu	Ni	Fe	Pb	Cr	Mn	Mg	Al
Apomu	0.99[f]	0.8[g]	2.4[c]	115[f]	4.2[f]	1[a]	103[g]	66.2[g]	135[e]
Efon	2.37[b]	2.9[c]	2.2[d]	182[d]	6[d]	0.6[b]	470[c]	177.5[c]	271[b]
Egbeda	2.5[a]	3.7[b]	3.6[a]	200[c]	8.2[a]	0.5[d]	663[b]	186.9[b]	126[f]
Gambari	0.69[g]	1[f]	0.03[h]	80[g]	5.3[e]	0.0[h]	135[e]	80.42[f]	255[c]
Itagunmodi	2.27[c]	7[a]	2.6[b]	318[a]	3.9[g]	0.6[c]	667[a]	307.8[a]	455[a]
Iwo	1.83[d]	1.2[e]	1.3[e]	130[e]	7.2[b]	0.4[f]	329[d]	105.5[d]	178[d]
Jago	1.17[e]	0.8[g]	1[g]	230[b]	6.6[c]	0.4[g]	58[h]	83[fe]	81[g]
Ondo	0.2[h]	1.4[d]	1[f]	47[h]	2.1[h]	0.4[e]	110[f]	86.1[e]	9[h]

Means with the same alphabets are not significantly different.

Results for pH, organic matter, clay, silt and sand are in Tables 4 and 5. In the results for pH, organic matter, clay, silt and sand (Table 4), the pH of the top soils differed significantly from one soil series to another. Egbeda soil series had the highest pH of 7.36 while Gambari series were the most acidic with a pH of 5.88. However, they all fall within the general literature values of 4.0-8.5 (Alloway, 1990). Brady (1984) also reported a pH range of 5-7 for soils of humid region and 7-9 for the soils of arid regions.

In general, pH, and percentage silt and organic matter in the samples were higher in the surface than subsoil. The pH of the soils ranges from 5.88-7.36, which indicates that the soils are generally acidic in nature.

In the grain size determination (Tables 4 and 5), soils of the Apomu series had the highest sand content (72%) while Itagunmodi had the least (32%). This trend agreed with previous studies (Adepetu et al. 1984) in which the Apomu soils were considered unsuitable for Cocoa, Coffee or Kola because of their sandy texture, while soils of Itagunmodi series ranked first among soils that were suitable for cocoa, kola or coffee. This suggested land use was also in agreement with the clay content of both soils. Previous studies (Smyth and Montgomery 1962; Adepetu et al., 1984) have shown that excellent qualities of water and nutrient retention and good drainage typified the Itagunmodi soil series, which agrees with its high percentage clay content. Table 4 also shows that the soils contain different levels of organic matters, although the amount and type vary considerably. Iwo series with the least organic matter content could be classed as an arable soil. It has been reported that the organic matter content of an arable soil is usually less than 2 (Alloway, 1990). Incidentally the percentage sand of Iwo soil series was quite high in correspondence to the low organic matter content. The organic matter content of the soils decreased with depth and ranged from 1.24 to 3.15%. Within the soil profile, the organic matter was always higher in the surface horizon, although podzols and vertisols may have some translocated humic material lower down the profile (Alloway, 1990). The high organic matter content of the topsoil is generally ascribed to phytocycling. The organic matter is expected to be higher in those soils where copper fungicides have been applied, as they cause a reduction in organic matter decompositions (Alloway, 1990). The significant differences in the selected properties of the soils were expected, since they developed from different parent materials (Table 1). Other probable sources of variations were anthropogenic such as land use and soil management amongst others. The soils Ondo, Egbeda and Itagunmodi series, whose land use includes cocoa, plantain had relatively high pH values, which could be associated with the use of copper-based fungicides which is mixed with $Ca(OH)_2$, that can raise the pH of the soils.

Table 4: General properties of the soils at 0 – 15 cm depth.

Soil series	P^H	% Organic matter	%Sand	% Silt	% Clay	Textural Class
Apomu	6.09g	2.00f	72a	12.00e	16^h	Sandy loam
Efon	6.61^c	3.15^b	58^h	12.00^d	30^b	Sandy clay loam
Egbeda	7.36^a	2.38^c	68^d	6.00^i	26^d	Sandy clay loam
Gambari	5.88^h	3.19^a	63^f	9.00^h	28^c	Sandy clay loam
Itagunmodi	6.28^c	3.00^c	32^i	20.00^a	48^a	Clay
Iwo	6.53^d	0.016^h	64^c	16.00^b	20^f	Sandy clay loam
Jago	6.18^f	3.15^b	62^g	16.00^c	22^c	Sandy clay loam
Oba	6.83^b	1.49^g	70^b	10.00^g	20^f	Sandy clay loam
Ondo	6.53^d	2.62^d	70^c	11.00^f	19^g	Sandy loam

Note: Means with the same alphabets are not significantly different.

Table 5: General properties of the soils at 15 – 30 cm depth.

Soil series	P^H	% Organic matter	% Sand	%Silt	%Clay	Textural Class
Apomu	5.28^g	1.41^f	71^b	11.00^e	18^h	Sandy loam
Efon	6.22^b	2.45^c	84^h	11.00^f	35^b	Sandy clay loam
Egbeda	6.10^d	1.44^e	64^e	4.00^i	32^d	Sandy clay loam
Gambari	4.81^i	2.68^b	58^f	8.00^h	34^c	Sandy clay loam
Itagunmodi	5.64^f	2.72^a	28^i	16.00^a	56^a	Clay
Iwo	5.90^e	0.989^i	68^d	12.00^c	20^f	Sandy loam
Jago	4.85^h	1.96^d	56^g	16.00^b	28^e	Sandy clay loam
Oba	6.24^a	1.24^h	70^c	11.00^d	19^g	Sandy loam
Ondo	6.17^c	1.31^g	74^a	8.00^g	18^i	Sandy loam

Note: Means with the same alphabets are not significantly different.

The results of the correlation tests between extractable metal concentration and selected soil properties are presented in Tables 6 and 7.

Table 6: Correlation between extractable metals and the selected soil properties (0 – 15 cm).

	Zn	Cu	Ni	Fe	Pb	Cr	Mn	Mg	Al
P^H	0.75398**	0.24332 (ns)	0.62470 (ns)	-0.1579 (ns)	0.22538 (ns)	0.18130 (ns)	0.63592 (ns)	0.20892 (ns)	-0.6228 (ns)
OM	0.08122 (ns)	0.28452 (ns)	0.06815 (ns)	0.34180 (ns)	-0.1794 (ns)	0.20283 (ns)	0.06483 (ns)	0.35878 (ns)	0.18639 (ns)
Sand	-0.02265 (ns)	-0.5835 (ns)	-0.58129 (ns)	-0.2138 (ns)	0.32795 (ns)	-0.64407 (ns)	-0.4937 (ns)	-0.8033**	-0.1659 (ns)
Silt	-0.46218 (ns)	0.22786 (ns)	0.12690 (ns)	0.36803 (ns)	-0.3149 (ns)	0.20375 (ns)	0.01371 (ns)	0.46504 (ns)	0.08439 (ns)
Clay	0.23298 (ns)	0.63852 (ns)	0.68035**	0.10818 (ns)	-0.2763 (ns)	0.72592**	0.61943 (ns)	0.84858**	0.17290 (ns)

*= significant at $P \leq 0.05$ **= significant at $P \leq 0.01$ ***= significant at $P \leq 0.001$ ns= not significant

Table 7: Correlation between extractable metal and the selected soil properties at15 – 30 cm depth.

	Zn	Cu	Ni	Fe	Pb	Cr	Mn	Mg	Al
P^H	0.42522 (ns)	0.34840 (ns)	0.51880 (ns)	-0.02483 (ns)	-0.0091 (ns)	0.025712 (ns)	0.78320**	0.38515 (ns)	-0.05337 (ns)
OM	0.18286 (ns)	0.46854 (ns)	-0.1314 (ns)	0.44601 (ns)	-0.1380 (ns)	-0.25987 (ns)	0.13572 (ns)	0.44842 (ns)	0.73715**
Sand	-0.5052 (ns)	-0.810**	-0.1984 (ns)	-0.83560*	0.03116 (ns)	0.02860 (ns)	-0.49366 (ns)	-0.81957**	-0.86969*
Silt	0.07564 (ns)	0.19066 (ns)	-0.1673 (ns)	0.56164 (ns)	-0.1589 (ns)	0.20860 (ns)	-0.21641 (ns)	0.24089 (ns)	0.39514 (ns)
Clay	0.55624 (ns)	0.86915*	0.28247 (ns)	0.77815**	0.01580 (ns)	-0.10066 (ns)	0.63394 (ns)	0.88311**	0.87144*

*= significant at $P \leq 0.05$ **= significant at $P \leq 0.01$ ***= significant at $P \leq 0.001$ ns= not significant

There was no significant correlation between the extractable metals and the soil pH except for Zn- pH (0-15cm) and Mn – pH (15-30cm) in which the correlation was significant at $P \leq 0.05$. The correlation of pH with Mn and Zn may be due to changes in the pH of the soil with continuous application of Mn and Zn containing fertilizer, as the oxides of these metals are basic in nature and could increase the pH of the soils. It was also observed that the organic matter contents of the soils at the two depths did not correlate significantly with the extractable metals except aluminum which was significantly correlated at $P \leq 0.05$, at 15-30cm depth. At the top soil, only Mg was negatively correlated with sand at $P\leq 0.05$, while at 15-30cm, Cu ($P \leq 0.05$), Fe ($P \leq 0.01$), Mg ($P\leq 0.05$ and Al ($P \leq 0.01$) correlated negatively with sand. This was expected as the major content of sand is silicon and a high level of silicon (a major element in the earth crust) in any soil would imply a low level of trace and minor elements, hence the negative correlation. At both depths, none of the metals correlated significantly with silt. Ni, Cr, Al, Fe, Mg are correlated significantly with clay. Cu was also significantly correlated ($P \leq 0.01$) with clay at 15-30cm depth. This agrees with the result obtained for total elemental determination (Okoya and Asubiojo 2009), as the soil with the highest clay content (Itagunmodi) has the highest concentration of virtually all the elements, both trace and minor. This trend also reflected in the concentration of the extractable metals of the soil, Table 2 and 3) and the clay content of the soils (Table 4 and 5).

CONCLUSION

The correlation between extractable metals and the physico-chemical properties of soils in some parts of Ife –Ijesa Area was investigated. In most of the soils, the concentrations of Zn, Cu, Ni and Mn decreased with soil depth which is attributed to application of copper fungicides and Mn and Zn containing fertilizers to the surface soils. The pH of the soils range from 5.88-7.36, which indicated that the soils were generally strongly to mildly acidic in nature and there was no significant correlation between the extractable metals and the soil-pH except for Zn-pH (0-15cm) and Mn –pH (15-30cm). The investigation also showed that the soil contained different levels of organic matter as expected, and that the organic matter content of the soils decreased with depth and ranged from 1.24 to 3.15%. Furthermore, the correlation test revealed that the organic matter contents of the soils at the two depths do not correlate significantly with the extractable metals except Aluminum which is significantly correlated at $P \leq 0.05$, at 15-30cm depth.

At both depths, none of the metals correlate significantly with silt. However, Ni, Cr, Al, Fe, Mg are correlated significantly with clay.

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CLIMATE CHANGE AND THE MAXIMIZATION OF NIGERIA'S FOOD RESOURCES

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Abstract

The reality of climate change has become a major contemporary issue affecting the development process and livelihood in both developed and developing nations. While economic prosperity, availability of diverse technology and consistent democratic norms will go a long way to help the developed nations reduce the negative impact of climate change, this is not so in developing nations. In fact, the negative consequences are expected to be worse in developing nations despite their minimal contribution to the process of climate change because of the absence of these ingredients of development, lack of information as to the depth and severity of the problem and lack of preparedness for the consequences of the problem. In Nigeria, major consequences of climate change will include flooding in the coastal areas as well as the hinterland. In the coastal area, massive flooding will result mainly from the rise in sea level and the poor infrastructural facilities of settlements bordering the coast while in the hinterland, flooding will result mainly from heavy rainfall concentrated within a very short period of time. Flooding results in erosion (sheet and gully) which degrade the agricultural resources. Other important effects include heat-wave and drought. These factors will, in turn, affect food production as well as well-being hence, the need to articulate a relevant policy framework to help policy makers and development experts develop the necessary policy interventions to address the issues to maximize food resources in Nigeria.

Keywords: Climate change, resources, maximization, ecological zones, natural systems, greenhouse

INTRODUCTION

Agriculture in Nigeria is critical to economic development goals as it contributes nearly 40% of the nation's GDP. In fact, development experts strongly believe that the agricultural sector holds the key to solving the problems of unemployment and poverty reduction in the country. This is because the nation has a total of 924,000 square kilometers (98 million hectares) of land, (Federal Environmental Protection Agency{FEPA}, 1992), agriculture employs 60 % of the national labour force and accounts for 90 % of the non-oil export earnings (United Nations Systems {UNS}, 2001). Incidentally the agricultural sector is dominated largely by small holder farmers who constitute nearly 60 % of the farmers in Nigeria (Toluyemi, 1990; Oluwasola, 1999) and holds an estimated 90 % of the cultivated land in the country (Federal Ministry of Agriculture, Water Resources and Rural Development {FMAWR & RD}, 1986; Nigerian National Committee on Irrigation and Drainage {NINCID}, 2006).

These small holder farmers practice three main farming systems: rotational bush fallow, semi-permanent or permanent agriculture and mixed agriculture, using little capital resources which make them heavily dependent on natural systems that are highly sensitive to climatic changes. Incidentally, the farming practices of the small holder farmers have detrimental effects on the natural systems especially in influencing climatic elements. For example, while deforestation and bush burning release

CO_2 into the atmosphere, livestock release nitrous oxide during enteric fermentation. In addition, fertilizers used to enrich the soil could potentially release nitrous oxide. All these tend to increase green house gasses (GHGs) which also affect atmospheric energy balance and hence global climate. In addition to particulates from agricultural sources that adversely affect global climate, burning of fossil fuel for industrial and transportation has contributed greatly to the problem of climate change. These factors, thus, make man, his institutions, and livelihood, social as well as natural systems vulnerable to the impact of climate change.

Vulnerability as defined by IPCC - Intergovernmental Panel on Climate Change (2000a) is the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate. Hence, a highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained. Climate change and its associated consequences such as changes in rainfall patterns rise in sea level, extreme drought or deforestation, loss of biodiversity (Lesser *et al.*, 1997) are the major problems that human beings will have to confront.

For developing nations like Nigeria with strong agricultural base, the challenge of climate change will be felt more in the agricultural sector. This is because small holder agriculture uses low resource inputs, is dependent on rainfall and is closely linked to natural systems; it will greatly feel the impact of climate change in terms of both temperature and rainfall. Hence the livelihood of millions of people could be at risk. The vulnerability of agriculture to climate change has long been an issue of major international concern as reflected in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) (International Institute for Sustainable Development{IISD} and Institute for Environmental Studies {IES}, 1997), which calls for the:

"...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent serious anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to:

i. allow ecosystems to adapt naturally to climate change;
ii ensure that food production is not threatened; and,
iii enable economic development to proceed in a sustainable manner".

Although climate variability and change may have an overall negligible effect on total food production (IIED & IES, 1997) on a global basis, the regional impacts are likely to be substantial and variable, with some regions (the temperate and cold regions) benefiting from an altered climate and other regions (the tropical and sub-tropical regions) adversely affected. Generally, food production is likely to decline in most critical regions (e.g. subtropical and tropical areas), whereas agriculture in developed countries may actually benefit because the resource, research and technology with appropriate adaptive adjustments are more available and will be employed. In the developing nations, especially the Sub-Saharan African nations of which Nigeria is a key component, the failure of development could adversely affect their capacity to weather through major climatic change that leads to major economic or social distortions.

In spite of the crucial role of climate change to the sustainability of the agricultural sector in Nigeria and other developing countries, very little information is available on the nexus between climate and agriculture. As opined by Mendelsohn and Dinar (1999), most empirical works done in the field are extrapolations from industrialized nations consequently excluding developing nations who face greater risks from imminent climate change. A cooperative research effort among some African countries excluded Nigeria thus creating a knowledge gap about climate change and its effect on agricultural development in Nigeria. Given the sensitivity of Nigeria's agriculture to climate especially as regards the variability and duration of rainfall, the uncertainty which exists in the climatic environment and the economic and social importance of this sector, there is a strong need for research to enhance the understanding of climate change and its impact on food resources in Nigeria. This paper examined the nature of climate change in Nigeria, the nation's food resources in the various ecological zones, the nexus between food resources and climate change, various policy measures put in place in the face of changing climate and proposed a model for nutrient maximization in food intake.

THE NATURE OF CLIMATE CHANGE IN NIGERIA

The world had gone through series of climatic epochs, which include the ice age, and consequently, the ice recessions among others. Thus, the earth's climate has always been dynamic as interactions in the natural systems continue to generate activities in the natural systems that induce changes in the earth climatic regime. Such changes were however gradual and took place over a long period that enabled the natural systems to adapt without much deleterious impact on the natural systems. In the last century however and with man's ability to control and use energy culminating in massive industrialization, there has been accelerated changes in the earth's climate beyond its natural capacity to absorb such changes.

While the emission of greenhouse gases and particulates into the atmosphere, that enhance climate change, is carried out mainly by the industrialized world, Nigeria also contributes to some extent to global warming process. First, 60 percent of its labour force is involved in agriculture thus burning bushes, using fertilizers that releases N_2O into the air as well as keep livestock which also release methane. The petroleum sector is also a major pollutant as gas flaring releases GHGs that contributes to global warming. In terms of sectoral contribution of CO_2, the transportation's sector contribution of 38 % represents the highest followed by manufacturing and construction sectors' contribution of 22 % (EarthTrends, 2003). In terms of source, the highest culprit in terms of CO_2 emission is gas flaring (52 %), liquid fuels (32 %) and gaseous fuels (14 %) (EarthTrends, 2003). These modest contributions added to the contribution of other nations have continued to increase the problem of global warming.

Thus, recent changes in earth's climate are a consequence of an intricate chain of interference in environmental processes. Since the 21st Century, the scale of human induced changes to atmospheric and biospheric processes has had discernable impacts on climate patterns and life forms on the planet. Recently, the IPCC, World Meteorological Organization (NMO) and United Nations Environment Programme (UNEP) established that the earth has become warmer over the last century. According to these agencies, the average surface temperature of the earth has increased during the twentieth century by about 0.6 ± 0.2° C. It is warmer presently in many parts of the world than at any time during the past 1000 years, with possibilities of warmer years than the previous centuries, occurring within the next few decades. This change in temperature usually leads to lower ozone levels near the earth's surface, and significant increase of smog problems in the cities where the release of carbon dioxide is greater (Obioha, 2008). The impact of climate change is felt in all sections of Nigeria although in varying degrees.

Nigeria has five major ecological environments ranging from the mangrove swamp in the coastal region, high forest, guinea savannah, Sudan savannah and the Sahel savannah to the northern fringes. The rainfall and temperature regimes vary from one ecological zone to the other. Mean monthly temperatures vary from 30^{o} C in the south to 38^{o} C in the extreme north. The major impact of the variability of climate in Nigeria is mainly manifested in terms of reduction or delay in the intensity of rainfall. The duration of rainfall has reduced but the intensity has increased in recent times (Namchi and Ozor, 2009).

The Sahel region borders the Sahara desert and as such enjoys rainfall for at most four months in a year. Agricultural activities are concentrated within these four months except in the oasis where the occurrence of underground water makes farming possible. Livestock farming is a dominant feature of this agricultural landscape although crops like millet, sorghum, cowpeas and maize grains are also cultivated during the short wet season. Drought and thus lack of water, in association with high temperatures (up to 45° C at certain periods of the year), is the most limiting factor for agricultural production in this region. Drought has been a recurrent feature in the Sahel, with early records dating back to the 1680s. Drought here is defined as a long period of abnormally low rainfall, especially one that adversely affects growing or living conditions (Allaby, 1989).The magnitude and intensity of these droughts have been on the increase over the last 100 years, and, consequently, in the destruction caused by it (Hulme, 2001). The most prominent of these droughts was that of the early 1970s, during which hundreds of thousands of people and millions of animals died (Mortimore, 1998). The Palmer Drought Severity Index indicates that the Sahel is still experiencing drought conditions.

The incidence of drought is not limited to the Sahel region alone as Adejuwon and Adejuwon (1990) noted a recent trend towards aridity in the whole Sub-Saharan Africa. Fakorede (2001) also observed that in recent years, the onset of the effective rainy season seems to have been delayed without a corresponding delay in the time of recession of the rains at the end of the year. This leads to a shorter cropping season and failure of food crops (annual) in the early vegetative phase. Fakorede and Akinyemiju (2001) also observed that Nigeria's agriculture is generally susceptible to climatic hazards and these hazards often have a counteracting effect on any effort to improve production through marketing incentives and technology. Climate change induced by global warming has thus compounded the problem of the Sahel region as well as other ecological regions in Nigeria.

A major consequence of drought especially in the Sahel region is the gradual conversion of savannah ecological zones to arid landscape as noted by Obioha (2009). Nigeria is presently losing about 351,000 square kilometers of its landmass to the desert, which is advancing southward at the rate of 0.6 kilometers annually. Another problem that has become an environmental menace is the problem of flood. In recent times, incessant flood, even in the water deficient regions of the savannah, has continued to ravage the nation. Flood is also frequently reported in other parts of Nigeria in addition to windstorm. Implicated in the problem of climate change in Nigeria are other environmental nuisances like soil erosion, disease infestation and air sultriness.

Clearly, while not having the necessary empirical data or a total understanding of the problem and consequences of climate change, the problem is here with us in Nigeria and a thorough understanding of it is necessary for adequate and timely policy response.

NIGERIA'S FOOD RESOURCES

The major food resources of Nigeria are presented in Table 1. These include maize, millet, sorghum, rice, wheat, acha, beans, cassava, yams, potato, plantain and vegetables. These crops are planted mainly by small holder farmers who employ slash and burn method. As indicated in the table, most of the cereals, notably, sorghum, millet and beans, are produced in the savannah ecological region while the tubers, mainly, yams, cassava and cocoyam are produced in the forest and guinea savannah belts. Rice and maize are planted in all ecological belts.

In spite of the substantial food resources, the increasing population which is growing at 3.0 % per annum, rapid urbanization at 5.5 % per annum (NPC, 2006); poor infrastructural support notably roads and post harvest losses (Oluwasola and Adewusi, 2008) continue to adversely affect Nigeria's capacity to feed her people. In fact, food importation is a very significant part of Nigeria's food security strategy mix. As much as 9.0 % of Nigeria's total imports is made up of food products (CBN, 2005) constituting a total of nearly7.0 million tonnes (Oluwasola and Adewusi, 2008). As the small farmers are resource poor, it is the size of the hectarage cultivated that significantly determine yield. Hence, any problem that adversely affects the natural systems of climate (notably rainfall) and the soil, will also adversely affect the capacity of the farmers to produce the necessary food crops needed to feed the nation and thus affect the food security balance of the nation.

Table 1: Nigeria's Major Food Resources and total Acreage Planted and Output in 2004

Food Crops.	Area Planted ('000 hectares)	Output ('000 tonnes)	Main Ecological Area produced
Maize	3,203.52	7,908.8	All ecological zones
Millet	3,835.58	8,211.6	Guinea, Sudan and Sahel Savannah zones

Sorghum	3,952.81	10,898.0	Guinea, Sudan and Sahel Savannah zones
Rice	1,454.57	4,605.4	All ecological zones
Wheat	NA	66.1	Montane region of the Savannah zone
Acha	NA	94.8	Montane region of the Guinea Savannah zone
			Guinea, Sudan and Sahel Savannah zones
Beans	2,153.51	2,793.9	Forest and Guinea Savannah zones
Cassava	2,570.25	44,693.4	Forest and Guinea Savannah zones
Yam	2,060.80	32,549.5	Forest and Guinea Savannah zones
Potato	NA	146.0	
Cocoyam	296.81	1,995.6	Forest and Guinea Savannah zones
Plantain	NA	2,503.0	Forest and Guinea Savannah zones
Vegetables	NA	5,472.7	
			All ecological zones

Sources: (i) CBN Statistical Bulletin, 2004

(ii) National Bureau of Statistics Agricultural Survey Report, 2007

NEXUS BETWEEN FOOD RESOURCES AND CLIMATE CHANGE

The dependence of Nigerian farmers as well as their counterparts in Sub-Saharan Africa on natural systems for food production and the failure of the economic system, research and technology (Oluwasola and Adewusi, 2008) to reduce the pervasive influence of the natural systems on small holder agricultural production means climate change could be a major threat to food production. (Parry *et al*., 1999; 2004; Döös and Shaw, 1999; IPCC, 2001a). This is because small holder resource poor agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risk and impacts of global climate change.

In Nigeria, rainfall and temperature are the climate variables most critical to food production. Not only does the range between high and low values matter, but also the frequency at which these extremes occur and the intensity of the events (Ziervogel *et al*., 2006). As noted by National Sustainable Agriculture Coalition [NSAC] (2009), as temperature rises, rainfall duration and intensity change and severe weather events happen more frequently. These changes could cause both negative and positive feedback outcome in agricultural systems in ways that are difficult to predict. In the developed nations, research work on the impact of climate on food production has been going on in the last three decades while in the developing nations, study on the subject is in its infancy thus, there is limited empirical evidence and hence, understanding of how climate change currently impacts food systems and associated livelihoods (Downing, 2002; Ziervogel and Calder, 2003). This not withstanding, the consensus of scientific opinion is that countries in the temperate, high-, and mid-latitude regions are generally likely to enjoy increased agricultural production, whereas countries in tropical and subtropical regions are likely to suffer agricultural losses as a result of climate change in coming decades (Arnell *et al*., 2002; Devereux and Edwards, 2004). Hence, the long term effect of climate change in Nigeria will be harmful to food production because reduction in rainfall and increased temperature will harm the agricultural sector and farmers who are not endowed with the necessary resources or technology to adapt to such changes.

The main effect of climate change, increased temperature and decreased precipitation, on livestock is distress. The increasing temperature can have varying effects, depending on when they occur. Warmer conditions can lead to stress on range and housed livestock since dry pastures, poor hay and feed production and shortages of water all lead to worse conditions for domestic animals. Water resources are critical to a successful livestock operation. As with crops, diseases and insects could have an adverse effect on much of the livestock industry. Insects and diseases, that livestock is unaccustomed to, could move into the production area. Secondary effects such as dust storm and wind erosion are also factors that could worsen conditions for livestock. However, livestock is more resistant to climate change than crops because of its mobility.

Agriculture is one of the oldest economic activities. This is because it is the backbone of our food supply and without it the world's population would experience food insecurity. For this reason, any effect that climate change has on agriculture will be passed on to society and the economy too. Since agriculture is also dependent on the natural resource base, changing climate will require the adaptation of agricultural practices that accommodate the new climate while conserving the natural resource base.

It is important to note however that while agriculture is adversely affected at least in the tropical and sub-tropical region by climate change, climate change is also induced by agricultural activities. As noted by LaSalle *et al.*, (2008), the IPCC concluded that worldwide, agriculture exacerbates climate change trends by contributing about 13.5 percent of global GHG emissions. The major GHGs emitted by agricultural production sources include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). As a GHG, CH_4 has a greater global warming potential than CO_2 but a shorter atmospheric life. Over a 100-year period; CH_4 is 23 times as potent as CO_2. N_2O has a relatively low warming effect but a very long atmospheric life and over 100 years has a global warming potential that is about 310 times that of CO_2. Both CH_4 and N_2O, though released in smaller over-all volumes than CO_2, have significantly higher global warming potential than CO_2. The categories of agricultural activity include the following:

- Agricultural Soil Management which includes a broad array of practices including fertilization with synthetic fertilizer and animal manure; manure deposition by grazing animals, soil cultivation; production on nitrogen fixing crops and forages; irrigation and other practices. The category covers GHG emissions from both cropland and grasslands.
- Enteric Fermentation is primarily methane produced by the digestive processes of agricultural animals which are emitted from the animals as gas.
- Manure Management emissions are methane and nitrous oxide released from manure during storage and handling.
- Rice cultivation under anaerobic conditions in flooded fields, results in methane emission.

- Bush and field burning of agricultural residues results mostly in CO_2 emission, which are not counted because it is assumed that CO_2 will be reabsorbed by plants in the next growing season. Field burning, however, also results in release of methane, nitrous oxide and other minor GHGs (LaSalle *et al.*, 2008).

POLICY ENVIRONMENT AND MEASURES TO MAXIMIZE FOOD RESOURCES IN THE FACE OF CHANGING CLIMATIC CONDITIONS

Some of the policies put in place by government to combat climate change and its deleterious impact on the nation are enshrined in the overall national policy on environment. Those that have bearing on climate change include National Erosion and Flood Control Policy; National Environmental Sanitation Policy; National Forestry Policy; National Drought and Desertification Policy; National Policy on E-Waste Control and Management; and Reforestation and Afforestation program. Within the African context, Nigeria is also resolutely driving the Green-wall Sahara Programme from Mauritania in the West to Djibouti in the East.

The Federal Government has created the Special Climate Change Unit (SCCU) under the Federal Ministry of Environment to specifically deal with and co-ordinate Climate Change issues in Nigeria. This institution closely collaborates with the Nigeria Meteorological Agency to build an Early Warning System to reduce disaster in the country. Nigeria has prepared and submitted its First National Communication under the United Nations Framework Convention on Climate Change (UNFCCC); participated among 14 Anglo- and Franco-phone countries in the Regional project to build capacity for greenhouse gases inventory in West and Central Africa; signed a Memorandum of Understanding (MOU) with both the Italian government in the area of Climate Change with particular reference to CDM implementation in Nigeria and the UNDP for capacity-building in the area of the Clean Development Mechanism. She has also participated in the Kyoto Protocol processes. Government, through the National Planning Commission, is working towards a national climate change preparedness and response masterplan, which includes early-warning strategies. The government has developed action plans to implement its climate change programmes. These include: National Action Plan to mitigate the effects of Climate Change; adaptation Strategies of Action for Nigeria; National Ozone Programme of Action; National Forestry Development Programme; National Action Plan to Combat Desertification and National Capacity Self-Assessment (NCSA) for programmes bordering on some multilateral environmental agreements.

MAXIMIZATION OF NIGERIA'S FOOD RESOURCES

Climate change has reduced and will definitely continue to reduce food production in Nigeria as shown earlier. This means a worsening food security position for the nation and an increase in nutrition related diseases such as kwarshiorkwor, marasmus and vitamin and mineral deficiency. The high prevalence of these diseases in Nigeria up to 1970s was not due so much to lack of food security as to ignorance about nutrition and food composition. Just recently, the Nigerian Society of Dietetics in their 2009 annual conference announced the upsurge in the prevalence of protein malnutrition in the country. This may get worse when the effect of climate change bites harder. It is therefore important to maximize the nation's food resources using the pool of knowledge in food production pattern, nutrition and food composition now existing in the country. For instance, why should Nigeria plant over 3 million hectares of land to millet, maize and sorghum each when soybean with better yield in terms of acreage and nutritional value is sidelined? Soybean has up to 40 % crude protein and about 20 % oil content compared to the cereals with about 10 % crude protein and 3 – 4 % crude oil content. In addition, acha, with a high level of sulfur amino acids, is planted in only Plateau and Bauchi states when it is well known that the legumes on which the majority of Nigeria's population depend is first limiting in these amino acids. This is why this paper calls for a redistribution of arable land to accommodate crops with higher yield, better nutritional value and could possibly adapt better to climate change.

People in each ecological zone are culturally dependent on a single crop or at best crops from a single nutritional group. For example, millet and sorghum are the predominant food crops in the northern part of Nigeria while yam and cocoyam hold sway in the central and southern part of the country. It is, however, well known that a combination of two protein sources often give better nutritive value because of the complementation of their protein content (Adegbola and Oke, 1973; Adewusi and Oke, 1980; Adewusi *et al.*, 1991, 1992). It is therefore important to carry out more investigation to optimize the food resources of Nigeria for better nutrition and health for all. A model, based on cost minimization linear programming is now being proposed to optimize food resources. This model would be used when the empirical work on the national food production is completed and will be subject to the objective function (Z), would be to minimize the cost of food intake per capita per day subject to some technological constraints.

That is

Minimize $Z = \sum c_j X_j$ $(j = 1, 2, 3 \ldots.)$

Subject to $\sum a_{ij} X_j \leq b_i$ $(i = 1, 2, 3, 4\ldots)$

$\sum X_j = 1$

$X_j \geq 0$

Where

X_j = amount of food type j and

c_j = cost of 1 kg of food type j

a_{ij} = technological coefficients such as amino acids, vitamins and other nutrients

b_i = minimum nutrient requirement per capita per day recommended by WHO/FAO.

CONCLUSION AND RECOMMENDATIONS

The issue of climate change and its attendant consequences have come at a time when national capacity to respond is very low because of the underdeveloped nature of the nation's technology, economy, and institutions of governance. This is further compounded by lack of information or a clear understanding of the issues related to the occurrence and impact of climate change. This not withstanding, there is the need for providing the necessary base line information necessary for a careful and well articulated policy measures to combat the problem. The imperatives for this lies in a number of factors:

First, nearly two-thirds of Nigerians depend on agriculture for livelihood. Incidentally, agriculture has always been dependent on the variability of the climate for the growing season and the state of the land at the start of the growing season. Crop failure even for a season could be disastrous. There is thus the need to be able to predict climatic conditions to adapt crop production to climate change. What is required is an understanding of the effect on the changing climate on land, water and temperature. (IIED & IES, 1997).

A second major issue that should be of utmost concern is the fact that Nigeria has a long coastline stretching 800km which is prone to sea level rise, fierce storms and floods. Incidentally the coastal areas have witnessed massive development in terms of industrial development and urbanization stretching from Lagos in the south west to Calabar in the south east. Coastal disasters as occur in Asia and Latin America could be disastrous if it happens in Nigeria that is clearly ill prepared to handle such disasters. Thirdly, two-thirds of Nigeria's land is prone to drought. The fast conversion of savannah lands to arid landscapes in States fringing the desert and the massive out migration of rural dwellers from such areas is a clear pointer to the fact that except clear measures are put in place, Nigeria could loose most of her productive lands to deserts and become food insecure.

Finally, the rapid rate of urbanization of 5.5 %, one of the highest in the world portends great danger in case climate change leads to undesirable consequences.

There is thus the need to act now. As a first step, there is the need for research to collect base line data to determine the level, cause and impact of climate change. Such research should be multidisciplinary to ensure no sector or region is left out in developing appropriate policy response to mitigate the problem. Research should also be conducted on how to maximize agricultural and food resources to enhance nutrition among the Nigerian populace given the imperative of climate change. The land use system needs to be reoriented to accommodate lesser known but highly nutritive food resources such as acha bread fruit along with popular ones like maize and yams. The need for awareness campaign, nutrition education and scientific planning on land use among Nigerian farmers and consumers is thus very crucial.

There is the need for capacity building to ensure that officials saddled with managing the problem of climate change possess the requisite expertise necessary to proffer solutions to climate induced problems.

Finally, there is the need for institutional strengthening to manage the process. There is the need for proactive and clear-cut policy guidelines to manage the problem. The passing of the Climate Change Bill is a step in the right direction. However the Special Climate Change Unit should be strengthened to be proactive as well as coordinate climate change matters in the country. Research Institutions involved in studying climate change and its problems should also be given the necessary financial and logistic support to be able to deliver.

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SEASONAL VARIABILITY IN PRODUCTION AND AVAILABILITY OF FISH AND FISH PRODUCTS IN RURAL NIGERIA

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Abstract

There is no gainsaying the fact that fish and fish products remain the cheapest source of protein for the teeming population of people living in developing countries of the world. This is because of its availability and affordability by a sizeable number of the poor living in these countries. It has also been established that fish allows for protein improved nutrition in that it has a high biological value in terms of high protein retention in the body, higher protein assimilation when compared with other animal protein sources, low cholesterol content and one of the safest sources of animal protein. However, seasonality in production and availability of this all-important protein source has continued to cause untold hardship to both the producers and consumers, with the resultant effect of declining production, reduced consumption due to rising prices and eventual protein under-nutrition. The result presented here relies on primary data collected from a random sample of 150 fish farmers from two States in southwest Nigeria. A descriptive analysis of the data revealed that average age of fish farmers was 42 years indicating that fish production is mainly in the hand of young people. A gender analysis of the respondents showed there were more men in the fish production business than women with over three-quarter of those surveyed being men. Analysis of by educational qualification indicated that only about one-third of the respondents were educated up to tertiary level with about 38 percent having no formal education. Meanwhile, a probit regression analysis done to ascertain the determinants of seasonal variability in production and availability revealed that water shortage (proxy for climate change) price change, accessible infrastructure (electricity), credit accessibility and poverty status of respondents were positively associated with seasonality. On the other hand, the coefficients of gender, educational status, income and years of experience were negatively associated with seasonality. Thus, respondents with tertiary education had lower likelihood of being affected by seasonality. Also, those with experience in fish production and high income had lower likelihood of being affected by seasonal variability. A further ranking of how important some of these factors were to production revealed that climate change was very critical to production with 47 percent of respondents indicating it as the most important factor. This was closely followed by poverty status of respondents with about 32 percent indicating it in their responses. It is therefore recommended that effort should be geared by government towards provision of adequate information on weather variables influencing fish production in the country since this will help curtail the uncertainties pervading the sector. Investment in capacity building through education is also very important as this will reduce respondents' vulnerability to seasonal variability. Also, provision/improvement in existing infrastructural facilities should be made a priority to enhance the earning potentials of the respondents.

Keywords: Climate change, Fish, Production, Rural Nigeria, Seasonality

INTRODUCTION

Fish and fish products play a vital role in feeding the worlds' population and contributing significantly to the dietary protein intake of hundreds of millions of the populace. On a global scale, almost 16 percent of total average intake of animal protein was attributable to fish in 1988 (FAO, 1990). In the developing worlds, fish is a highly acceptable food that supplies as much as 40 percent of all animal protein available. Of the countries where fish is the main source of animal protein, 39 out of the top 40 are found in the developing world. There is now an increasing knowledge among Nigerians of the importance of fish as a preferred source of protein supply in human diet. Okorie (1978) stated that although fish contain no carbohydrates, they are rich in fat, phosphorus, sulphur, potassium, iron, calcium and copper. The flesh of fish is reported to be more quickly broken up by the gastric juices and remains in the stomach for a shorter period of time than does meat. Fish is known to provide 40 percent of the protein intake of two-thirds of the world's population (FAO, 1993). Fish ranks amongst the most superior of protein foods because of its balanced amino acid configuration, digestibility and low cholesterol (Bada, 2004). Given the high quality protein and quick digestibility rate that fish possess the demand for fish and fish products in human diet grew steadily over the last two decades.

According to Federal Department of Fisheries, FDF (2002), in the year 2000, total domestic fish production in Nigeria stood at 467,098 metric tons out of which aquaculture fish accounted for 25,720 mt, representing 5.5 percent of total domestic fish production. FDF (2004) reported that in 2003, domestic fish production from aquaculture accounted for only 9.9 percent with 52,000 mt out of Nigeria's total domestic fish production of 524,706 mt. Fish production (aquaculture) in Africa has come a long way since it was first introduced. However, in comparison to the rest of the world, aquaculture production in Africa is still insignificant at the global level and accounts for about 0.9 percent (404,571 t) of the total global aquaculture production in 2000 (FAO, 2003). Nonetheless, aquaculture in Africa is going through an exciting phase of evolution and growth after numerous false starts that did not result in any meaningful aquaculture development. This lack of development exists against a backdrop of conditions that would benefit greatly from the rapid development of aquaculture on the continent, namely, high incidence of poverty, malnutrition and unemployment (Hecht, 2000).

Again, households in developing agrarian economies in Africa face many risks, but among the many risks faced, recent research suggests that commodity price changes, droughts (water shortage/climate change), and health shocks are the major risk factors both in terms of the frequency of their occurrence as well as the severity of their effects (Christiaensen, Hoffman and Sarris, 2007). The impact of sharp increases in food prices in the short run depends very much on whether people are mainly producers or consumers of food. A low-income household that spends a large proportion of its income on tradable food staples is more likely to suffer a decline in overall welfare. The extent of this decline depends on the ability of the household to shift consumption towards less expensive foods. Hence, the poor spend proportionally more on fish than on meat or other sources of animal protein. The challenges are substantial, particularly in the developing world. Developing countries have a high dependence on climate sensitive natural resource sectors for livelihoods and incomes and the changes in climate that are projected for the tropics and sub-tropics, where most developing countries are found, are generally adverse for agriculture (fish production inclusive). The means and capacity to adapt to changes in climate are scarce due to low levels of human and economic development and high rates of poverty. These conditions combine to create a state of high vulnerability to climate change in much of the developing world.

From the foregoing, there is therefore no gainsaying the fact that fish and fish products play a vital role in feeding the worlds' population and contributing significantly to the dietary protein intake of hundreds of millions of the populace. On a global scale, almost 16 percent of total average intake of animal protein was attributable to fish in 1988 (FAO, 1990). In the developing worlds, fish is a highly acceptable food that supplies as much as 40 percent of all animal protein available. Meanwhile, the inability of Nigerians to meet their protein requirements could be linked to their poverty levels. Animal protein sources such as beef, mutton and chicken are beyond the reach of an average income earner resulting in Nigerians settling for fish being the cheapest animal protein source (Samson, 1997). In short, Evans (2005) posited that today we face a tremendous challenge - one that is growing. As the world's population increases, so too does the demand for fish protein. And human activities - from overfishing, to pollution of inland and coastal waters, and destruction of nursery grounds - are putting increasing pressures on fish stocks, and are undermining the basis for future productivity and recovery. Research findings have also rated fish nutrients quality very high thus making it an ideal source of vital nutrients both for nourishment and medicinal purposes. Given that there are considerable evidences in the use of fish and fish products for solving health problems (Mumba, 2005; Onasanya, 2002), thus, an examination of the causes of seasonal variability in production and availability of fish and fish products in the study area becomes very important if the much clamoured food security in terms of quantity and quality are anything to go by.

LITERATURE REVIEW

The United Nation's Population Fund, UNFP (1993) report posited that the demand for agricultural products is expected to reach unprecedented levels in the near future as world population is estimated to double in 50 years to about 11 billions with 98 percent of the future population growth likely to be in developing countries, Nigeria inclusive. Potentials therefore exist for demand – supply imbalance. National Governments in many developing countries responded to this assertion by making efforts to conquer poverty, food insecurity and malnutrition. In Nigeria, poverty is found to be more pronounced and severe in the agricultural sector (FOS, 1998; 1999). There is also high rate of rural – urban migration, high prices of food items and precarious food security situation (Okumadewa, 2001). This makes the citizens vulnerable to dietary associated diseases. Recent estimates show that at least 41 percent of the Nigerian population is food insecure with 16 percent being severely undernourished (Olayemi, 1996). Fish and fish products are therefore important in the anti-poverty agenda (Evans, 2005). Fish and fish products are a vital source of nutrition for the world's poor. 400 million poor people in Africa and Asia rely on fish and fish products for more than half of their daily protein intake. Adding to this is the heightened demand for high-valued fish by economies in transition – and a growing middle class eager to eat fish.

Yet, we know from the Food and Agricultural Organisation (FAO) and other sources that the world's fisheries are in dire straits. Global production of capture fisheries has stagnated since the late 80's with over 25 percent of wild stocks estimated to be overexploited and another 50 percent fully exploited – with little scope for increase (Evans, 2005). Small species, like anchovies and sardines, which constitute by far the largest component by volume of the global marine catch, are siphoned off and reduced to fishmeal to meet competing demands in livestock production. While most of this is now being converted to fish feed for aquaculture, which is growing at a rapid rate, the higher value fish produced are either exported or sold at prices beyond the reach of most of the worlds' poor. Notwithstanding inequities in the production and consumption of higher value farmed fish in many parts of the world, and the environmental impacts often associated with it, aquaculture remains the leading hope for bridging the widening gap between demand for fish and fish products and our current ability to supply it.

Globally, the livelihoods of about 150 million people rely on fisheries, aquaculture and associated activities and over 20 percent of the world's 38 million full-time fishers earn less than $1 per day. Many fishers live in the world's poorest countries where their communities are often marginalised and landless. As fishing is often the livelihood of last resort and fish often the only source of animal protein for the poor, the state of the world's fisheries can be critical in the fight against poverty in many parts the developing world. The export value of world trade in fish – US$ 58 billion in 2002 – is more than the combined value of net exports of rice, coffee, sugar and tea. Half of global fish trade comes from developing countries, while global consumption increased by 21 percent between 1992 and 2002. Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries (Al- Jufaili and Opara, 2006).

Fish supplies a good balance of protein, vitamins and minerals. It has a relatively 10 percent calories content hence its role in nutrition is recognised (Akande and Tobor, 1992). Fish and fish products constitute more than 60 percent of the total protein intake in adults especially in the rural areas (Adeleye, 1992). They are widely accepted on the menu card and form a much-cherished delicacy that cuts across socioeconomic, age, religious and educational barriers (Adeleye, 1992). Fish flesh is one of the best sources of protein. Its flesh is tender due to bundles of muscle fibers, which are held together by fibrous material when heated (Fagade, 1992). It is better digested than beef or other types of protein. In Nigeria, fish is eaten fresh, preserved or processed. The percentage composition of the different methods of fish disposed for consumption in the artisanal sector according to Tobor (1984) are as follows; live fish 7 percent, fresh fish 27 percent, smoke dried 45 percent, sun dried 20 percent salted and sun dried 10 percent.

Meanwhile, a wide variety of production systems, such as cages, ponds, tanks and raceways are being used for fish production (aquaculture), freshwater and marine environments in Africa. These systems are being used in small, medium and large scale operations and at various levels of intensity (Machena and Moehl, 2001). Currently, earthen ponds are the dominant production system in Africa.

A major proportion of public sector research and development effort has been directed towards increasing the productivity of pond systems. In order to increase the production potential of aquaculture in Africa, research and development should focus on a wider range of production systems for fish farming and on increasing the intensity of production in fishponds to help farmers achieve higher yields. The future of aquaculture in Africa lies in increasing production efficiencies and intensities so as to produce more fish using less land, water and financial resources. Also, an understanding of the causes of variability in production seasons is very crucial especially in the face of rapidly changing climate. Seasonal weather forecasts and early warning systems are frequently suggested as useful for informing the management of climate risks. But, as shown by Adejuwon et al (2007), they require an effective knowledge network to deliver their promised benefits. Seasonal forecasts are made for West Africa and Nigeria, but few farmers use them. Their reliability is low, the variables forecast are not ones that are most relevant to farmers' decisions, and the spatial resolution of the forecasts is coarse compared to what farmers' need. The forecasts are poorly disseminated, are delivered only shortly in advance of the forecast period, do not regularly reach smallholder farmers, and are in forms that are not readily understood by farmers.

A number of steps can be taken to improve this knowledge network so that farmers are provided with forecasts that they would use. Agricultural extension agents, working with both farmers and forecasters, could help forecasters to focus on the climate variables and spatial resolutions that matter to farmers and provide feedback from farmers to the forecasters about the performance and utility of the forecasts. The extension agents, who are based in over 700 local government units and work in local languages, could develop methods for communicating forecasts to farmers in ways that are useful and understandable. They could assist farmers to interpret and apply forecasts for making production decisions based on water availability. This will not only curtail the losses and problems often associated with seasonal fluctuations but will help in stabilizing production all year round.

RESEARCH METHODOLOGY

Study Areas and Sampling Technique

Two states were randomly selected out of the six states in southwest Nigeria. The selected states were Ekiti and Oyo States. Southwest Nigeria is one of the six geopolitical zones of the country and it's the region where one of the major ethnic groups (the Yorubas) resides. Also the region is known for a very large agrarian/rural setting. Other southwestern states are: Lagos, Ogun, Ondo and Osun. Primary data were collected through the aid of a well-structured questionnaire administered on 150 fish farmers. Also personal interviews and physical observations were also employed to complement the data for accuracy and reliability. A multistage random sampling method was employed. The first stage involved a selection of two states. Selection of local government areas (LGAs) was the second stage. Three LGAs were selected in Ekiti State (one from each senatorial district) and six LGAs were selected from Oyo State (two from each senatorial district) to make it representative. Thus a total of nine LGAs were selected in the second stage. The third stage was the selection one rural area (village/community) from each of the selected LGAs while the fourth stage was a random selection of fish farmers based on probability proportionate to size.

METHODS OF DATA ANALYSIS

Data collected were analysed using descriptive statistics and probit regression model. While descriptive statistics (tables, frequencies, pertcentages and averages) were used to summarise and describe respondents socioeconomic characteristics, probit model was employed to examine the determinants of seasonal variability among fish producers in the study area.

The probit regression model employed takes the form:

$$Y_i = f\left(X_1, X_2 - - - - - X_{12}, \varepsilon_i\right)$$

Y_i = Seasonality index (Y_i = 1, if affected by seasonality, Y_i = 0, if unaffected by seasonality)

Where $X_1 - - - - - X_{12}$ = Socioeconomic variables

X_1 = age^2 (years)

X_2 = gender (male = 0, female = 0)

X_3 = marital status (married = 1, single, divorced or widowed = 0)

X_4 = household size

X_5 = years of formal education

X_6 = main occupation (farming = 1, non-farm = 0)

X_7 = income from main activity (Naira)

X_8 = access to water- proxy for climate change (yes = 1, no = 0)

X_9 = access to electricity (yes = 1, no = 0)

X_{10} = access to credit facility (yes = 1, no = 0)

X_{11} = farming experience (years)

X_{12} = extension contact (yes = 1, no =0)

ε_i = Error term (stochastic)

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Fish Farmers in Ekiti and Oyo States

The result presented in Table 1 shows the distribution of respondents based on their socioeconomic characteristics. It was observed that respondents were still young and in their active working age with a mean of 45 years. Going by gender, there were more males (56 percent) than females (44 percent) and household size of respondents was fairly large with an average of 8 members and this could be attributed to the low level of wellbeing of the inhabitants of the study area. Thus as household size increases, income per capital declines which invariably lead to reduced wellbeing. About 43 percent of respondents were educated up to tertiary level with about a quarter having no formal education. This to some extent explains why a sizeable number of respondents patronize local medical practitioners.

Also, going by the source of livelihood (primary occupation), the distribution generally revealed the relative importance of farming (agriculture) as the main source of income for most inhabitants of urban Nigeria. This was closely followed by civil service job and this explains why young people in rural Nigeria migrate to city or urban centres in search of while collar or salaried jobs.

Table 1: Distribution of Fish Farmers by Socioeconomic Characteristics

Variable	Frequency	Percentage (%)
Age		
≤30	17	11.3
31-40	31	20.7
41-50	63	42.0
51-60	28	18.7
>60	11	7.3
Total	**150**	**100.0**
Gender		
Male	113	75.3
Female	37	24.7
Total	**150**	**100.0**
Marital Status		
Single	26	17.3
Married	84	56.0
Divorced	19	12.7
Widowed	21	14.0
Total	**150**	**100.0**
Household Size		
1-3	25	16.7
4-6	38	25.3
7-9	51	34.0
10-12	29	19.3
≥13	7	4.7
Total	**150**	**100.0**
Educational Status		
No formal education	57	

		38.0
Primary education	28	18.7
Secondary education	16	10.7
Tertiary education	49	32.6
Primary occupation		
Farming	79	52.7
Trading	20	13.3
Civil Service	15	10.0
Private salaried job	07	4.7
Artisan	20	13.3
Others	9	6.0
Total	**150**	**100.0**

Source: Survey Data, 2008

Ranking of Factors Influencing Fish Production and Availability in Southwest Nigeria

As revealed in Table 2, water shortage (proxy for climate change) was the most important factor affecting fish production and availability in the study area. From the table, about 46.7 percent of the respondents indicated this factor as the most pressing among all the factors considered. This was closely followed by poverty with 32.0 percent indicating it as the next to climate change. Following poverty was the cost of feed with about 7.3 percent of the respondents indicating it as the third factor influencing their production. Other factors include price changes (4.7 percent), lack of credit (3.3 percent), infrastructure (2.7 percent), labour shortage (2.0 percent) and disease infestation (1.3 percent). From this, it was very clear that climate change was a fundamental factor influencing fish production.

Table 2: Ranking of Factors Influencing Fish Production based on Farmers' Responses

Variable	**Frequency**	**Percentage (%)**
Poverty	48	32.0
Price changes	7	4.7
Climate change	70	46.7
Infrastructure	4	2.7
Lack of credit	5	3.3
Cost of feed	11	

7.3	
Labour shortage	3
2.0	
Disease infestation	2
1.3	
Total	**150**
100.0	

Source: Survey Data, 2008

Determinants of Seasonal Variability in Fish Production and Availability

Probit regression model was employed in ascertaining a number of factors considered to be determinants of fish production and availability seasonality in the study area. As shown in Table 3, the result of the analysis revealed that while the coefficients of age, household size, water shortage, accessible infrastructure, credit accessibility and poverty status were positively associated with seasonality, those of gender, years of formal education, income and years of experience were negatively related to it. In other words, respondents with experience, tertiary education, high income, had lower likelihood of being affected by seasonality. This is because education enhances productivity through easy adoption of improved and modern technologies which and invariably translate to better income and improved living conditions. Also, those with experience in fish production would have understood the challenges inherent in fish production and can easily take advantage of the seasonal fluctuations to improve their earnings through proper and informed planning. Water shortage, a proxy for climate change will negatively affect seasonality knowing fully well that water is crucial to fish survival. Thus any fluctuation in water availability as a result of climate change will affect fish production and its availability. Again, while the coefficients of climate change, years of formal education and experience were significant at one percent ($p<0.01$), those of household size, income and gender were significant at 5 percent ($p<0.05$). The coefficients of access extension contact and age were significant at ten percent ($p<0.10$). The levels of significant of these variables indicate how important they are in influencing fish production and availability in the study area.

Table 3: Probit Analysis Indicating Determinants of Seasonality in Fish Production in the Study Area

Variable	**Coefficient**
Age (X_1)	0.511
	(1.420)
Age^2 (X_2)	0.036*
	(2.012)
Gender (X_3)	-1.619**
	(2.180)
Household size (X_4)	0.275**

	(1.964)
Years of formal education (X_5)	-0.323***
	(2.901)
Main occupation (X_6)	0.829
	(1.006)
Income from main activity (X_7)	-0.103**
	(2.341)
Access to water (X_8)	1.185***
	(3.126)
Access to electricity (X_9)	-0.053***
	(0.149)
Access to credit facility (X_{10})	0.389
	(0.133)
Farming experience (X_{11})	-0.201***
	(2.914)
Extension contact (X_{12})	0.230*
	(1.970)
Constant	-0.101
	(1.864)

***Coefficients significant at 1 percent, **Coefficients significant at 5 percent, *Coefficients significant at 10 percent

Number of Observations = 150, Log-Likelihood = -0.0003582, Figures in parenthesis are t-values

Source: Computed from Survey Data, 2008

CONCLUSION AND RECOMMENDATIONS

The study examined seasonality in fish production and availability in southwest Nigeria. Findings revealed that average age of respondents was 42 years with more men involved in fish production activity than women. Also, household size of fish farmers in the study area was fairly large averaging 8 members and that about one-third of them were educated up to tertiary level. However, ranking of factors influencing seasonality showed that water shortage, poverty and cost of feed were very conspicuous in their responses. The result of the probit analysis employed to ascertain the determinants of seasonal variability in fish production and availability revealed that water shortage, education, farming experience, income, gender of respondents and extension contacts as very important. Based on the findings of the study, it is therefore recommended that;

1. Effort should be geared by government towards provision of adequate information on weather variables influencing fish production in the country since this will help curtail the uncertainties pervading the sector.

2. Investment in capacity building through education is also very important as this will reduce respondents' vulnerability to seasonal variability.

3. Provision/improvement in existing infrastructural facilities should be made a priority to enhance the earning potentials of the respondents.

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ANALYSIS OF SEQUENCE HOMOLOGY AND DIVERGENCE OF DROUGHT TOLERANT GENES IN PLANTS

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Abstract

It has been established that drought tolerant (DT) trait in plants is under control of many genes, which are expressed at different parts of plants at various stages of growth. Bioinformatics tools were employed for analysis of DNA sequences encoding DT genes available at public database (Genbank). About 70% of DT genes reside in the nucleus while limited proportion of DT genes are localized in other parts of cell like chloroplast, endoplasmic reticulum, cell wall and endomembranes. Phylogenetic tree analysis using Neighborhood-Joining method of DT sequences revealed six distinct gene groups belonging to several gene families and subfamilies, which are largely based on gene localization, primary and secondary functions and expression pattern. Sequence alignment by *clusta IV* programme showed several conserved regions of DT genes. Information from the conserved sequences was used to design oligonucleotide primer pairs for isolation, cloning and characterization of similar DT genes in crop plants. The oligonucleotide primer pairs length ranged from 20 to 22 base pairs with estimated product size of between 266 and 428 base pairs and annealing temperature of 59 – 60.2^{0}C. The primers were capable of DNA amplification by polymerase chain reaction (PCR) without the problems of hairpin formation, 3' complementarity and self-annealing. Compositions of candidate genes with suitable promoters for transformation of crop against water deficit were suggested.

Keywords: drought, gene, homology, sequence, tolerant.

Abbreviations: ABA – abscisic acid, ABF3- abscisic acid factor, AP2/ERF – APETALA 2/ethylene-response factor 3, AREBI- ABA-responsive element binder 1, AREB/ABF- ABA-responsive element binder/ABA-factor, Bzip – basic region leucine zipper, cDNA – complementary deoxyribonucleic acid, DNA- deoxyribonucleic acid, DRE/CRT – dehydration –response element/C-repeat, GC- guanine-cytosine content.

INTRODUCTION

A major impact of climate change is drought which imposes limited-water environment on plants. Under drought condition, water available for plant uptake for metabolic reactions fall below requirement, thus producing water deficit in plants. The effects of water deficit on crop plants are many and vary depending on length and intensity of drought and stage of growth of plant (Bray, 1997). Drought can result in total crop loss if no effort is made to mitigate the effect of water deficit on plants. Under water deficit, crop yield reduces significantly as major biochemical and physiological changes with direct impact on yield are negatively affected. In some situation where crop produces yield under drought condition, low quality yield results as assimilate production, distribution and partitioning are affected. This situation produces low nutrient content and other yield qualities from drought-stressed plants (Boyer, 1982). Where efforts are made to reduce the effect of water deficit on crop like irrigation and other crop production practices like mulching, it increases cost of production which reduces profit margin on crop farming. High incidence of disease and pest is common in drought condition. Some pathogens proliferate under condition of drought when water-stressed plants could not resist their entrance while some pests reproduce under drought condition for latter invasive attack of crops struggling for life (Boyer, 1982; Bray, 1997).

Water deficit elicits some biochemical and physiological changes in plants, which are mainly adaptive means of coping with water-limited environment. Physiological and biochemical changes at the cellular level that are associated with drought stress include turgor loss, changes in membrane fluidity and composition, changes in solute concentration, and protein–protein and protein–lipid interactions (Chaves *et al*.,2003). Plant tissues can maintain turgor during drought by avoiding dehydration, tolerating dehydration or both (Kramer and Boyer, 1995). These forms of stress resistance are controlled by developmental and morphological traits such as root thickness, the ability of roots to penetrate compacted soil layers, and root depth and mass (Pattan *et al*., 2004). Constitutive phenotypic traits (e.g. root thickness) are present even in the absence of stress conditions. By contrast, adaptive traits, such as osmotic adjustment and dehydration tolerance, arise in response to water deficit (Serraj and Sinclair, 2002) Reduction of photosynthetic activity, accumulation of organic acids and osmolytes, and changes in carbohydrate metabolism, are typical physiological and biochemical responses to stress. The reduction in photosynthetic activity is due to several coordinated events,such as stomatal closure and the reduced activity of photosynthetic enzymes. Synthesis of osmoprotectants, osmolytes or compatible solutes is one of the mechanisms that plants have evolved for adaptation to water deficit. These molecules, which act as osmotic balancing agents, are accumulated in plant cells in response to drought stress and are subsequently degraded after stress relief (Tabaeizadeh, 1998). Osmoprotectants include amino acids, polyols, and quaternary ammonium and tertiary sulfonium compounds (Rontein *et al*., 2002). Early studies on changes in the carbohydrate metabolism of plants that are exposed to drought stress suggested that, under dry conditions, the hydroxyl group of polyhydroxy compounds can form a hydrogen bond with the polar heads of membrane phospholipids, and that these hydrophobic interactions are important for membrane stability (Chaves *et al*.,2003:Villadsen *et al.,*2005)

The biochemical and physiological changes that occurred in drought-stressed plants are under control of certain genes. These genes can be grouped into functional and regulatory genes (Shinozaki *et al*., 2005). Functional genes produces their protein products under water-stressed conditions which encode enzymes associated with the synthesis of osmotically active compounds, transporters chaperones and reactive oxygen species scavengers. Regulatory genes are DNA sequences which induce other genes in response to drought. These regulatory genes are transcription factors (TF) which regulate the expression of downstream target genes that are involved in drought stress tolerance and response. Most of the TF falls into several large families such as AP2/ERF, Bzip, NAC, MYB, MYC and Cis2HIS2 zinc-finger. Furthermore, genes that are involved in drought tolerance are categorized into absicic acid (ABA)-responsive and ABA-independent ones. Production of ABA precedes the formation of ABA-responsive genes, and they generally responds to externally apply ABA. Examples of ABA-responsive genes in plants are galactinos synthase, late embryogenesis abundant proteins, early response proteins, AREB/ABF proteins, MYC and MYB proteins. Formation of ABA does not accompany induction of ABA-independent genes and they are not responsive to external application of ABA. Mannitol dehydrogenase, trehalose phosphate synthase, DRE/CRT proteins and TFs like ERF/AP2 family and ABF3 (Yamaguchi-Shinozaki *et al*., 1992; Kiyosue *et al* 1994). Some of the drought tolerance genes had been isolated from genomic and cDNA libraries, cloned, sequenced and their DNA sequences (partial or complete) deposited in public databases. The objectives of this study were to (i) identify conserved nucleotide sequence regions among drought tolerance genes in plants and (ii) design oligonucleotide primer pairs for discovery of drought tolerance gene in crops.

METHODOLOGY

A nucleotide sequence search of a drought tolerant gene, *SIDRI* (*GenBANK* accession No At3g55530), in *Arabidopsis thaliana* was performed at National Centre for Biotechnology Institute (NCBI)'s database. The SIDI sequence was used to conduct a BLAST search which produced 33 nucleotide sequences encoding drought tolerant genes in Arabidopsis, rice and other crop plants. Phylogenetic analysis of the sequences was carried out using Neighbourhood-Joining Method (Saitou and Nei, 1987) with *CLC* DNA analysis software version 6.1. Multiple alignments of the sequences were performed by *clusta v* programme to identify region of homology and divergence among the sequences. Oligonucleotide primer pairs were designed from conserved region of the sequences using primer 3 programme as described by Rozen and Skaletsky (2000). Suitability of the primer pairs was confirmed by primerblast programme of NCBI.

RESULTS AND DISCUSSION

Cell localization and role of DT genes in *Arabidopsis*

A list of gene involved in drought tolerance in *Arabidopsis* is presented in Table 1. About 70% of the genes controlling responses to drought in *Arabidopsis* are located in nucleus. Drought tolerance genes were also located in chloroplast, microsome, plasma membrane and cell wall. About 54% of these genes had drought tolerance as their primary function while 46% had drought response as their secondary function. Chromosome 1 and 2 contained the largest proportion (38% each) of drought tolerance genes. Some drought inducible genes, e.g. *SAL1*, were highly active, involving in as many as 14 cellular processes (data not shown). In addition, some drought tolerance genes,e.g. *SIZI, NF-YB1,LEW1 and SAL1*, exhibited constitutive expression pattern: they were detected in as high as 24 different plant structures at 15 growth stages (data not shown). Because of the small genome of *Arabidopsis* compare to other plants,it has been serving as model plant for discovery of drought-inducible genes. Microarray technology employing cDNA or oligonucleotides is a powerful tool for analysing gene expression profiles of plants exposed to abiotic stress such as drought, high salinity, or cold, or to ABA treatment (Seki *et al*., 2001). A 7000 full-length cDNA microarray was utilized to identify 299 drought-inducible genes, 54 cold-inducible genes, 213 high salinity-inducible genes, and

245 ABA-inducible genes in Arabidopsis (Seki *et al*., 2002). More than half of these drought-inducible genes were also induced by high salinity and or ABA treatment, implicating significant cross-talk between the drought, high salinity, and ABA response pathways. In contrast, only 10% of the droughts –inducible genes were also induced by cold stress. Data from microarray technology analysis of stress-inducible genes in rice were consistent with the overlap of gene expression in response to drought, salinity and cold observed in *Arabidopsis*. In eukaryotes, most genes are not organized into *operon* as in prokaryotes. Instead genes are dispersed in the genome which are coordinately controlled by one or more enhancer DNA sequences located near each gene that interact with transcriptional activator proteins (Shinozaki and Shinozaki *et al*.,2007). The high activity and wide expression pattern of the drought tolerant genes could be due to involvement of most of them in multiple stress response.

Phylogenetic analysis of DT genes in plants

Six distinct gene group were obtained from phylogenetic analysis of DNA sequences controlling drought tolerance traits in plants (Fig.1). Five out of the six gene groups contained *Arabidopsis* genes involve in drought tolerance while similar genes in cultivated crops formed a group. Group A was peptidyl cis-trans isomerase and ABA-independent gene located in chloroplast, particularly the thylakoid lumen. Group A had 89% homology with conserved nucleotide region of 899 bp located at position 60-959 in single form (Fig. 2). The identity of nucleotide sequences among DT genes was the basis of grouping by phylogenetic tree (Saitou and Nei, 1987). The presence of DNA in chloroplast has been documented , which makes it capable of reproducing itself somewhat independent of nucleus (Bray,1993). The discovery of drought-inducible gene as in group A which localized in chloroplast further confirmed the presence of DNA in chloroplast. Group B consist of DNA binding, small ubiquitin modifier ligase gene. They are ABA-independent functional gene located in cell nucleus. They had 96% identity which occurred as a single stretch for a length of 2815 bp between nucleotide 1 and 2815. Group C were nuclear factor transcription sequences. They were ABA-independent regulatory gene located in CCAAT-binding factor complex. They shared 63% homology with double conserved nucleotide regions. The first conserved region was 517 bp long located at 17- 534 nucleotide position and the second was 53 bp long located between 623-675 position. Group C is a subfamily of a large family of regulatory proteins. These protein factors were reported to be involved in further regulation of signal transduction and stress-responsive gene expression (Bartels and Sunkars, 2005).Other example of transcription factors documented to date are protein kinases, protein phosphatases, enzymes involved in phospholipids metabolism, and other signaling molecules such as calmodulin-binding protein (Shinozaki and Shinozaki *et al*.,2007).These transcription factors could govern expression of stress inducible genes either co-operatively or independently, and may constitutes gene networks in *Arabidopsis*. Valliyodan and Nguyen (2006) established that transcription factors in drought stress tolerance are conserved across dicot and monocot lineages because they have similar impacts on specific phenotypes. Group D consist of DNA and protein binding regulatory

ABA-dependent genes. They had 72% identity with conserved region of 1192 bp long between nucleotide 22-1217 in a single form. Group E consist of functional gene with drought responsive element (DRE) and consist of both ABA-dependent and ABA-independent genes. They had 38% homology with no conserved nucleotide sequence region. Group D and E contain drought responsive genes that contain ABA-responsive element which allow ABA-mediated signal for their activation under drought condition. This phenomenon is due to ABA-dependent phosphorylation of genes. Overexpression of ABF3 caused ABA hypersentivity, reduced the transpiration rate,and enhanced dought tolerance in transgenic Arabidopsis plants (Kang et al.,2002).Recently,transgenic plants expressing a phosphorylated form of AREB1 with multisite mutations displayed induction of many ABA-responsive genes without exogenous ABA application (Fujita et al.,2005).These data suggest that such constitutively active forms of transcription factors rendered by point mutations may contribute to enhancement of drought tolerance in transgenic plants. Group F were genes involved in drought tolerance in other plants. They had 45% identity with conserved nucleotide scattered along the length of the sequence. Group F consist of orthologues of functional and regulatory genes which are drought-inducible cloned from *Arabidopsis* and present in cultivated crops. They had scattered conserved nucleotide along their sequence because they represent member of different gene families with limited sequence similarity except that they are drought-inducible genes in crops.

Oligonucleotide primer pairs

Twenty oligonucleotide primer pairs were designed from five conserved nucleotide sequence regions from five distinct gene groups (Table 2). No primer pairs were obtained from group E because of the scattered conserve nucleotide sequence. The length of the oligonucleotide primer pairs ranged from 20-22 bp with GC content of between 45-60%. The melting temperature of the primer pairs ranged from 59-60.2 0C with 266-428 bp product size. The oligonucleotide primer pairs are gene-specific short nucleotide sequences for DNA amplification using polymerase chain reactions. The primers are made up of both forward and reverse strands for accurate amplification of DNA. The problems of hairpin formation, 3' complementarity and self-annealing were eliminated using primer 3 programme to predict the efficiency of the primers. The GC contents of the primers were adequate for specific amplification of interested drought tolerant genes. Mundree *et al*. (2000) identified, isolated and cloned an aldose reductase gene from the resurrection plant, *Xerophyta viscosa* Baker, while Mowla *et al*. (2002) and Qin *et al*. (2004) cloned a novel stress-inducible gene from the same plant with similar approach.

Candidate DT gene construct

The conserved nucleotide sequence of group B which was 2815 bp long could serve as candidate functional gene for engineering drought tolerance in crops while the conserved nucleotide sequence of group D which was 1192 bp long could serve as effective regulatory gene for genetic modification of crops to induce ABA-responsive drought-tolerant genes on crops (Fig.2). The two candidate genes could express themselves at any plant growth stage at different plant parts when place under the controll of plant promoters of viral origin such as cauliflower mosaic virus 35S (CaMV 35S) and cassava vein mosaic virus (CsVMV). Stress tolerance was enhanced in tomato by introduction gene responsible for trehalose biosynthesis (Cortna *et al*.,.2005).Similarly gene construct designed from Arabidopsis DREEB1A was used to enhance water stress tolerance in wheat (Pellegrineschi *et al*., 2004)

In summary, we searched for DT genes in *Arabidopsis* and other plants from public databases. The DT genes were classified into six distinct groups based on the homology of their nucleotide sequences. The conserved nucleotide sequences in the six gene groups were identified and used to design oligonucleotide primer pairs for discovery and cloning of similar genes in crops. The compositions of candidate gene constructs for transformation of crops to enhance drought tolerance were suggested.

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Table 1:Plant cell localization, chromosomal position and drought tolerance role of some DNA sequences encoding drought tolerance genes in Arabidopsis (*Arabidopsis thaliana* L.)

Accession Number*	Name of gene	Description	Localization	Chromosomal position	DT role
NM_001125993	*SIZI*	DNA binding/ligase	nucleus	5	secondary
NM_129445	*NF-YB1*	nuclear factor	nucleus	2	primary
NM_179446	*ABF2*	ABA binding factor	nucleus	1	primary
NM_125794	*SAL1*	inositol phosphatase	nucleus,chloroplast & cytoplasma	5	primary
NM_117994	*IRX1*	cellulose transferase	cell wall & plasma membrane	4	secondary
NM_115410	*SDIRI*	protein binding	microsome	3	primary
NM_100466	*POMI*	chitinase	endomembrane system	1	secondary
NM_101405	*SHINE 1*	DNA binding	nucleus	1	secondary
NM_179974	*NF-YB1*	nuclear factor	nucleus	2	primary
NM_121165	*OCP3*	transcription factor	nucleus	5	secondary
NM_125434	*SIZI*	DNA binding	nucleus	5	secondary
NM_100554	*DRIPI*	protein binding	nucleus	1	primary
NM_202252	*ABF2*	DNA binding	nucleus	1	primary

*Genbank accession number   DT - drought tolerance

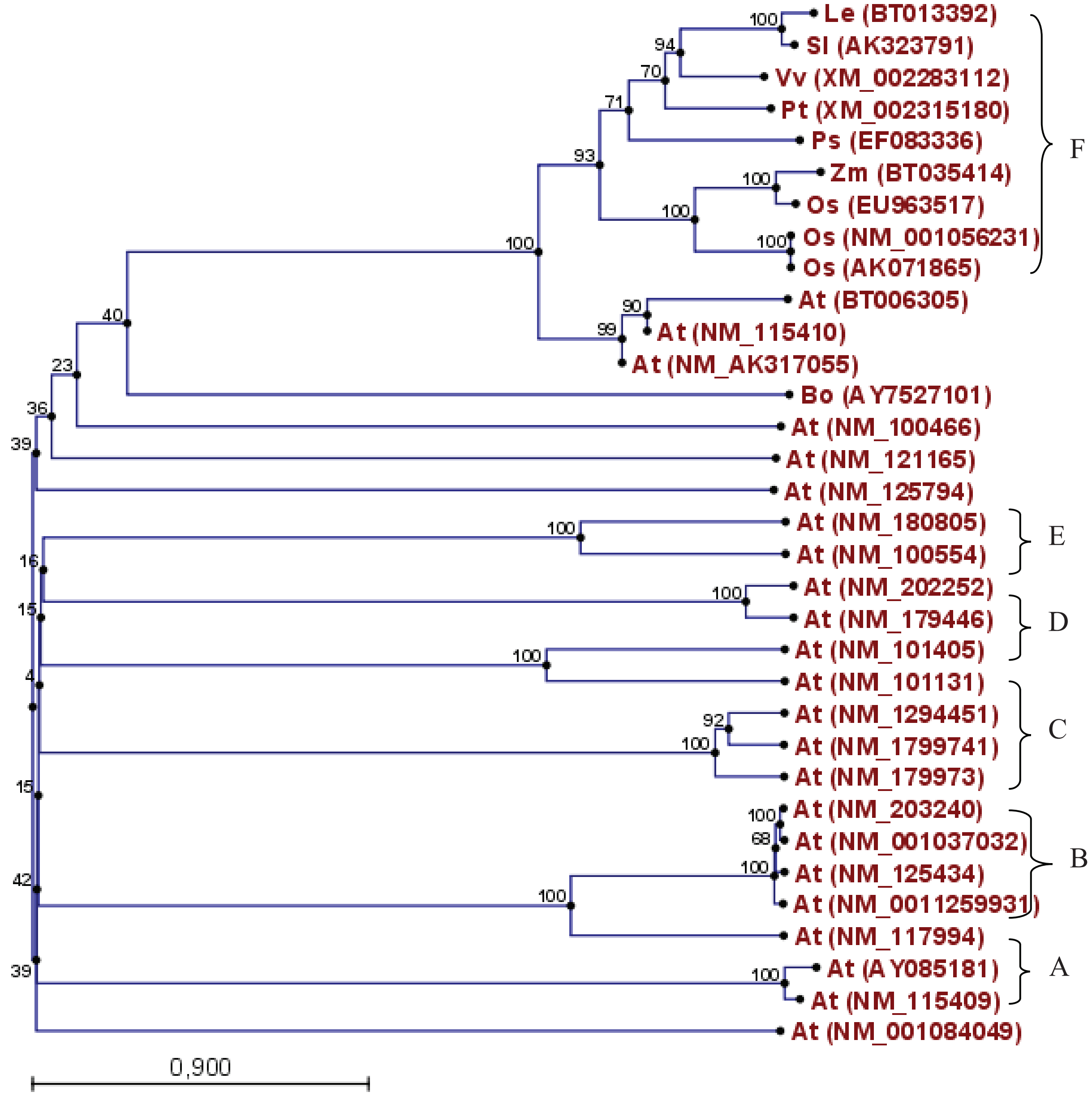
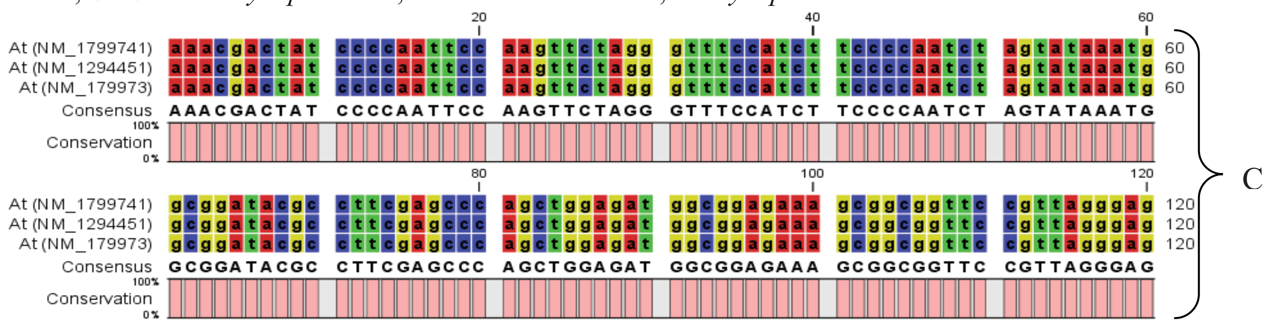


Fig. 1: **Phylogenetic tree of drought tolerant genes in plants.** The number of bootsrap replicates is indicated next to each branch. The six distinct gene groups are indicated. The scale indicates the average substitution per site. The abbreviations and number in brackets are GenBank accession numbers At- *Arabidopsis thaliana*, Os- *Oryza sativa*, Zm- *Zea mays*, Ps- *Pisum sativum*, Vv- *Vitis vinera*, Sl- *Solanum lycopersicum*, Ps- *Picea sitchensis*, Le-*Lycopersicon esculentum*



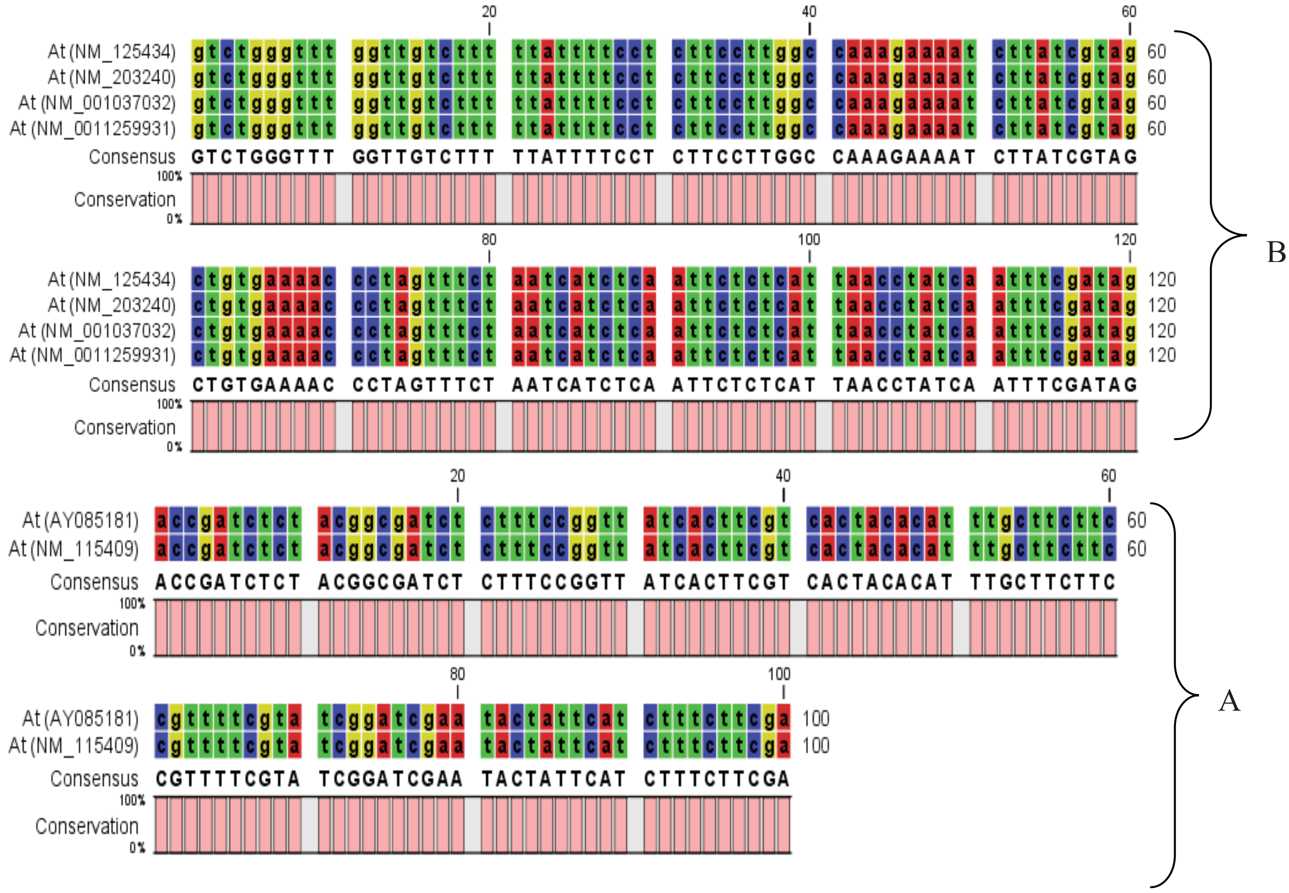


Fig. 2: Three conserved nucleotide sequence regions of *Arabidopsis* drought tolerant genes.

Table 2: Oligonucleotide primer pairs for amplification of drought tolerant genes in plants

Group	composition	MT (^{0}C)	PSIZE (bp)	GC (%)
A	1. 5'-TTTGCTTCTTCCGTTTTCGT-3'	59.86	423	40.0
	5'- CCTTTTCGTCTTCAGCCAAG-3'	59.99		50.0
	2. 5'- TTTGCTTCTTCCGTTTTCGT-3'	59.86	351	40.0
	5'-CATCAGGTTTGGCACTCCTT-3'	60.11		50.0
B	1. 5'-CTGTGCAGGCAAGAATTGAA-3'	59.99	374	45.0
	5'-AACCACTGTGCCCACTTTTC-3'	60.10		50.0
	2. 5'-CTGTGCAGGCAAGAATTGAA-3'	59.55	280	45.0
	5'-GAACCACTGTGCCCACTTTT-3'	60.10		50.0
C	1. 5'-GCGTTGCCTCCTAATGGTAA-3'	60.10	428	50.0
	5'-ACCCTCCAACTCCCTGTACC-3'	60.23		50.0
	2. 5'-GGCAATGGCAACATTAGGAT-3'	59.79	375	45.0
	5'-TTACCAGCTCGGCATTTCTT-3'	59.85		45.0
D	1. 5'-GCGTTGCCTCCTAATGGTAA-3'	60.10	428	50.0
	5'-ACCCTCCAACTCCCTGTACC-3'	60.23		60.0
	2. 5'- GGCAATGGCAACATTAGGAT-3'	59.79	266	45.0
	5'-TTACCAGCTCGGCATTTCTT-3'	59.85		45.0
F	1. 5'-TCAGGCACACAGGTTCTCTG-3'	60.02	374	55.0
	5'-TCACCCACACTGACTTGCTC-3'	59.87		55.0
	2. 5'- ACCAATTCCCTGGCTTTTCT-3'	69.94	312	45.0
	5'-GCAGCTCAGTGTGACCAAGA-3'	60.19		55.0

MT- melting temperature PSIZE- product size GC –guanine-cytosine

SOIL CARBON DIOXIDE EVOLUTION IN RESPONSE TO AGRICULTURAL LAND USE

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Abstract

Global climate change due to greenhouse effect induced by the increase in the atmospheric carbon dioxide is one of the problems confronting this generation. Agricultural land use has been implicated as one of the sources of carbon dioxide emission into the atmosphere. This study investigates the influence of land use on the emission of CO_2 from the soil. Using a static chamber method with the use of alkali to trap CO_2, the CO_2 emission from a maize farm subjected to different management was investigated. An experimental plot originally set up to evaluate the influence of the use of difference bush fallow species on soil quality and maize yield was evaluated. The treatment consisted of Pueraria, Panicum, Euphorbia, natural fallow and natural fallow with fertilizer all of which were ploughed under and then planted to maize. Carbon dioxide emission was monitored during the period when the plots were under maize cultivation. The result showed that there were no significant differences in the CO_2 evolved among the treatments. However, the CO_2 emission was found to be positively influenced by soil water content and soil temperature. This study demonstrated that arable agricultural soil may contribute as much as 14-18 t ha^{-1} of CO_2 annually to the atmospheric CO_2 load. By careful manipulation of the soil temperature regime through canopy cover or through some vegetated means it may be possible to reduce CO_2 emission from agricultural soils.

INTRODUCTION

The increasing global warming which is a challenge to this generation has been ascribed to the increased concentration of the greenhouse gases in the atmosphere. This is mainly due to activities of man such as CO_2 from the burning of fossil fuels and from agricultural activities. Conversion of forested land to agriculture, bush burning, swamp rice cultivation and ruminant animals production among others have been implicated in the production greenhouse gases. Carbon is stored in the soil as organic matter and is respired by plants, bacteria, fungi and animals. Release of CO_2 from the soil occurs through different processes such as microbial decomposition of SOM and root respiration which together is referred to as soil respiration. Soil respiration has been identified to play a significant role and as well as being a driver for climate change. It can be partitioned to root respiration, microbial respiration, as they consume the labile carbohydrates exudates from plant roots, decomposing litters and oxidation of soil organic matter. Decomposition of litters is responsible for a greater part of soil respiration (Wang et al., 1999). Soils altogether contain an estimated 1,700 Gt (billion metric tons) to a depth of 1 m and as much as 2,400 Gt to a depth of 2 m. An estimated additional 560 Gt is contained in terrestrial biota (plants and animals). In contrast, the carbon in the atmosphere is estimated to total 750 Gt. Thus, the amount of organic carbon in soils is more than four times the amount of carbon in terrestrial biota and three times that in the atmosphere (Cox et al., 2000; Hillel and Rosenzweig, 2009). Researchers have estimated that soil respiration accounts for 77 Gt of carbon released to the atmosphere each year. This level of release is one order of magnitude greater than the carbon released due to anthropogenic sources (6 Gt per year) such as fossil fuel burning. Alteration of soil conditions such as moisture content, aeration and temperature to a large extent determine soil biological activities and hence both the potential of soil to either release carbon as CO_2 to store it as SOM (Almagro et al., 2008). It is generally agreed that only soil offer the potential to mitigate atmospheric CO_2 by sequestering it as carbon over a short time period. All other methods will take several years before they can bring about any noticeable change in atmospheric carbon dioxide level (West and Marland, 2001; Hillel and Rosenzweig, 2009). Agricultural soils therefore play a key role in C cycling by acting as either source or sink of C and thereby impacting greenhouse emissions (Paustian et al., 1997; Dumansk et al., 1998; Berroux et al., 2002). There can be no simple universal prescriptions regarding practices to manage soils so as to help mitigate the greenhouse effect. While the basic principles can be stated in universal terms, their application to different sites will require specific adjustments (Hillel and Rosenzweig, 2009). The Kyoto Protocol however affirms that part of the CO_2 emissions from fossil-fuel use and from other sources, can be offset by removal of CO_2 from the atmosphere via a net increase in the C stocks of the biosphere. Emissions offsets via reforestation and afforestation are endorsed by the Kyoto Protocol now, and sequestration service by farmers and other landowners could provide a source of C-emission credits to be sold to emitters of C and hence provide an additional source of income for farmers (West and Marland, 2001). In sub-Sahara Africa, little efforts have been made to quantify the extent of CO_2 emission resulting from different agricultural landuse. This is required to be able to effectively trade in C stock under the clean development mechanism (CDM). In several of the developed countries of the world, the potentials of different types of land use and different levels of input to either sequester or to release CO_2 are already clearly documented and are being used by farmers to negotiate for C sales. However in Nigeria, there is a dearth of information on the association between different agricultural landuse and the level of carbon released as CO_2 or sequestered as SOM under different types of agricultural land management. In Nigeria, like other developing economies, there is little data available on the potential of different land use management practices on the magnitude of C stored or released from the soil. It has therefore not been possible to evaluate the quantity of C stored under these landuse management practices such as practiced in these developing countries. This has not enabled farmers in these countries to participate actively like their counterparts in the developed economies in carbon trading. The objective of this study is to determine the relationships between some soil properties to soil CO2 evolution and to quantify the contributions different agricultural land use to the release of CO2 from soil

MATERIALS AND METHOD

The field experiment was carried out at Obafemi Awolowo University Teaching and Research Farm (T&RF), Ile-Ife (latitude 7°25´ N, and longitude 4°39´E), Nigeria. It is located in the rainforest ecosystem in the southwestern region of Nigeria with a mean annual rainfall of about 1400 mm which is bimodally distributed with peaks in June and September. Average annual insolation/radiation is 18.7 MJ m^{-2} day^{-1}. The soil derived from coarse grained granite and gneisses is classified at series level as

Iwo series (Smyth and Montogomery, 1962) and as Oxic Haplustult and Ferric Acrisol respectively according to USDA Soil Taxonomy and WRB soil classification systems (Nwachokor and Uzu, 2008). The soil is well drained with the surface texture varying from sandy loam to sandy clay loam. It was located on a 1-2 % slope. The 0.7 ha experimental field was previously cultivated to different fallow species to determine the effects of controlled fallow on soil properties and the yield of succeeding maize crops (See Tijani et al., 2008 for full description). The fallow treatments were: NNF (native fallow), NFF (native fallow with addition of fertilizers during cropping), PAF (*Panicum maximum* J.), EUF (*Euphorbia heterophyllum* L.), and PUF (*Pueraria phaseoloides* B.). The treatments were replicated four times. The static chamber method was used to measure CO_2 flux. It consisted of a 13-litre transparent plastic container. The container was pushed into the soil to a depth of 5 mm at each of the sites. A solution of 0.5 M NaOH in a beaker was placed inside the plastic container to trap the CO_2 evolved from the soil. The NaOH was removed after 2 hours and immediately titrated against 0.5 M H_2SO_4 to determine the CO_2 absorbed. Measurements were taken twice during the growing season and compared with an adjacent undisturbed forest. At the time of determination, the soil moisture content, pH, temperature and the organic matter content at each sampling point were determined. Soil samples collected at each sampling date were analysed for pH in water (1:1) using an ISFET pH meter.

RESULTS AND DISCUSSION

Soil properties

There was no significance difference in soil moisture content under the different treatments (Table 1). This is apparently because the effects of previous fallow treatments had waned after it was tilled and then subjecting it to uniform maize cultivation. The soil temperature early in the season was however highest under both plots that were under previously under Pueraria and Panicum fallows. The darker coloration of these soils consequence upon higher soil organic matter (SOM) contents could have resulted in the absorption of more sunlight thus raising the soil temperature. This is more so at the early stages when the cultivated maize had not established enough cover to shield the soil surface from the heat of the sun. Soil pH was significantly lowest (5.90) on the plot that was treated with inorganic fertilizer after previous native fallow. Nitrogen based inorganic fertilizers have long been associated with soil acidification in the savannah ecosystems of Nigeria (Singh and Balasubramanian, 1979). This modification of the soil reaction is expected to influence the soil biota and hence the SOM dynamics. Both the control (forest) and Pueraria plots however had the highest soil pH levels. The soil water content at the second sampling during the late season (Table 2) followed a similar pattern as that in the early season with no significant difference among the treatments. Soil temperature was however significantly lowest under the forest while there was no significant difference among the other treatments. This is because at the late maturing stage, the maize had established a uniform canopy cover across all the treatments. Lower soil temperature recorded under the forest was due to a much higher canopy cover under the forest gallery consisting of vegetation cover at different heights thus achieving maximum soil cover. Soil pH at the second sampling also followed a similar trend as the first season. There was however the soil pH at late season was lower than at early season across all the treatments.

Carbon dioxide evolution

The carbon dioxide evolved from the cultivated soils ranged from about 15 t ha^{-1} to about 18 t ha^{-1}. This amount is by a magnitude of 2 higher than the amount released from the forest soil. However, previous fallow had no significant effect on the magnitude of CO_2 evolved from the soil after it was cropped to maize. This again may be attributed to the uniform effect of tillage and the cultivation of maize monocrop. The early season measurement was significantly lower than the late season values. This may be ascribed to lower soil moisture contents coupled with lower temperature at the time of sampling. The late season sampling was done in November which is a period at which the ambient air temperature and hence the soil temperature is generally low. This will expectedly retard the activities of SOM decomposing soil microorganisms.

Correlation between soil properties and CO_2 evolution

The correlation matrix between soil properties and CO_2 evolution is presented in Table 3. Soil water content and temperature were significantly ($p < 0.01$) with soil CO_2 release. This relationship is similar to earlier findings. Almegro et al. (2008) observed positive relationships between soil CO_2 efflux and both soil water content and temperature. They concluded that while temperature is important when the soil is uniformly wet, soil moisture became more important during the dry summer periods such as experienced in the Mediterranean regions. The relationships between soil temperature and soil CO_2 efflux however have been found to be exponential (Hoshimoto et al., 2009). This is in consonance with earlier findings of Fang and Moncrieff (2001).

CONCLUSIONS

The study quantified the CO_2 efflux from arable agricultural soils showed that increased soil water content and temperature are driving factors for its release from arable agricultural soils. It also demonstrated that the conversion of forest to conventional arable cultivations more than doubled the release of CO_2 from the soil. Thus measures that keeps the soil temperature down while ensuring minimum soil disturbance has a promise of reducing soil CO_2 efflux. Therefore agricultural practices such as the planting of cover crops, no tillage and the use mulch and other measures to keep the soil temperature minimal are recommended for greenhouse mitigation in such agricultural soils.

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Table 1: Effects of previous fallow on soil properties and CO_2 evolution from cultivated farmland early in the season (4 WAP)

Treatments	Water content (cm^3 cm^{-3})	Temperature (˚C)	pH	CO_2 (t ha^{-1} yr^{-1})
Native fallow	0.145a	30.56ab	6.58a	15.21a
Fertilized after fallow	0.125a	30.00b	5.90b	16.62a
Pueraria	0.143a	31.53a	6.38a	17.51a
Panicum	0.125a	31.33a	6.28ab	15.21a
Euphorbia	0.123a	30.84ab	6.23ab	14.98a
Forest	0.141a	26.33b	6.55a	7.35b

Means in the same coloumn followed by the same alphabets are not significantly different according to Duncan's Multiple Range Test

Table 2: Effects of previous fallow on soil properties and CO_2 evolution from cultivated farmland late in the season (8 WAP)

Treatments	Water content (cm^3 cm^{-3})	Temperature (˚C)	pH	CO_2 (t ha^{-1} yr^{-1})
Native fallow	0.073a	29.72a	6.48a	11.42a
Fertilized after fallow	0.093a	29.58a	5.83b	14.54a
Pueraria	0.07a	30.0a	6.25a	11.13a
Panicum	0.078a	30.28a	6.18ab	8.98a
Euphorbia	0.084a	29.72a	6.13ab	7.49a
Forest	0.091a	26.52b	6.45a	5.32b

Table 3: Correlation between CO_2 evolved and some soil properties in early season

	Water content	Temperature	pH	CO_2
Water content	1.00			
Temperature	-0.49^{**}	1.00		
pH	0.79^{**}	-0.43^{*}	1.00	
CO_2	0.54^{**}	0.45^{**}	0.16	1.00

** = P < 0.01; * = P < 0.05.

PROMOTING SUSTAINABLE AGRICULTURE IN A PERTURBED ENVIRONMENT: THE ROLE OF SCIENCE AND TECHNOLOGY

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Abstract

Food crop production is intricately linked to climate and weather. Any significant change in the two natural factors could affect crop production. Quite a number of scientific literatures now agree that over the coming decades, higher temperatures and changing in precipitation regimes caused by climate change will affect crop yields in many countries. The impact of this climate change will be significant in the low-income countries, where adaptive capacities are already low. The main source of income in most rural communities in Sub Saharan Africa still remains agricultural production. Therefore, adopting appropriate technologies by the local farmers to mitigate and adapt to the impacts of climate change and climate variability is of utmost importance to the sustainability of their livelihoods. This paper enumerates various conventional and emerging technologies that can achieve sustainable agriculture. It concludes that in spite of the enormous challenges posed by climate change, appropriate and timely science and technology interventions would make a significant impact in the development of a vibrant sustainable agricultural production system.

BACKGROUND

Agricultural lands are estimated to occupy 37% of the Earth's land surface while the various agricultural activities account for 52% and 84% of global anthropogenic methane and nitrous oxide emissions respectively (Smith, 2007). The agriculture sector is a major contributor to the current economy of most developing countries, averaging 21% and ranging from 10% to 70% of the GDP (Mendelsohn et al., 2000). Food crop production is intricately linked to climate and weather. Any change in the two natural factors could affect crop production globally. Quite a number of scientific literatures now agree that over the coming decades, higher temperatures and change in precipitation regimes caused by climate change will affect crop yields in many countries. The impact of this climate change will be significant in the low-income countries, where adaptive capacities are already low. Moreover, many of the developing countries that practise rain-fed agricultural systems are particularly vulnerable to climate change impacts. Thus, for many low-income countries that are highly vulnerable to effects of climate change, designing appropriate adaptation strategies to climate change impacts is very important. Of more importance is the role that science and technology can play in reducing their level of vulnerabilities to climate change and increase food securities.

The basic components of technology development and dissemination are the same both in the developed and developing countries. Some of these components include good market, policy incentives to adopt new technologies and skills to use the technologies effectively (USDA, 2003). It is generally believed that countries that have policy, regulatory, and institutional frameworks to support science and technology, have increased agricultural productivity. Thus, having the capability to reduce chronic hunger and increased opportunities to participate in global markets and stimulate economic growth (Bryan et al., 2009).

There is now a general consensus that the atmospheric concentrations of greenhouse gases (GHG) are increasing as a result of human activities and that climate change is inevitable (Bryan et al., 2009). Most countries in the Sub-Saharan Africa are expected to experience higher increase in temperature more than the global average and a decline in rainfall in some parts of the region (IPCC, 2007). These anticipated climate changes do not only pose great threats to food and water security but also, public health, natural resources, and biodiversity (McCarthy et al., 2001).

The main source of income in most rural communities in sub Saharan Africa still remains agricultural production. Therefore, adopting appropriate technologies by the local farmers to mitigate and adapt to the impacts of climate change and climate variability is of utmost importance to the sustainability of their livelihoods. Moreover, it is imperative that the processes and the procedures involved in adopting the right technology involve the policymakers, agricultural extension agents, agricultural-based Non-Governmental Organisations, researchers, communities, farmers and other stakeholders. For instance, farmers need information on production technology that involves cultivating, fertilizing, pest control, weeding and harvesting. This sort of information could be given by extension workers, other farmers, government parastatals and agricultural equipment dealers.

RESEARCH AND DEVELOPMENT IN AGRICULTURE

Agricultural research and development (R&D) investments are one of the most crucial determinants of agricultural productivity growth, besides basic education. Investments in research to develop risk-reducing and productivity-enhancing technology are of critical importance. The major problems facing many developing countries like Nigeria are the need to transform their agricultural industry to one depending on modern input with high productivity which enables them to meet the rising production demand. Philip et al (2008) have identified a number of sector-wide constraints to increasing agricultural productivity in Nigeria. These include: poor agricultural pricing policies, low fertilizer use, low access to agricultural credit, land tenure insecurity, land degradation, poverty and gender issues, low and unbalanced investment in agricultural research, and poor market access and marketing inefficiency. A country with poorly funded agricultural R&D has a lot of impacts on the development of agricultural technologies, farmers' income, rural employment generation, food prices, establishment of agro-based industries, and economic growth of the rural community.

Public R&D spending in Nigeria has been low and unstable since independence, and the government budget process for funding agricultural research is complex (Philip et al, 2008). The time between the submission of planned budgets by research agencies and the approval and release of funds is lengthy and often out of tune with research work plans. The approved amounts and the disbursement processes very often fall short of the planned budgets of the research agencies. Private sector involvement in agricultural research has remained insignificant to date in Nigeria. Sustained agricultural research holds the key to improved agricultural productivity; it is perhaps the most important single determinant of agricultural development. This is because no nation has been known to have achieved any significant progress in agricultural growth without huge investments in agricultural research.

AGRICULTURAL TECHNOLOGY

One of the most important aspects of agriculture is technology. In recent times, science and technology has enhanced marketing, processing, and transportation of agricultural produce. However, the 21st century has seen a lot of improvements in science and technology with the potentials of increasing agricultural production even in this era of climate change in the developing countries. These technological innovations could be adapted to preserve and deliver vitamin-rich foods to help reduce food insecurity in Sub Saharan Africa. From the foregoing, it becomes obvious that these Scientific and technological advances in the 21st century should be harnessed to promote food security in these less developed countries. In this face of continuing advances in science, engineering and technology relevant to agriculture, it has been difficult to find means of adequately applying these advances widely and effectively in most developing countries, particularly in Nigeria. Experiences show that developed countries suggest that significant progress was achieved in agricultural development as a result of machines (technology) invented and manufactured during the industrial revolution, (Ekpere, 1998). Adigun and Oni (1995) noted that one of the country's problems in ensuring sustainable agricultural production is that farm machinery were never used up to an appreciable length of time before they were grounded and eventually abandoned. They also observed that some of the factors accountable for short useful life of agricultural machinery are inadequacy maintenance culture, unequipped workshops and unavailability of spare parts. Application of appropriate indigenous technology into our agricultural practice has been identified by Alatise (1996) as one of the reasons for the failure of meaningful agricultural mechanisation in Nigeria.

In an attempt to address some of these problems and help overhaul agricultural production in Nigeria, many policies/programmes have been introduced at one time or the other. These include:

- Green Revolution,
- Operation Feed the Nation,
- Integrated Rural Development
- Accelerated Food Production Programme,
- Agricultural Development Programme,
- Directorate of Foods, Roads and Rural infrastructures,
- National Agricultural Land Development Authority.

Although these programmes were well conceived to address food insecurity, they never succeeded. The reasons are not far fetched. Agricultural research and technologies need to be innovative. They must be able to tackle user priority needs and problems, and must be diffused properly for effective adoption. However, this is not the case in most developing countries.

Effective use of appropriate technology for agriculture is a function of so many factors. For instance in Nigeria as one of the developing countries, one of such factors is the adoption of mechanised farming by the farmers. The major factors militating against full mechanisation of Nigerian agricultural sector include:

- Land holding and government policies
- Climatic and environmental condition
- Lack of energy and industrial infrastructure and
- Inadequate economic strength of farmers to acquire necessary technological aids

Thus, to attain food sufficiency in these economies, there is the need to look into the development of agricultural technology for the small scale farmers with the aim of reducing drudgery of farm tasks.

THE ROLE OF SCIENCE AND TECHNOLOGY AGRICULTURAL PRODUCTION

There are views that suggested that poor agricultural performance in most developing countries could be attributed to lack of appropriate technology, physical and human capital. Recent decades have seen even bigger challenges on this front. The future looks even bleaker with food shortage issue looming large. The challenge is how to feed the growing population by producing more on a stagnant or shrinking landscape; with lesser input costs and with lesser hazards to the ecosystem. Another adjunct to this problem is how to add to the income of agricultural producers so as to sustain their motivation to grow crops. This also leads to the question as to how to add value to what is being produced. And at the same time, how to make the transaction in agro products smooth, safe and reliable. Thus, all across the world, an urgent need is being felt for more scientific and targeted management of the agriculture and food sector.

In this section, specific areas through which S&T is expected to significantly impact on agriculture and food security in the current global context are discussed. The scientific and technological applications identified here are those that have the potentials to mitigate the effects of the disturbances pre-conditioned by climate change and past S&T applications that prevail in today's environment. They are particularly useful to agriculture because they permit cleaning up of toxicity in soils where agricultural activities and the attendant use of insecticides, pesticides, fertilizers and other chemicals had been pronounced thereby enhancing food security.

BIOREMEDIATION

Bioremediation is a broad term that is used to refer to any process that uses microorganisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition (Meagher, 2000). It is a clean, efficient, inexpensive and environmentally benign method of pollution control wherever the soil or static water environment has become polluted or is suffering ongoing chronic pollution. For instance, the toxic heavy metals in the harvested biomass could be further concentrated by incineration or even recycled for industrial use (Diaz, 2008). Bioremediation has found applications in attacking specific soil contaminants, such as degradation of chlorinated hydrocarbons by bacteria; or the cleanup of oil spills by the addition of nitrate and/or sulphate fertilisers to facilitate the decomposition of crude oil by indigenous or exogenous bacteria. Some examples of bioremediation technologies are bioventing, landfarming, bioreactor, composting, bioaugmentation, rhizofiltration, and biostimulation. These technologies will allow agriculture to succeed in poorer soils, thus adding more land to the global production base.

NANOTECHNOLOGY

Nanotechnology describes the study of the control of matter on an atomic and molecular scale. Generally nanotechnology deals with structures of the size 100 nanometers or smaller, and involves developing materials or devices within that size. Nanotechnology is very diverse and finds applications in several fields of endeavour including agriculture and food security. Applications of nanotechnology have the potential to change the entire agriculture sector and food industry chain from production to conservation, processing, packaging, transportation, and even waste treatment. Nanoscience concepts and nanotechnology applications have the potential to redesign the production cycle, restructure the processing and conservation processes and redefine the food habits of the people. Major Challenges related to agriculture like low productivity in cultivable areas, large uncultivable areas, shrinkage of cultivable lands, wastage of inputs like water, fertilisers, pesticides, wastage of products and of course food security for growing population can be addressed through various applications of nanotechnology.

More than the smart devices for producing, processing and packaging, the convergence of nanotechnology, information technology and bio technology has really given us a new whole world of agriculture. Through cell engineering, cells can be made to form and multiply faster. This will mean that crops which take months to get ready can be available in week's time; that too on much less costs.

A nanocomposite coating process could improve food packaging by placing anti-microbial agents directly on the surface of the coated film. Nanocomposites could increase or decrease gas permeability of different fillers as is needed for different products. They can also improve the mechanical and heat-resistance properties and lower the oxygen transmission rate. Research is being performed to apply nanotechnology to the detection of chemical and biological substances for sensing biochemical changes in foods.

In the United States for instance, new consumer products created through nanotechnology are coming on the market at the rate of 3 to 4 per week. This includes cooking oil, tea and chocolate diet shake. The production of additives called "nanodrops" designed to carry vitamins, minerals and phytochemicals through the digestive system has also been reported. Cocoa infused "NanoClusters" have also been used to enhance the taste and health benefits of cocoa without the need for extra sugar. Nano-membranes have been produced that are portable and easily-cleaned systems that purify, detoxify and desalinate water meaning that third-world countries could get clean water and solve many water related health issues (Savage et al, 2008).

GENOMICS

The desire to produce nutritious food more efficiently has led to the increasing use of advanced molecular technologies in nutritional sciences (van der Werf et al. 2001). This area of research can be considered to fall within the emerging science of nutritional genomics. Whilst the focus of nutritional genomics has been human health (Stover, 2004), its utility is now beginning to extend beyond the study of human systems to include agriculture and food science. The significant advances made within the field of nutritional genomics have been underpinned by the advent of genome sequencing projects, which has led to an explosion of available genetic information. Genomics involves the study of genes and their functions in an organism. It aims to understand the structure of the genome, including the mapping of genes and the sequencing of DNA. However, the realisation that the genome sequence fails to explain the fundamental nature of many biological processes has led to the development of post-genomic strategies (transcriptomics, proteomics and metabolomics) aimed at relating gene expression to phenotypic outcome. Brown and van der Ouderaa (2007) discuss the applications of nutritional genomics to agriculture and the food industry. The review outlines how investigators are now using nutritional genomics to identify crops with desired genetic characteristics and enhance the nutritional quality of plants (DellaPenna, 1999). These approaches have previously been employed to produce Genetically Modified crops and to profile their molecular composition (Kuiper et al. 2003; Cellini et al. 2004). The authors also describe the use of these technologies as part of selective breeding programmes of livestock (Georges, 1999). The focus of these studies is an understanding of the genetic basis of commercially important traits of farm animals such as reproductive health, disease resistance, growth, fat deposition and milk production. The ability to predict such traits is of immense value to agriculture and food production and there is a clear role for nutritional genomics in developing the knowledge obtained from these studies.

Nutritional genomics has also influenced the monitoring of food composition, authenticity and safety, a key area for the food industry. Nutritional genomic strategies are increasingly being employed to confirm the origin and source of food ingredients (Popping, 2002) and feed products (Ocana et al. 2004). These technologies are powerful tools with which to detect food allergens and evaluate changes in plant- and meat-based foods upon processing (Carbonaro, 2004). They can also be used to evaluate meat quality (Bendixen, 2005; Mullen et al. 2006), and provide a means of identifying markers of food spoilage in fruits, vegetables, meats and dairy products (Brul et al. 2006).

BIOINFORMATICS

Bioinformatics is the application of information technology to the field of molecular biology. Bioinformatics now entails the creation and advancement of databases, algorithms, computational and statistical techniques, and theory to solve formal and practical problems arising from the management and analysis of biological data. Common activities in bioinformatics include mapping and analyzing DNA and protein sequences, aligning different DNA and protein sequences to compare them, and creating and viewing 3-D models of protein structures.

The primary goal of bioinformatics is to increase our understanding of biological processes. What sets it apart from other approaches, however, is its focus on developing and applying computationally intensive techniques (e.g., data mining, machine learning algorithms, and visualization) to achieve this goal. Bioinformatics was applied in the creation and maintenance of a database to store biological information at the beginning of the "genomic revolution", such as nucleotide and amino acid sequences. Development of this type of database involved not only design issues but the development of complex interfaces whereby researchers could both access existing data as well as submit new or revised data.

Comparative genetics of the plant genomes have shown that the organisation of their genes has remained more conserved over evolutionary time than was previously believed. These findings suggest that information obtained from the model crop systems can be used to suggest improvements to other food crops. At present the complete genomes of Arabidopsis thaliana (water cress) and Oryza sativa (rice) are available. Genes from Bacillus thuringiensis that can control a number of serious pests have been successfully transferred to cotton, maize and potatoes. This new ability of the plants to resist insect attack means that the amount of insecticides being used can be reduced and hence the nutritional quality of the crops is increased. Scientists have recently succeeded in transferring genes into rice to increase levels of Vitamin A, Iron and other micronutrients. This work could have a profound impact in reducing occurrences of blindness and anaemia caused by deficiencies in Vitamin A and Iron respectively. Scientists have inserted a gene from yeast into the tomato, and the result is a plant whose fruit stays longer on the vine and has an extended shelf life. Progress has been made in developing cereal varieties that have a greater tolerance for soil alkalinity, free Aluminium and Iron toxicities. These varieties will allow agriculture to succeed in poorer soil areas, thus adding more crops to the global food production. Research is also in progress to produce crop varieties capable of tolerating reduced water conditions. Sequencing projects of many farm animals including cows, pigs and sheep are now well under way in the hope that a better understanding of the biology of these organisms will have huge impacts for improving the production and health of livestock and ultimately have benefits for human nutrition.

CONCLUSION AND POLICY RECOMMENDATIONS

This paper has discussed key issues relating to the management of agriculture towards achieving sustainability and food security within the context of today’s highly unstable environment. The relationship between agriculture and national wealth as well as how S&T contributes to this was examined. We have also discussed the specific challenges to food security posed by climate change as well as how S&T has been and could be further applied in meeting the challenges of food security.

From the discourse, we conclude that in spite of the enormous challenges posed by climate change, appropriate and timely S&T interventions would make a significant impact in the development of a vibrant sustainable agricultural production system. Specifically, new and emerging technology applications including nanotechnology, bioremediation and genomics would be much more important in the coming years as far as food security is concerned. Within this context, we make the following recommendations, particularly bearing in mind the present levels of development in the Sub Saharan African economies:

i. the building of capacity in agricultural management is critical if food security would be achieved

ii. it is crucial for developing economies, especially in Africa, to embrace the new and emerging technologies and deploy them towards the achievement of food security. Specific challenges in this regard include the engagement of researchers in relevant multidisciplinary R&D and investment by government in such.

iii. in the developing world, government still remains a major source of funding for S&T engagements, but experiences have shown that government funding is not sufficient. Assistance from the private sector and relevant development partners are therefore welcome

iv. since much of the agricultural production in developing economies like Nigeria presently takes place in the rural areas by practitioners with low skills, a high demand for extension workers, capacity building and the diffusion of new knowledge exists.

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DISPELLING THE "FALLACY" OF CLIMATE CHANGE: PERCEPTION AND ATTITUDE OF YOUTHS IN ILE-IFE, NIGERIA TOWARDS CLIMATE CHANGE

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Abstract

Review of literatures has suggested a greater vulnerability to the climatic change threat in Africa countries than many other parts of the world. Scorched landscapes, withered crops, dried-up rivers and lakes; or the opposite – dying livestock, droughts, hunger, abject poverty in an unprecedented frequency and invariably, collapse of all human supporting systems are among the aftermath of the new life. The study of people's perception is rather a new phenomenon among the developing world unlike developed nations. A descriptive study of perception and attitude of Nigerian youths (largest proportion in Nigerian population) towards climate change was conducted in Ile-Ife, Southwestern, Nigeria. Knowing fully well that awareness precedes perception and attitude; the study employed a structured questionnaire to assess respondents' level of awareness of climate change and its suggested threats. Statistically, Likert-type scale was employed to rate respondents' level of attitude and perception. Of the total 350 respondents, one hundred and forty-four (41%) reported previous awareness of climate change, while majority (68%) of those that never aware of climate change dispelled anything called climate change, and the balance 48 (13.7% of the total respondents) called climate change another "April fool" of our time. Education varies positively and significantly with awareness ($p<0.01$), more male displayed better awareness than female ($p<0.05$). While there are various sources of information, internet and foreign news (Cable News Network) take the lead (90% and 83% respectively). More male compared to female reported good knowledge ($p<0.05$). While only 58 (16.6%) of the total respondents displayed a positive attitude towards climate change. No demographic factor was found to have a significant influence on attitude. The study concluded with a low level of awareness and knowledge of climate change among the youths. And since good awareness precedes knowledge and positive attitude, the authors call for active education of the populace about the subject matter for an enhanced management of climatic change risk.

INTRODUCTION

Despite a steady and overwhelming risen in climate change's and its environmental impacts' awareness among the residents of developed nations, the available data on people's awareness in most developing and least developed countries is not encouraging. Though the subjects of climate change may sometimes appear esoteric (CIDA, 2007) but tracing the history of climate change, one begins to wonder if there would be any excuse for any part of the world not knowing at least little about climate change, not at this computer age.

Historically, scientists have been discussing the greenhouse effect and noticing planet warming since early 19th century. Scientist Jean-Baptiste Fourier identified the greenhouse effect in 1827; and the idea that planet was warming had entered the public imagination as early as the 1930s (Evans and Steven, 2007). Since then, globally, there have been a great implication and reaction of the climate change on both physical and atmospheric human nature. Rapid climate change, for example, the sustained global warming of 0.2^{O}C per decade since 1970s, however, raises questions about how natural ecosystems and species will respond (Kovats et al. 2001). It was reported that average temperatures have already risen 0.6^{O}C and they are continuing to increase (Houghton et al. 2001). They further stated that over the remainder of this century we will experience an increase in average temperatures of between 1.4^{O}C and 5.8^{O}C combined with large increases in atmospheric rainfall patterns (Williams et al. 2003).

Climate change has already produced significant and measurable impacts on almost all ecosystems, taxa and ecological processes (Williams et al. 2003). Each country is naturally concerned with potential damages and benefits that may arise over the coming decades from climate change impacts on its territory and international policies, trading patterns, resource use, regional planning and ultimately the welfare of its people (Fischer et al. 2005). Review of series of literatures has suggested a greater vulnerability to the climate change threat in African countries than many other parts of the world despite its (Africa) least contribution to the key greenhouse gases emission such as carbon dioxide, methane and nitrous oxide. African disaster - scorched landscapes, withered crops, dried-up rivers and lakes; or the opposite – dying livestock, droughts, hunger, abject poverty in an unprecedented frequency and invariably, collapse of all human supporting systems are among the aftermath of the new life - climate change risk (Vedal et al., 2003; Knowlton et al. 2004; RC/RCCG, 2007). Ihedioha Damian in Nigeria once reported that “we have an increasing incidence of disease, declining agricultural productivity, and a rising number of heat waves” that “there is glaring evidence that climate change is not only happening, it’s changing our lives” (CIDA, 2007).

Public attitude towards the environment and global warming depend on their understanding of climate change. A recent study of public perception and attitude towards climate change in America revealed that more Americans than ever before have serious concerns about environmental threats; a fully 83 percent of American now say global warming is a “serious problem” (Evans and Steven, 2007; Webwire, 2007). Since awareness precedes knowledge and attitude, the objective of this study is to examine the perception and attitude of Nigerian youths towards climate change.

MATERIALS AND METHODS

The community-based study which employed primary source of data collection with a structured questionnaire that assess the youths’ level of awareness of climate change and its suggested threats was carried out between March and April 2009 in Ile-Ife, Southwestern, Nigeria. Attitude and perception of respondents towards climate change were investigated by their socio-demographic characteristics. A multi-stage random sampling technique was adopted to select 350 respondents aged 20-40 years. Ile-Ife community, a semi-urban settlement in the tropical rain forest zone of Southwest Nigeria and has an estimated population of 313000 (Fatusi *et al.,* 2003) was divided into three residential areas of low, middle and upper socio-economic status adopting Bamiwuye *et. al*. style (Bamiwuye *et al.,* 2004). We thereby randomly selected 20, 10 and 10 streets from low, middle and upper socio-economic status respectively.

Questions related to respondents' knowledge, perception and attitude were scored for the aid of likert-type scale. Causes of climate change according to the respondents (without being guided) were taken into consideration in the testing of the level of respondents' knowledge of climate change, while scores less than the average of four were classified as poor, those respondents who scored four and above were taken as those that have good knowledge of climate change. Statistical package for Social Scientists (SPSS) for Windows (13 version) was used for the statistical analysis of the quantitative data. Frequency distributions of variables were displayed with corresponding tables, while interval measured variables were changed through recoding into ordinal variables with few categories. Pearson's $\aleph^2$ test was employed to test the significance of the bivariate relationship. To ascertain the validity of the statistical relationship and to probability (p) value of less than 0.05 was considered in the test of variables' association.

RESULTS

Socio-demographic characteristics of the respondents

As shown in Table 1, while 31 percent of the respondents were aged between 25 and 35 years, very few of them (18%) were less than 25 years and majority of the respondents were between 35 and 40 years. A little above half (to be precise 52.3%) of the respondents were male. Less than half (41%) had higher education and about 38.3 percent of the youths reported "completion of secondary education". The marital status of the respondents revealed 71 percent had never married, while the remaining 102 (29.1%) had ever married (Table 1). Source(s) of information was sought from 144 respondents who reported previous awareness regarding climate change; all respondents' sources of information were later grouped under local news, foreign news, internet and others. While 130 (90%) and 120 (83%) responses claimed internet and foreign news (print and electronic) respectively, 62 (43%) and 35 (24%) laid hold to local news (print and electronic) and others sources (from friend, relative, in school or books, seminars and conferences) as their sources of information respectively (Table 1).

Table 1 Percentage Distribution of Socio-demographic Features of Study Respondents.

Variables (categories)	***Frequency***	*%*
Age (years) (n=350)		
<25	63	18.0
25-35	107	30.6
>35	180	51.4
Sex (n=350)		
Male	183	52.3
Female	167	47.7
Educational level (n=350)		
Primary or less	73	20.9
Secondary	134	38.3
Higher	143	40.9
Marital Status (n=350)		
Ever married	102	29.1
Never married	248	70.9
Source of Information (n=144)**		

Local News	62	43.0
Internet	130	90.0
Foreign News (Cable News Network etc.)	120	83.0
Others	35	24.0

*** Multiple responses allowed*

Table 2 Percentage Distribution of Respondents' Awareness and Knowledge of Climate Change.

Variables (categories)	***Frequency***	*%*
Awareness (n=350)		
Yes	144	41.0
No	206	59.0
Knowledge (rating)(n=144)		
Good	136	94.4
Poor	08	05.6

Awareness of climate change is a principal thing going by the objective of this study; it precedes knowledge, perception and attitude. Less than half of the study population, about four in every ten youths (41%) in Ile-Ife had previous awareness of climate change, while 206 (59%) of the total had no previous awareness of the subject matter of the study (climate change) (Table 2). Respondents' knowledge of climate change being facts, truths or understanding of the subject matter was also investigated among the 144 youths who reported previous awareness of climate change and the result as shown in Table 2 revealed that 94.4% and 5.6% of the 144 respondents had good and poor knowledge of climate change respectively. There were so many responses by the respondents about their awareness, belief or knowledge of climate change. While some believed the change in climate is just an ordinary act of God, some claimed that the variability in rainfall is not a new thing but a change that will normalize itself. Some called it "April fool" and some believed it was a total "myth". Some of the youths said it was another agenda of the (white) developed nations or the devil to deceive us (developing countries).

Table 3 Relationship between respondents' age, sex, education and awareness of climate change

Variables(categories)	**Yes**	**No**	**Total**	***p* Value**
***Age** (years)*				
<25	23(36.5)	40(63.5)	63	NS
25-35	51(47.7)	56(52.3)	107	
>35	70(38.9)	110(61.1)	180	
Total	144	206	350	
Sex				
Male	101(55.2)	82(44.8)	183	0.05
Female	43(25.7)	124(74.3)	167	
Total	144	206	350	
Level of Education				
Primary or less	14(19.2)	59(80.8)	73	0.01
Secondary	46(34.3)	88(65.7)	134	
Higher	84(58.7)	59(41.3)	143	
Total	144	206	350	

NS = Not significant

Climate change awareness increased progressively and significantly with level of education (p=0.01), the proportion of youths with their level of educational attainment ranged from 19.2% for primary or less group to 58.7% for those with higher (tertiary) education. More male (55.2%) among the youths in Ile-Ife showed previous awareness of climate change than female (25.7%) (p<0.05) (Table 3). Climate change awareness in relation to age as shown in Table 3 runs almost the same pattern among the ages, while 36.5% and 47.7% of youths aged < 25 years and those aged between 25 and 35 years respectively claimed previous awareness of climate change, 38.9% of those aged > 35 years reported previous awareness regarding climate change. Climate change awareness did not vary significantly between age groups.

Table 4 Percentage distribution of respondents' age, sex, education by knowledge of climate change

Variables(categories)	***Knowledge rating (144)***		**Total**	***P* Value**
	Good	**Poor**		
Age				
<25	18(78.3)	05(21.7)	23	NS
25-35	48(98.0)	01(02.0)	49	
>35	70(97.2)	02(02.8)	72	
Total	136	08	144	
Sex				
Male	98(94.2)	06(05.7)	104	0.03
Female	28(70.0)	12(30.0)	40	
Total	126	18	144	
Level of Education				
Primary or less	13(19.2)	06(80.0)	19	0.04
Secondary	42(34.3)	01(65.7)	43	
Higher	81(58.7)	01(41.3)	82	
Total	136	08	144	

NS = Not significant

Knowledge of climate change being facts, truths or understanding of the subject matter was also investigated via respondents' age, sex and educational attainment. The responses were rated and scored, titled good and poor knowledge. Sex and educational attainment were found to be significant factors with regards to knowledge of climate change (p<0.05). More male (94%) than female (70%) had good knowledge of climate change. As seen in Table 4, climate change knowledge was seen to vary progressively as education increases. Fifty-eight (16.6%) of the total respondents displayed a positive attitude towards climate change, others displayed all-round negative attitude ("I do not care attitude" and imminent of end-of-live).

DISCUSSION

The study of people's perception is rather a new phenomenon among the developing world unlike developed nations, interestingly, among very few discussions that were found on climate change in Nigeria among which are (Adejuwon and Odekunle, 2006; Adesina et al., 2006; Ekanade, 2006; Adesina, 2008; Salami, 2009) none was found on people's perception and attitude as regards climate change. Though, literature search in the course of this study revealed that the first world conference on climate change was held in 1979 and the second was not held until eleven years after (1990), and the first Intergovernmental Panel on Climate Change (IPCC) in 1988 with its first report two years later should not be an excuse of not been aware of the global climate change. After all, historically, discussions on greenhouse effect and planet warming have been on since early 19th century. The idea that planet was warming had entered the public imagination as early as 1930s, Scientists like Jean-Baptiste Fourier identified the greenhouse effect in 1827 (Evans and Steven, 2007). Since it is our belief as social scientists that awareness precedes perception and attitude, this study, a descriptive study of perception and attitude of youths (largest proportion in Nigerian population) towards climate change was conducted in Ile-Ife, Southwestern, Nigeria to assess respondents' level of awareness of climate change and its suggested threats. Statistically, Likert-type scale was employed to rate respondents' level of attitude and perception.

The findings reveal that only a few of the total selected sampled respondents had previous awareness of climate change. About four in every ten youths reported previous awareness of the subject matter, which shows a low level (41%) of climate change awareness among Nigerian youths. Looking at the effect of education on climate change awareness, it was seen in the study that there was a positive and statistical significance relationship between awareness and educational attainment. Therefore, this low level of climate change awareness among the respondents might be due to many reasons which range from poor attitude of Nigerians to getting information and the low literacy level in the country. While some believed the change in climate is just an ordinary act of God, some claimed that the variability in rainfall is not a new thing but a change that will normalize itself. Some called it another "April fool", perhaps because the field study was carried out in April and some believed it was a total "myth". Some of the youths said it was another agenda of the (white) developed nations or the devil to deceive us (developing countries). There was equally a significant relationship between sex and climate change awareness; more male had more awareness than female (55.2% and 25.7% respectively). The reason for this could be the fact that more male than female are conversant with those climate change sources of information (internet and foreign news like cable network news) mentioned in the study.

Knowledge being facts, truths or understanding of a subject matter, real understanding of climate change was thereby investigated among the 144 youths who reported previous awareness of climate change the result that almost 6% of the 144 respondents had poor knowledge of climate change. This is to confirm the low awareness level that exists among the respondents. By the findings of this study, though, very few (less than 10%) but some of them who claimed previous awareness still do not have good knowledge of the subject (climate change). Like awareness, education still varies directly and significantly with knowledge of climate change.

It is imperative to note that the issue of climate change is no longer about finding facts and figures to back it up, from all indications and evidences, it is a reality. Therefore peoples' attitude towards it is as important to social scientists as well as natural and physical scientists. While only 58 (16.6%) of the total respondents displayed a positive attitude towards climate change, the whole lot of the remaining respondents 292 (83.4%) despite their prime ages still do not displayed a positive attitude towards the issue. No demographic factor was found to have a significant influence on attitude. The study therefore concluded that a low level of awareness and knowledge of climate change exist among Nigerian youths as sampled in Ile-Ife. And since good awareness precedes knowledge and positive attitude, the authors call for active education of the populace about the subject matter for an enhanced management of climatic change risk.

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“SO THAT OUR EARTH SHALL NOT DIE”: THE ENVIRONMENTAL IMAGINATION OF NIYI OSUNDARE’S *VILLAGE VOICES AND THE EYE OF THE EARTH*

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INTRODUCTION

> *Order and beauty means, that not only our houses must be stoutly and properly built, but also that they be ornamented duly: that the fields be not left only for cultivation, but also that they be not spoilt by it any more than a garden is spoilt: no one for instance to be allowed to cut down, for mere profit, trees whose loss would spoil a landscape: neither on any pretext should people be allowed to darken the day light with smoke to be foul rivers, or to degrade any spot of earth with squalid litter and brutal wasteful disorder – Morris William, 1995.*
> *Let us not, however, flatter ourselves over much on account of our human victories over nature. For each such victory nature takes its revenge on us. Each victory, it is true, in the first place brings about the results we expected, but in the second and third places it has quite different unforeseen effects which only too often cancel the first… at every step we are reminded that we by no means rule over nature like a conqueror over a foreign people, like some one standing outside nature-but that we, with flesh, blood and brain, belong to nature, and exist in its midst– Marx and Engles, 1976.*

The above epigraphs represent a serious warning to mankind to ensure that the organic community is respected in all its dealings with nature. Attempts by science to conquer nature creates environmental crisis and other forms of ecological hemorrhage. This may be because of the wrong assumption to think that man is not part of the biotic community. This is a wrong assumption to say the least as, the biotic community includes not only living things but also all members of the ecological system, including water, soil, and air. To think ourselves as part of the biotic community is to reject the view that we are masters of nature who assume that nature is there for us to conquer and exploit.

It is a truism to state that the survival of biosphere is important in human existence. As has been argued by Taylor (1992), the well-being of humans is dependent upon the ecological soundness and health of many plant and animal communities, where their soundness and health does not in the least depend upon human well-being”. Human activities cause ecological problems. Land-use change due to rapid urbanization, deforestation, agricultural practices and lots of other activities by man affect the physical and biological properties of the land surface in a country-what F. R. Leavis and D. H. Lawrence would term the loss of the organic community – a term that captures clearly the loss of a human naturalness or normality in the bid by man to wantonly and insensitively destroy humanity and the environment.

This essay is an attempt to show how Niyi Osundare, arguably the best poet to emerge out of Nigeria after the first tradition of peotic experience championed by the like of Wole Soyinka, Christopher Okigbo and John Pepper-Clarke, responded to the issues of the environment owing to the exploitation and degradation which the latter has been subjected to by man. As will be demonstrated presently, Osundare in the two collections chosen for our analysis, trenchantly deprecates all activities of man that have led to environmental ruination occasioned by a private accumulation drive which promotes social irresponsibility and ever ubiquitous illegality.

THEORETICAL GUIDE

In trying to do justice to our set goal of locating the environmental imagination of Osundare, we are adopting Ecocriticism as our theoretical guide. Ecocriticism is the scholarly examination of the relation between literature and environment which is conducted in a spirit of commitment to environmental praxis and justice. According to Slovic (1992), Ecocriticism is the study of explicit environmental texts by way of scholarly approach or, conversely, the scrutiny of ecological implications and human-nature relationships in a literary text, including texts that at first glance, seem obvious of the non-human world. To Glotfelty (1996), Ecocriticism is defined as the study of the relationship between literature and the physical environment.

The concern of Ecocriticism is to critically examine nature as contained in texts through words, images, and in the process articulate a position that might affect our cultural attitudes and social practices which in turn, affect nature itself. Commenting on literature and nature, Edward Thomas has this to say:

> *Literature sends us to nature principally for joy, joy of the senses, of the whole frame, of the contemplative mind, and of the soul, joy which if it is found complete in these several ways might be called religious (Thomas, 1909).*

This means that as a theoretical construct, Ecocriticism celebrates nature, berates its despoilers, and tries to reverse the harm done on nature by its insistence on redirecting humanistic ideology using whatever ideas available from the national sciences to engage in a viable reading of texts.

By adopting the Ecocritical stance, we are challenging the logic of industrialism, which assumes that nothing matters beyond technological progress. Again, the ecocritical paradigm sees planetary life as being in a "critical" condition and it is to this sense of "crisis" that it offers a response and in the process impacts on the way people think, behave and react to planetary pollution and degradation. We are also concerned with the larger question of environmental justice, of the rights of our fellow-creatures, of forests and rivers, and ultimately of the biosphere itself. In all, our reliance on the Ecocritical theory addresses the urgent need to address and redress the consequences of human civilization's insatiable desire to consume the products of the earth.

NIYI OSUNDARE AND THE *ENVIRONMENTAL IMAGINATION*

As indicated in our opening paragraphs, Niyi Osundare is certainly a leading figure of the second generation of Nigeria poets. His poetry seen as a reaction to the first generation poets of Nigeria's Ibadan/Nsukka school.[1] Osundare started a movement towards the democratization of poetic language in Nigerian poetry of English expression. He also criticizes and prescribes solutions to the problems confronting the Nigerian state and its people in a poetry that is partisan in the service of a revolutionary struggle and emancipation of the oppressed.

As a poet, Osundare operates within the vast and rich Yoruba cultural universe which he exploits in order to express his vision. According to Abdul Raheem (2003), Osundare combines and juxtaposes "the rustic and the rural, the profane and the urbane, the verbal and the non-verbal resources of language to produce an artistic paradigm of contemporary Nigerian society and experience". This paradigm is seen as representing the Alter-Native Tradition, in Nigerian poetry in particular and literature in general. The whole essence of this tradition is to deepen the dialectics of revolutionary pressure in favour of the down-trodden and disposed in society.

Because of Osundare's consistency in matters concerning the poor and their threatened existence, he is seen and acknowledged as having distinguished himself as the "voice of the underprivileged in his country Nigeria, and as a prophet of hope for the African continent" (quoted in Abdu Sale, 2003:2). Aiyejina (1988), speaks of Osundare's achievements in African literature thus:

> *In all modern African poetry, ALL, I repeat, only in the poetry of Augustino Neto and David Diop will you find the same depth of passion and lyricism, in solidarity with the oppressed, the down-trodden, the disposed and a corresponding faith in their aspirations and will to revolutionary change as we confront in Osundare's poetry.*

His poetry is also pastoralist in diction and his style highly romantic. Like Walt Whitman and his major disciple and admirer, Pablo Neruda, the voice of the Earth sounds and resonates in his poetry. Those who exploit the planet and exploit the poor with the consequent degradation of the planetary environment do not escape his poetic whiplash.

Osundare's poetry evokes "romantic ecology", a phrase popularized by Jonathan Bate in his book *Romantic Ecology: Wordsworth and the Environmental Tradition,* published in 1991. The pioneers of this tradition (environmental tradition) were writers like Wordsworth, John Ruskin, William Morris and Edward Thomas. Their works engaged with a search for symbiosis between mind and nature and the human and non-human. In fact, Wordsworth, the leading voice of the Romantic Movement was involved in environmental campaigns as can be seen in his *Lyrical Ballads* published in 1800. For environmentally concerned poets like Wordsworth and his disciples a regard for nature was seen as a guarantee of an ethical sense. The affection for one's environment occasioned by industrial capitalism's denial of an organized way of life with its consequent denial of a fundamental human need pushed the Romantics into an ecological campaign to recreate the world in green language and metaphors. Nature became idealised in the face of its threatened destruction.

Osundare's poetic arrival tune reads like Clare's[2]:

Bred in a village full of strife and noise
Old senseless gossip, and blackguarding boys,
Ploughmen and themselves, whose discourses led
To nothing more than labour's rude employs,
'Bout work being slack, and raise and full of bread
And who were like to die, and who were like to wed.

According to Adagboyin (1996:109), Osundare concedes the fact that he is greatly influenced by William Wordsworth, "whose perception of nature and also his utilization of the inexhaustible potential of nature are extremely tremendous." Like Leo Marx in his *Machine of the Garden* the loss of the paradisal landscape dominates Osundare's *oeuvre,* especially the two volumes of poetry which we have adopted as our guide in the understanding of his environmental imagination. The care-free attitude of profit mongers has led to the plundering of resources which makes development unsustainable and exposes future generations to the risk of stagnation or even decline. The quest for large raw material resources and market outlets leads to greedy assertion of control over countries that are weak.

The causes of environmental destruction are quite clearly the interests of capital. It is a matter of profit maximisation and destruction of nature for the sake of short-term profits. Free market, especially its underlying principle of self-interest, is largely responsible for the ecological crisis.

T. S. Eliot offered a trenchant critique of industrial capitalism's abuse of nature in his work, *The Idea of Christian Society.* He condemned "the exploitation of the earth for commercial profit and the immediate benefits leading to dearth and desert". This means that the critique of modernity anticipated the ecological age. Modernity stemmed from the eighteenth-century Enlightenment, with its faith in intellectual and material progress. This was resisted by a "counter-Enlightenment" which usually went under the name of romanticism.

It is important to note that the critique of modernity had been informed by the memory of nature which has been lost, polluted, neglected or denied. Osundare debates nature in order to defend nature. Author of several plays, many esssays(academic and political), a regular contributor to many newspapers and magazines, Osundare has so far published twelve full-length volumes of poetry. These include *Songs of the Market Place (1983); Village Voices (1984),A Nib in the Pond (1986); The Eye of the Earth (1986); Moon Songs (1988); Waiting Laughters (1990); Songs of the Season (1991); Midlife (1993); Seize the Day (1995); Laughing Winds (1990); Tender Moments (2006) and Days (2007).*

Osundare's first volume of poetry is faithful to the local, oral culture of his people and is preoccupied with a variety of themes. And as Abdu (2003) has noted, "most of the poems of *Songs of the Market Place* are built around rejected skeletons of preceding poems or composed as satirical pods at, or better alternatives to, them". Osundare takes a decidedly different approach in his poetic composition from the earlier Nigerian poets as he reconceptualises poetry and invests it with a new language and meaning which he considers very accessible to the people. With this poetic vision as a guiding principle poetry for him is fully explained as:

What the soft wind
musics to the dancing leaf
What the sole tells the dusty path
what the bee hums to the alluring nectar
what rainfall
to the lowering eaves (Songs of the Market Place, pp. 3-4).

And in the final stanza of the collection he concludes on a note of finality an all-embracing and all-encompassing definition of poetry as:

Poetry
is
man
meaning
to mean

In all the twelve collections of poetry so far published by Osundare, he preoccupies himself with what Ashcroft (1989) has described as "the problematic of post- colonial identity" and crises of governance and development, aligning, predictably with the disinherited and exploited members of the lower class. This preoccupation is not only with the problems of the Nigerian messes but of all the under classes wherever they are located. This is because, this world, in spite of the promises of science and technology, is one in which the resource gap and the gaps in the standards of living have widened more and more between the large majority of people and the ruling elites in the poor countries. A whole lot of colonial and post-colonial exploitation was pivotal on lay arable and permanent crops such as tea, coffee, cocoa, oil palm, rubber, peanuts, etc. Substantive colonial and neo-colonial sub-cultures were also built on these crops.

From the above discussion, it is clear that the concerns of Osundare in his poetic vision are issues bordering on economic and environmental justice as they affect the poor of the world whenever they may be. In the remaining part of our discussion, our attention is focused on the two volumes-*Village Voices and The Eye of the Earth* which constitute the focal collections for our analysis.

The Village Voice is Osundare's second volume of poetry which was published a year after *Songs of The market Place.* Osundare's predilection for the lowly and the victims of discrimination in society which feature in the poems of *Songs of the Market Place* is developed and sharpened in his focus on the villager in *The Village Voices.* There are thirty-eight poems in the collection which is divided into three sections-*rising voice…; Voices about coming and going and Voices of anger and indictment.* The persona of the poems assumes the voice and worldview of the villager with his simplicity and modesty. Villagers are not like the city diverllers-they are nearer to nature nad are not affected by the chaos and bedlam which constitute city life.

In the first poem of the collection, "I wake up this Morning", the poet-protagonist remembers his past which was idyllic, serene and in tune with nature in its original essence as "the youthful breeze heaps the leaves". This poem which announces the arrival of the poet-protagonist clearly and unambiguously demonstrates that he is not afraid of anybody and therefore will not pretend to be part of all the negative things that have underdeveloped his society: He is out to trenchantly attack the forces of reaction and decadence. The second poem "A Dialogue of the Drums" again supports the poet-protagonist's assertion that he will stridently raise his voice against all forms of injustice in the world.

In "Not in my season of Songs", the poet-protagonist praises the normalcy in nature: "Bees hum peacefully in a fallowing farm/A restless boy punctures their love/With a crooked stick" (p.9). Man, this poem suggests, has engaged in activities that disrupt the order and rhythm in nature. This observation is pursued further in "Eating with all the Fingers" as he cautions against greed and its attendant consequences for man and his environment. Poems like sleeping at five and twenty", "killing without a sword" and "Chicken Story", "Eating Tomorrow's Yam", "An In-law's Message", "Search for a Wife", "Advice" and "Feigning Rebel" pursue further the themes of balance, reticence, equity, equilibrium and order in the way and manner we do things.

The poet-protagonist in the poem "Akintunde, Come Home" resumes his attack on the city. As noted earlier on, the poet-protagonist associates the city with industrialism, commercialism and other forms of exploitation and profiteering unknown to the village and its inhabitants. In this poem, Akintunde is summoned to come home with a view to experiencing a better and fulfilled life. The city has been devalued with all sorts of emissions making life short, nasty and brutish. The poem suggests that if Akintunde comes home, he will ultimately become part and parcel of the new hope of his society. His society is in dire need of people of his stature and temperament. Perhaps, if the like of Akintude return home, they might be able to ward off the incipient activities of men and women of the city who are moving to the village to exploit the people and the resources therein as can be seen in the poem "The prisoner's Song". In "The Prisoner's Song" an attack is carried out on a warder who is being used by the forces of oppression against the people. The warder who is of course operating under the influence of false consciousness is reminded of how his own father lost his farm including his economic trees to a moneyed man from the city. The poet-protagonist shows that the village is ill at ease.

The inevitable clash between the upper and lower classes is explored in the poem “A Reunion”. The poet-protagonist uses the differences between the city and the village of his colleague who dropped out of school to construct the class divide in the society: “We must smash this wall/built of the inequalities/of class and crime. In this poem again, the city is represented as belonging to the upper class with its contradictions while the village represents the lower class.

“The Stars Sob” bemoans the exploitation of nature by man. The level of this exploitation is such that even the stars weep for the earth:” Forests drop their tuft of green/vegetables go pale/on the market stall” (p. 36). People are unhappy as a result of the exploitation of nature and its resources. Unfortunately, as this exploitation goes on, those at the lower wrung of the ladder who are used by the upper class are not made to enjoy the fruit of their labour as the poem “Cradling Hands” attests to. The poet-protagonist, in realisation of this criminal exploitation asserts strongly that the labourer must enjoy the fruit of his/her labour.

The poet’s optimism about life and the consequent return to nature by man is explored in “New Birth”. In this poem, a new dawn is bound to emerge. The emergence of the new society will not come by easily. This is acknowledged in “The Land of Unease” where the poet– protagonist preaches for a revolutionary change arising from his disenchantment with the unequal power relations in the society. This mood is also captured in “A villager’s protest”, “The New Farmer’s Bank”, “A Farmer on Seeing Cocoa House, Ibadan”, The Eunuch’s Child”, “The politician’s Two Mouths” “Unequal Finger” among other poems in the collection.

“A Grass in the Meadow” is a celebration of the poor who are in the majority. The poor people, in spite of their state of being appear more joyous and fulfilled than the rich and exploiting class. The poet-protagonist appears to be saying that there is joy in being part of the multitude of the poor instead of belonging to the few who exploit.

There is something very intrinsic and insightful about *The Village Voices* and it is the volume’s concern about the people and their environment. The collection is awash with nature and agricultural imagery: “I wake up this morning”, “a youthful breeze haps the cleaves”, “my sole treads the dew”, “to the virgin cool of earth”, “the coasting sea”, “of cloudiness sky”, “plant the earth with potent steeds”, “fluttering leaves in a barren forest”, “a festival in the rain”, “fallowing farm”, “a bag of cocoa with a small ball”, “when cutting a tree in the forest”, “slapping the sky’s face”, “the stars sob”, “fireless wood”, vegetables go pale”, “a twig in the harmattan”, “termites have eaten up,” sky at dawn”, “hours of lengthening shadows”, “a snake just sloughed”, “Earth, unyoked”, of vibrating roofs”, “a new moon enlightens the sky, etc. The poems in the collection promote the people and their environment. The poet appears to be saying that conflicting economic interest and economic greed engenders crisis that affects the people and their environment.

The Eye of the Earth is a collection whose poems are tied together by a sustained concern with the fate of the Earth. The thought of these poems is heavily influenced by Osundare’s sustained evocation of Yoruba myths concerning the physical environment, and in particular, the mysticism attributed to the Earth’s god-like essence which the Yoruba express in the folk-prayer which says: “May we never tread on the earth when it has eyes" (quoted in Abdu, 2003" 75-76). Anyokwu (1997) comments that *The Eye of the Earth* is not only a celebration of forests of the past, or more aptly, a celebration of their greenness and luxuriance of the teeming rainforest in Africa but also a song of sorrow, bewailing the treachery, the gratuitous cruelty, of the deadly blows recklessly and remorselessly inflicted on the earth. *The Eye of the Earth*, therefore, shows how man in his folly has threatened the fragile ecosystem with his chaotic urbanisation and the so-called modern civilisation and technological advance.

In the collection, the poet expresses a passionate nostalgia for his past and raises queries about the state of the earth. Osundare himself explains in the preface to the collection:

> *The poems in this collection are a journey into these times and beyond, when the earth's head stood on its neck and a hand sprouted but five fingers. If there is a passionate nostalgia in the rendering it is the legitimate flame of the inevitable fire often kindled when an embattled present makes a forward thrust difficult (surely not impossible:) and looking back becomes one of the weapons against looming monster. But all this resides in the house of memory where doors open into the backyard of time,… For in the intricate dialectics of human living, looking back is looking forward; the visionary artist is not only a remember, he is also a reminder (The Eye of the Earth 1986: Xii).*

The position of Osundare accords with the view of Coupe (2000) to the effect that the critique of modernity is impossible without memory. Nostalgia arises from the need for a "return to home", the earth being our home or household, *Oikos* by the Greeks. This desire to return to the original earth is necessary to retain balance and a fruitful existence.

Again, Osundare acknowledges the fact that with the coming of modernity from the West, the paradisal landscape is lost by the African people. He asserts:

> *…A cancerous god called MONEY crashed in from across the seas, with a blind sword and a crown of noisy gold, smashing old customs, assailing the very core of ancient humanistic ethos. To acquire it on Europe's terms, Africa abandoned what she ate, committing her fertile soil and rugged energy to those alien crops which cushioned the European stomach (The Eye of the Earth xi-xii).*

As this became entrenched the earth itself became polluted, depleted, neglected, denied, and in fact, devastated. The forest, which in the past was full and luxuriant, is now "essentially, shades and shadows of a remembered landscape". Capitalism is implicated by the poet in this exploitative gambit of the earth for commercial profit. It bears repeating that the very essence of capitalism stands in the way of resolving the environmental crisis as many environmental entities like rivers, air, seas, etc become endangered.

Structured into three movements, *The Eye of the Earth* with its personification of the earth as can be seen in the title, signals the poet's intention to make the earth a metaphor of survival throughout the collection. The first movement takes us back to those rich forests of Africa which are no longer in existence as they remind us of the devastating effects of colonial exploitation. The poem "Earth" stands as a prologue, announcing the concerns and thrust of the rest of the collection. It is a song of the attributes of Mother Earth:

Temporary basemen
and lasting roof

First clayey coyness
and last alluvial joy

and compost bed
rocks and rivers

mud and mountains
silence of the twilight sea

echoes of the noonsome tide
milk of mellowing moon

fire of tropical hearth
spouse of the roving sky

virgin of a thousand offspring
The Eye of the Earth 1986:1).

In the above introductory poem, Osundare explores the ambivalent, antithetical nature of the earth. The earth gives and takes. Man walks on and works the earth, a "temporary basement" filled with "breadbasket" and "a thousand offspring", but he soon dies and is committed to earth, the "last alluvial joy" and "silence of the twilight sea". In the mythic imagination of the Yoruba, the earth and the sky are a couple, forever interfused conjugally; hence, the earth, we are told, is "spouse of the roving sky". What this means is that a bond stronger than death binds man to the earth. He subsists on the earth and finally brings himself, at death, a living (?) sacrifice to the Earth-alter, the ultimate oblation.

The first movement is subtitled "back to earth" and the first poem is titled "Forest Echoes". The forest itself is virginal while the echo approximates its deforestation or violation. Nostalgia is the main emotion that energises the long poem; nostalgia for a longed-for recent past that is both personal and collective. The poet-protagonist remembers the "greedy" past with "forest of a thousand wonders" which have been "wounded" by greedy tree cutters. Various images of the forest denizens, plants and animals alike, that once made the forests pulsate with life rush upon us, insisting on registering their existence if only fleetingly in our mind's eye. That "green desire" or the desire to visualize the verdant tropical vegetation and the poet's "perfumed memories" and "leafy longing" lure his "wandering feet" "to this (imagined/dry) forest. We accompany the poet-protagonist into this primordial forest where:

…the horizon dips into an inky grove
like a masquerade scribbling loric fear
in the lines of festival streets (p.3).

In the vision of Osundare, the forest offers protection. In a manner reminiscent of the Romantic poets, Osundare describes the Oke Ubo Abusoro forest with great passion, intimate observation and keen knowledge. He goes further to celebrate the marvelous denizens of the forest, beginning with the Iroko:

Iroko wears the crown of the forest
Town's rafter, roof of the forest
Ironwood against the termites of time
Iroko wears the crown of the forest
Its baobab foot rooted against
a thousand storms (p.5).

Obviously, the Iroko, by virtue of its sheer majesty and great height remains the incontestable natural monarch of the plant kingdom. Other important trees and animals are praised. These include the palm, a "tree of all seasons" which produces wine, "nuts and kernels" for man. One by one, the animal population in the rainforest is praised. The weaver bird is rhapsodized for "singing mute straws into eloquent patterns", the squirrel solves the difficult riddle of the palm nut with its scalpel-like teeth; the chameleon "dazzles the forest with a garment of a million mirrors". He recalls:

A bevy of birds, a barrack of beasts,
a school of truant antelopes

Obey my head masterly steps,
The Partridge, alert like roadside grass,
roars in the clearing
its skyful guffaw a triumphant mockery
of a missing shot;
the hunter watches in flightless ire
his powder doused by drops
of salivating anger (pp. 7-8).

In "The Rocks rose to meet me", the poet-protagonist remembers the memorable contact between him and the rocks. Even the trees "are swaying their leafy heads" during the encounter: "Tall rocks, short rocks/sharp rocks, round rocks"-rocks of all sizes and descriptions are involved in this encounter. It is regrettable that these monuments of beauty and environmental sustainability that made the society of the poet-protagonist in the past have all been destroyed by the greedy and exploiter class. This sentiment runs into "Harvestcall" which is also a complaint about what has happened to the society of the poet-protagonist. In the time past, everything was in order as "pounded yam rested its feted arms/On the back of stooping stakes/yams are ripe and randy" but over time lack and want take a centre stage in the land as the "yam pyramids which challenged the sum" have all disappeared. The "uncountable seeds lie sleeping/in the womb of earth" (p. 20). We can observe that in "Harvestcall", the poet-protagonist evokes the season of harvest through a tone of elation in lines chanted against the background of lively music.

A ringing condemnation of the sterility of the land is further pursued by the poet as can be seen in the lines "the gloomy alleys/of NEPA's darkroom". This poem captures the reality of Nigerian life. Life in Nigeria has lost all its allure and enchantment occasioned by the lack of vision in the leadership of the country. NEPA is the acronym for the institution that is saddled with the responsibility of generating, transmitting and managing electricity supply in the country. This agency has proved to be very inefficient and ineffective. The inability of NEPA to provide electricity (light) is a symbolic representation of the crisis in the land.

The second movement, "Rainsongs", Osundare says "in a way is a logical continuation of "Forest Echoes", for it is a celebration of the giver and sustainer of life. As agent of the difference between plenty and famine, life and death, the rain occupied a god-like place in the consciousness of Ikare's agrarian people" (p. xii). Rain is the natural antidote to drought. Therefore, in "Let Earth's pain Be Soothed", the poet-protagonist prays: "the sky carries a boil anguish. Let it burst" (p. 27). This prayer is meant to cleanse the Augean stable taking into consideration the sterility that has engulfed the earth for a long time. It is expected that if this prayer is heard, the earth will witness a buoyant life once again considering the fact it has suffered so much

Dust
dust in brewing kitchens
dust in eating halls
dust in scheming boardrooms
dust in retrenching factories
dust in power brothels… (pp. 27-28).

Typically, rain takes on a metaphoric significance since it carries a purging potency to rid the human society of moral filth and evil.

"First Rain" and "Rain-Coming" capture the infantile thrills experienced by both young and old when the much-awaited rain falls and the pores are liberated and our "earth breathes again". In the poems the needed effect of rain on the earth including the flora and fauna is felt as "the early rains ring the bell/and the earth springs green" (p.30). "Raindrum" beats the soporific rhythms of rainfall as the oral/aural impression made by the recitation of the poem titillates the imagination:

Streets break into liquid dance
Gathering legs in the orchestra of the road
streets break into liquid dance…(p. 32).

Again, in "Meet me at Okeruku" the poet-protagonist celebrates the coming of the rain as a productive and re-invigorative power. The celebration is presented through a festive atmosphere reminiscent of children's dance of joy whenever rain falls. "Who says that drought was here" is also an expression of the recuperative and regenerative potential of rain:

Aflame with herbal joy
trees slap heaven's face
with the compound pride
of youthful leaves
drapering twigs into groves …(pp. 35-36).

To say that there was formerly drought might sound ludicrous. The poet-protagonist, yields to a blissful sense of awesome wonder at the teeming luxuriance of the Sub-Saharan rainforest belts, and in mock-consternation, queries the despoliation agenda of drought which can reduce an Amazon forest to a Sahara decent.

Even so, the poem "But sometimes when it rains" exposes poignantly the seamy side of rain. The contrastive conjunct "But" is replete with meanings as it introduces a tone of destruction and relativity to the prevailing festive mood just experienced in "who says that drought was here". The rain, like every other phenomenon, has its blessings and its troubles. It can be destructive:

Sometime when it rains
and a heartless storm beheads
the poor man's house
sometimes when it rains
you wonder who sent the skies weeping (p. 36).

The ruinous rain can fell "an impregnable mahogany" across "farmward path", destroy farms and other edibles, and bring on a pall of drab existence. It may be argued that by showing the negative effect of rain, alongside its beneficial impact, the poet-protagonist is presenting the rain phenomena in man's life.

"Homecall," the last section of *The Eye of the Earth,* is composed of seven poems, which collectively explore and amplify a thematic concern with the fate of humanity. In the words of Abdu (2003) "in the poems of this section, the general theme of the volume which is throughout poetically interwoven with the fate of the earth, is given a more direct and clearer articulation". In "Dawncall", the first of the eight, the poet-protagonist evokes the beauty of the morning and the joy it gives. It is a kind of poetic musing on the action of time on nature and the earth itself.

The remaining poems in the collection continue to present direct and indirect powerful and fresh allusions to the interwoven essences of the earth and human life. The second poem "Excursion" takes us on a roller-coaster wide:

Past bush paths tarred by tireless treading
Past the depleted copper of harvested cornfields
Past the leafy grove of ripening yams
with a flower in one hand
Homeward. (pp. 41-42)

The poem dwells mainly on farm produce like "ripening yams", groundnut, the bean, etc. The courage of the peasant farmers is celebrated by the poet-protagonist, for their labour sustains life.

"Farmer-Born" is the poet-protagonist's recollection of his childhood. In fact, it reads like a poetic autobiography of Niyi Osundare as he recalls his background and up-bringing in rural Ikare-Ekiti. The poem also revels in the things the poet-protagonist enjoyed in his rural environment. These include food, fruits and other edibles in a setting lived by genial and beneficial flora and fauna:

Farmer-born peasant-bred
I have frolicked from furrow to furrow
Sounded kicking tubers in the womb
of quickening earth

and fondled the melon breasts
of succulent ridges (p. 43).

This society in question was one of peasants whose exploits on the land and the environment were not as destructive as the current one in place. The poet-protagonist is juxtaposing the old with the new.

"They too are the earth" identities with the poor and the down-trodden. It is a song of praise to the poor and marginalized. The poet-protagonist goes further to attack those who fritter away the forests and engage in other destructive activities on the earth. These are the people and forces "who live that earth may die". In a twist of style, the poet makes the earth speak to us in "What the Earth Said." In a narrative full of a tone of anger and distemper, the earth chronicles the distinctive activities of those who have undermined it, but in a twist of poignant irony ultimately end up in the bowels of the earth.

In the second to the last poem of the collection, "Ours to Plough, Not To Plunder", the poet-protagonist calls on humanity to make the planet (earth) a productive, conducive and improved environment. The inhabitants of the earth are advised to work for the improvement of the quality of life of all, after all, the earth belongs to man and therefore, he should be the least to think of plundering or destroying it. Through idioms, metaphors and symbols from agriculture and mining, the poem reminds man of his obligation to earth-his planet-home:

This earth is
ours to work not to waste
ours to man not to maim (p. 49).

The volume is concluded with a rich and exhaustive submission, "Our Earth Will Not Die". The tone of the poem is optimistic and hopeful. The poet-protagonist believes that in spite of the degrading and devastating behaviour of man on the earth, the latter is bound to survive. The poet employs a variety of means to express his tenacious belief in the planet's continued survival. Even though the Earth is "Lynched/the lakes slaughtered /the seas/Mauled/the mountains…" the earth will not die. This positive and hopeful conclusion portrays Osundare as a poet who believes strongly in his commitment to promoting, defending and articulating the right of the earth and all its inhabitants.

We dare say that despite the recurrence of what we might consider as expressions of pessimism in some of the poems, Osundare affirms that Our Earth Shall Not Die. He warns that human culture can only function through the links and reciprocal relations with nature.

CONCLUSION

In this essay, we have attempted a discussion as it relates to the survival of the earth given the destructive activities of man in his quest for survival and profit-seeking ventures. Employing the Ecocritical method, we reviewed Osundare's green imagination using two of his collections of poems-*Village Voices* and *The Eye of the Earth.* Our interrogation of the poems shows that Osundare is an ecologically engaged poet who is acutely dissatisfied with the degradation of the ecosystems, deforestation, unsustainable use of land, trampling and even aesthetic pollution.

The implication of the foregoing is that, to rescue humanity, man, must refocus his attention and energy on non-market values, such as recreation and aesthetic uses of natural resources. This calls for an ethic that is based on man-to-man relationships or on man-to society relationships which must be extended to include an ethical relationship between man and his environment as have been canvassed by Leopold (1949) and Odum (1974). It also presupposes that the human community should assume some obligation and make some sacrifice for the beleaguered and abused biotic community.

It is true that in the collections and in our analysis, technology is implicated as a strong factor in the devastation of the environment, we agree with Blackstone (1974) that the answer to environmental degradation "is not to stop technology, but to guide it toward proper ends, and to set up standards of antipollution to which all technological devices must conform." Technology has been and can be used to destroy and pollute the environment, but it can also be used to save, regenerate and beautify it. We therefore must choose a course of action that will enhance the diversity, integrity, beauty, and stability of the biotic community, the health and well-being of the land organism in holistic environmental ethic. The well-being of humans is dependent upon the ecological soundness and health of many plants and animal communities, while their soundness and health does not in the least depend on human-well-being.

Most of the poems in the collection are concerned with the future of the planet earth itself-the ecological battle and the survival of the biosphere. Osundare envisions an eminently liveable, modern, systemic, *civilized* technological society well adapted to and at peace in harmony with its organic environment. These are the concerns of Osundare in the two collection chosen for our analysis in this essay.

Notes

1. The first generation poets of Nigeria's Ibadan/Nsukka School are criticized by the like of Osundare and Chinweizu et al for what the latter consider as poetry of obscurantism informed by a Euro-modernist temperament.
2. John Clare is known for his pioneering work on nature like Wordsworth in his expression of affection for his environment.

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CLIMATE CHANGE AND ENVIRONMENTAL DEGRADATION IN NIGERIA'S NIGER DELTA: THE IMPERATIVE FOR ENVIRONMENTAL JUSTICE AS A COMPREHENSIVE POLICY FRAMEWORK

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Abstract

Climate change no doubt has effects on the quality of life of many people today, in both measurable and less tangible terms. Those who are at disadvantage are perhaps the ones who are already marginalized by their social status, indigenous people dependent for their immediate survival on local ecologies and workers in nature related trades, such as fishing, forestry, farming, and hunting. The paper notes that though the climate change policy is an internal political issue, with wider global dimensions, it is rarely cast as an issue related directly to distributive and environmental justice. No where in Nigeria, is the environment severely as threatened as in the Niger Delta region, due to many years of oil exploration and environmental degradation. Observers have noted that the root cause of the crisis in Nigeria's Niger Delta is environmental injustice as a result of systemic neglect of the region's development by several administrations that have come up with strategies to address the situation only to pay lip service to their own policies. This paper argues that climate change could act as a further and perhaps the ultimate catalyst towards taking the issue of environmental justice seriously in the Niger Delta and other parts of the country. This is significant because it raises so many decision making points that we cannot separate from the fairness issues resultant from the resiliency of the tremendous discrepancies of life opportunities that characterize the international system. While Nigerian state cooperates with other African countries and developing countries in attempting to find ways of adapting to climate change, as well as funding options for effective adaptation by negotiating with the developed and industrialized countries, it is imperative that Nigeria develops even better measures at home.

INTRODUCTION

Climate change is one of the most pressing challenges facing the human race. It has been predicted that in the coming decades, several changing weather conditions including droughts, floods, and rising sea levels are likely to affect countries such as Nigeria, Mozambique and several other African countries (Cilliers, 2009). Though not much analysis has been published on the relationship between climate change and conflict, there is no doubt that climate change is already affecting the quality of lives of people around the world. Those who are at disadvantaged are perhaps the ones who are already marginalized by their social status, indigenous people dependent for their immediate survival on local ecologies and workers in nature related trades, such as fishing, forestry, farming, and hunting. Pulido (1996), observed that, 'the poor and marginalized of the world often bear the brunt of pollution and resource degradation'. It is often those who lack access to public defense mechanisms that are most affected by extreme weather events such as floods, erosion, droughts, and forest fires. The state, acting to protect its citizens as well as private property and investments, most times privileges those with structural power and enables them to either escape or avoid the negative impact of undesirable environmental change.

The Niger Delta region is highly susceptible to adverse environmental changes occasioned by climate change because it is located in the coastal region of the world. It has been observed that coastal regions of the world are already experiencing flooding due to rise in temperatures and sea levels (IPCC, 2007). In addition, the Niger Delta region is already faced with myriads of environmental problems resulting from oil exploration and systemic neglect of the region's development by previous administrations. This has led to agitations by the oil producing communities that have been demanding for environmental justice.

The paper argues that climate change could act as a further catalyst and perhaps the ultimate catalyst towards taking the issue of environmental justice seriously in the Niger Delta, and other parts of Nigeria. This is significant because it raises so many decision making points that cannot be separated from the fairness issues resultant from the resiliency of the tremendous discrepancies of life opportunities that characterize the international system. While the Nigerian state cooperates with other states in Africa, and the developing world, in finding ways to mitigate and adapt to climate change, as well as funding options, by negotiating with the developed and industrialized countries, it is imperative that Nigeria develops effective policy measures at home.

The paper which is divided into six sections, consist of the introduction in section one and followed by section two that deals with conceptual issues in climate change and environmental justice. Section three is titled climate change, environmental degradation and the Nigeria Delta. Section four, examines the oil producing communities and the quest for environmental justice, while section five discusses environmental justice as a comprehensive policy framework for the Niger Delta. Section six concludes the paper and offers some recommendations.

CONCEPTUAL ISSUES IN CLIMATE CHANGE AND ENVIRONMENTAL JUSTICE

According to the UN Intergovernmental Panel on Climate Change (IPCC, 2001), the climate change is as a result of man-made emissions of greenhouse gases (mostly Carbon dioxide, Nitrous Oxides, Chlorofluorocarbon, Hydrocarbon such as methane, ozone, and water vapour). Increase in production activities occasioned by the revolution in technology has led to rise in fossil burning and land use changes. There have been increase in quantity of greenhouse gases emissions into the atmosphere and a rise in the amount of heat from the sun withheld in the earth's atmosphere, heat that would normally be radiated back to space. Thus increase in heat has led to the greenhouse effect resulting in the climate change.

The main characteristics of climate change are increase in average global temperature, changes in cloud cover and precipitation. The world is also witnessing melting of ice caps and glaciers, reduced cover and increased ocean temperatures, and ocean acidity due to water absorbing heat and carbon dioxide from the atmosphere. The fourth assessment report of the IPCC released in February 2007 stated that temperatures have risen by 0.76 degrees Celsius since the 19th century and predicted a minimum increase of 2.5 degrees in Africa by 2030. The report also noted that, “Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity” (IPCC, 2007). The IPCC report of 2001 had noted that over the last century, atmospheric concentration of carbon dioxide increased to 379 parts per million in 2005 from a pre-industrial value which stood at 278 parts par million. The average global temperature rose by 0.74C within the same period (IPCC, 2001).

The long term concerns about climate change expressed by the IPCC and other studies do not just evoke concerns about a more frequent and less predictable weather, but also the impact of greenhouse gases on the very ability of nature to sustain itself. Coastal areas such as Nigeria’s Niger Delta where a number of people depend on nature related trade, and have low income, are vulnerable to impact of such changes. This of course, does not negate the fact that extreme weather conditions and manifestations of climate change will affect both the rich and poor. But certainly, those with fewer resources are at more risk because of dependence on the ecology for their source of livelihood. Increase in water scarcity could further harm and alienate those whom accessible clean water is already a problem. Food security could be further compromised without adaptation measures as increased droughts are likely become common in areas such as northern Nigeria where people depend on subsistent farming. Coastal areas, such as the Niger Delta, are likely to face challenges of not only rising sea levels, but also effect of oil exploration activities such as land and sea pollution by oil spillage. Those who depend on fishing are also at risk because the fish industry could collapse. This may not be as a result of over fishing, but because of warm water, due to rising temperature and oil spillage on the water. The fact that those who are at higher risk of climate change are those who benefit less from industrial processes such as oil exploration in the Niger Delta, makes this an issue of not just need, but of justice, and to be specific, that of environmental justice.

The term environmental justice is a very sensitive issue, especially in the context of Nigeria’s Niger Delta, as in other parts of the world where the issue also relates to that of ‘resource control’ (Obi, 2008:11). Definitions of environmental justice vary. Some argue that environmental justice is concerned with achieving intergenerational justice (Almond, 1995). It is also associated with debates about ‘distributional inequalities and actions needed to address them’ (Illsly, 2002:70). Another definition offered by the US Environmental Protection Agency, argues that environmental justice is ‘the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies’.

While attempted has been made to clarify the concept of environmental justice as noted above, we consider the definitions inadequate in relation to the complex issues in Nigeria’s Niger Delta. Environmental injustices vary across communities, regions and sub regions of the world. The peculiarity of the Niger Delta situation and the contextual challenges necessitate a deeper examination of the concept. An alternative definition as used in this paper, conceptualizes environmental justice as a situation when access to environmental investments, benefits, and natural resources are equally distributed; and when access to information, participation in decision making, and access to justice in environment-related matters are enjoyed by all. Environmental justice also entails the right to a safe, healthy, productive, and sustainable environment for all. This definition considers the environment in its totality to include the ecological (biological), physical (natural and built), social, political, aesthetic, and economic environments. Environmental justice also refers to the conditions in which such rights can be freely exercised, whereby individual and group identities, needs, and dignities are preserved, fulfilled, and respected in a way that provides for self-actualization and personal and community empowerment. On the other hand environmental injustice exists when members of disadvantaged, ethnic, minority or other groups suffer disproportionately at the local, regional, or national levels from environmental risks or hazards, and/or suffer disproportionately from violations of fundamental human rights as a result of environmental factors, and/or denied access to environmental investments, benefits, and/or natural resources, and/or are denied access to information; and/or participation in decision making; and/or access to justice in environment-related matters.

Arguably, the issue of environmental justice is yet to be taken seriously by politicians and policy makers, nationally and internationally. The issue of environmental protection has been largely politicized and hardly transcends the rhetoric that characterizes north-south debates on environment and development. The same scenarios have been played out since the 1972 Stockholm United Nations Conference on Human Environment, the Rio de Janeiro Conference on Environment and Development in 1992, and the 2002 Delhi Ministerial Declaration on Climate Change and Sustainable Development. The Kyoto Protocol which was adopted on 11 December 1997 with a view to achieving stabilization of greenhouse gas concentrations in the atmosphere has not been spared of such rhetoric that has characterize issues on the environment. As at January 2009, 183 parties had ratified the protocol (UNFCCC, 2009). The assumption underlying the lack of seeming commitment is that environmental protection should not override priorities of economics and investments, poverty reduction eradication and development (Stoett, 2008:60).

CLIMATE CHANGE, ENVIRONMENTAL DEGRADATION, AND THE NIGER DELTA

The discourse on the Niger Delta has tend to focus more on oil, militancy, environmental degradation, human rights and security, and related issues (Obi, 2008; Okonta, 2008). Studies that focus on climate change and the Niger Delta are negligible (Uyigue and Agho, 2007:7). That not withstanding, some studies have linked the rise in sea levels in the coastal regions of the world with global warming (IPCC, 1990; IPCC, 2001; IPCC, 2007; IFRC, 1999; Uyigue and Agho, 2007). Studies carried out by the IPCC have noted that strong relations exist between greenhouse gas emissions and climate change, and between increase in global temperature and sea rises. The problems of coastal erosion and floods are already a menace in the Niger Delta. The Nigerian Environmental Study/Action Team (NEST, 2004), reported that sea level rise and repeated ocean surges will worsen the problems of coastal erosion and floods in the Niger Delta. The intrusion of sea water into fresh water will also destroy stabilizing systems such as mangrove and affecting agriculture, fisheries and general livelihoods.

Uyigue and Agho (2007:8) have noted that floods do not only paralyse economic activities of the people, but also makes them vulnerable to water related diseases such as malaria, dysentery, cholera, and diarrhea. In some cases, areas are completely cut off from other communities when flood occur.

In the Niger Delta, not so many persons work in the civil service and even fewer in the oil companies operating in the area (Uyigue and Agho, 2007). Many people in the region whose source of livelihood depended on natural resources such as farming, fishing are left with the options of changing their means of livelihood because of the degradation of their environment. Most of the youths who are unable to adapt have become restive and are forcefully demanding for change (Obi, 2008). Most farmers in the southern part of Nigeria depend on rain fed agriculture. Oladipo (2005), notes that the decline in rainfall in Nigeria started as far back as the 1960s. According to him, the low level of rainfall in the last few decades in Nigeria is an indication of abrupt climate change. The change of rainfall in the Niger Delta has affected farmers who find it difficult to predict when rain will start and end for the planting season which is suppose to be from May to September. Change in climate which affects rainfall patterns has also affected vegetation cover. Even though other man-made activities account to a large extent account for lost of vegetation, this includes logging to develop urban areas. The changes in vegetation have deeper implications for biological production and resultant effect on biomass production. To a large extent it could lead to alteration of biodiversity and various plants species may become extinct as a result.

Since the discovery of oil, the black gold, in the late 1950s, the Niger Delta became the centre of attraction for the Nigerian state seeking revenue, and the Oil Multinational Corporations (OMNCs), seeking oil mining activities for the accumulation of wealth. The activities of the OMNCs in the region have both environmental and social implications, which are quiet extensive. Gas flaring, oil pipeline explosions and oil spillages are major problems in the region. The preponderance of gas flaring has been practice in the region for several decades. It has been noted that Nigeria is one of the highest emitters of greenhouse gases in Africa (Iyayi, 2004). Greenhouse gases are responsible for acid rains which have also been reported in the Niger Delta (Uyigue and Agho, 2007). Agbola and Olurin (2003) noted that some 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger Delta everyday. Gas flaring has also been noted to have raised temperatures and rendered some areas uninhabitable. According to Awosika as quoted in Uyigue and Agho (2007), a total of about 125.5 million cubic metres of gas was produced between 1970 and 1986 in the Niger Delta. About 102.3 (81.7%) million cubic metres were flared, while only 2.6 million cubic metres was used as fuel by the oil companies and about 14.6 million cubic metres was sold to other consumers. Gas flaring contributes in no small way to environmental degradation, as acid rain is caused by gas flaring. Though more scientific research is needed on the impact of acid rain on the Nigeria Delta, vegetation cover in the area have been altered by acid rain and the soil is no longer as fertile for the production of crops. The location of communities close to faring sites also brings to question the health implication on the people in the region.

Oil pillage has reduced the Niger Delta in Nigeria into an ecological disaster. Frequent oil spills are serious problem that contribute to the degradation of the environment of the Niger Delta. Spilled oil is sometimes discharged into the source of water for the people, thus polluting the water bodies. Water bodies polluted with oil affects both human and aquatic live. Oil spillage affects farmlands, crops, fishing and other activities of the people who depend on farming and fishing for their livelihood. A report by Civil Liberties Organisation (1996), notes that between 1976 and 1990, the region has experienced not less that 2676 cases of oil spills and most of this took place in Rivers, Bayelsa and Delta states. Pipeline explosions have also caused major oil spillages in some cases. Though pipeline explosion can take place as a result of other causes such as pipeline vandalisation. Several pipeline vandalisation have in the passed led to fire outbreaks and leading to the lost of lives and property. In 1998, about 1000 people lost their lives in Jesse village and about 12 people lost their lives in Ekakpamre in Ughelli Local Government Area in Delta State. In 2000, over 50 people lost their lives at Nnagiji and Umuegbede in Abia State, 300 people in Egborode village in Okpe Local Government Area of Delta state (Okecha, 2003). The environmental cost of oil exploration and exploitation in the Niger Delta is very extensive. The effects include on biodiversity, wildlife, loss of fertile soil, pollution of air and water, degradation of farmlands and damage to aquatic ecosystems.

OIL PRODUCING COMMUNITIES AND THE QUEST FOR ENVIRONMENTAL JUSTICE

The local people are no longer taking to farming and fishing which are their major occupations. As a result of environmental damage brought about by the oil companies, the people, especially youths have protested against the oil companies and the government (Obi, 2008:3). The main grievances of the armed militants that have emerged over the years is that, the ethnic minority groups in the Niger Delta are being cheated out of the share of oil revenues because they are marginalized politically by a federal government who in alliance with OMNC exploit their region. The OMNC are seen as taking over their land and exposing it to pollution and environmental degradation. Oil multinational corporations in alliance with the Nigerian state contribute significantly to the environmental destruction of the Niger Delta (Obi, 2008). The alliance is largely is largely sustained by a common interest of sharing revenue derived from oil resources in the area. As a result of the common interest between the Nigerian state and the OMNC, the state does little to exert its influence and enforce environmental legislation on the OMNC. Majority of the people in the region lacking in power and wealth, can do little to bring the OMNC to observe environmental standards.

The demand for environmental justice which began as a ‘local protest has given rise to resistance in form of different militant groups’ (Obi, 2008:13). The rise of the Movement for the Survival of the Ogoni People (MOSOP) founded in 1992 and led by Ken Saro Wiwa was to organise the Ogoni ethnic group to stop the destruction of their home land by oil companies such as Shell, Chevron, and many others, and to seek compensation for the destruction of farmlands and fisheries (Ken Saro Wiwa, 1995). The government of General Sanni Abacha failed to address the grievances of the people and instead hanged Ken Saro Wiwa, together with eight other Ogonis, following the killing of the Ogoni four, and the conviction of the Ogoni nine by a military tribunal in November 1995. The fate that befell Ken Saro Wiwa and the other Ogonis did not stop the struggle for environmental justice. The challenge was taken up by other groups including the youths in the Niger Delta. The challenge was taken up by the Ijaw youths, who in December 1998 formed the Ijaw Youth Council (IYC), and issued the Kaiama Declaration. To underscore the thrust of their demands, which is environmental justice, the IYC had as its slogan, '*Operation Climate Change*' (Obi, 2008:14). But rather than respond and engage the youth in constructive dialogue, the military government sends in troops that forcefully put down the uprising against transnational oil in the region. Newer groups that have emerged since then have employed other militant strategies with some deviating to criminality including kidnappings and demand of ransom. Prominent among the militant groups are the Movement for the Emancipation of the Niger Delta (MEND), the Niger Delta Peoples Volunteer Force (NDPVF), the Joint Revolutionary Council (JRC) and the Movement for the Survival of the Ijaw Ethnic Nationality (MOSIEN).

Against the backdrop of federal government relationship with the OMNC, perceptions have trailed the government's efforts to address problems in the Niger Delta. There were previous initiatives to address the Niger Delta crisis. The recommendations of the Wlkins Commission in 1958 led to the birth of the Niger Delta Board in 1961, however not much was achieved. Another effort to develop the region was the setting up of the Niger Delta Basin and Development Authority in 1976. The Oil and Mineral Producing Areas Development Commission (OMPADEC) was set up in 1992. The initiatives did not achieve much largely because of lack of accountability, bad governance, environmental injustice to the people of the region.

Expectations were relatively high in the Niger Delta that Nigeria's return to democracy would reduce tension in the region, and bring 'environmental justice' and also democratic dividends to the people. Apart from increasing the derivation principle to 13 percent in May 1999, the federal government also set up the Niger Delta Development Commission (NDDC) in 2000. The NDDC was set up with a mandate to conceive, plan, and implement projects and programmes for sustainable development in the region. Perceptions and criticisms have also trailed the operations of the NDDC since it began operations in 2001. In addition to lack of transparency, it has been accused of not involving the communities in the planning and implementation of developmental projects, thus lacking ownership.

The crisis in the Niger Delta has been on the increase as observed in the reports of both local and international media. The setting up of the Ministry of Niger Delta by the administration of President Umaru Yar Adua is yet to yield any tangible results in terms of addressing the grievances of the oil producing communities which include oil pollution, poverty, unemployment and socio-economic and political marginalization. The people in the Niger Delta have continued to demand for environmental justice in the face of myriads of environmental problems caused by activities of the OMNC and further exacerbated by changing climatic conditions.

THE IMPERATIVE OF ENVIRONMENTAL JUSTICE AS A POLICY FRAMEWORK FOR THE NIGER DELTA

The quest for environmental justice is an integral part of social justice, human rights and the promotion of peace. Environmental injustice such as unfair access to land and water can deepen poverty, marginalisation and conflict as in the case of the Niger Delta. Climate change and its diverse consequences such as sea rise and flooding, acid rains and loss of vegetation, droughts and desertification, add a new dimension to links between conflict and the environment. Scholars have attempted to link the environment and conflict from three perspectives namely the distribution of natural resources; competition over natural resources; and environmental degradation. Distribution based conflict arise, in part, from poor state policies to ensure equitable access to water, land, forest, pasture, fisheries and others. The state's ability to govern and manage the distribution of natural resources according to need, for example across regions, ethnic groups, influences the extent to which environmental resources become a factor in political and social instability. Grievances over unfair access to resources, combined with loss of biodiversity and means of livelihood, could lead to violent conflict. Climate change impacts such as unpredictable rainfall, acid rains and others could put pressure on the Nigerian state that is already weak in terms of regulating the activities OMNC in the Niger Delta and managing environmental degradation. Climate change and further degradation of the environment could increase the likelihood of poverty and aggravate problems in the Niger Delta. The depletion of fish stocks, deforestation, and polluted water supplies can lead to scarcity of resources and further displace communities from ancestral lands. Displacement can have adverse consequences on communities who depend on traditional and ancestral lands and water for basic sustenance, livelihood and cultural survival.

The fallout of global warming such as increased flooding, erosion, unpredictable rainfalls in the Niger Delta, are combining with environmental degradation caused by oil exploration by the OMNCs in the region to cause community unrest, resistance and protests. According to the International Crisis Group (2007), three factors underline the vulnerability to climate change. These include: the extent to which societies are dependent on natural resources and ecosystem services; the extent to which the resources and services that societies rely on are sensitive to changes in climate; and adaptative capacity. Climate change poses an added challenge for states with weak governance capacity, because the inability of the state to manage the adaptation could compound social, economic and political tensions in societies dependent on natural resources for immediate sustenance and livelihood.

The impact of climate change must be seen as an additional crisis to the existing crises entrenched in the commodification of natural resources and pillaging of the global commons (Obi, 2005). Climate change is accelerating adverse impacts of environmental degradation. No doubt, those who feel the climate change's harmful effect the most are the poor who are already marginalised by their social status; including men and women and children. In addition to existing challenges of poverty, environmental degradation and resultant protest and agitations in the Niger Delta, climate change will add another pressure on the Nigerian state's capacity to adapt and respond to the crisis.

POLICY CONSIDERATIONS

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as 'adjustment in natural and human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities'. Adaptative capacity is defined as the ability of a system to adjust to climate change to moderate potential damages, take advantage of opportunities or to cope with the consequences. The IPCC identifies three categories of adaptation: anticipatory or proactive adaptation (that takes place before impacts of climate change are observed), spontaneous adaptation (which is triggered by observation of changes) and planned adaptation (adaptation as a result of deliberate policy decision) (IPIECA, 2007).

Developing countries have been discussing mitigation and negotiating for climate change adaptation funds to assist the poor and vulnerable communities in their states to adapt to adverse climate change impacts. Nigeria belongs to the African Group on Climate Change. The group has held meetings within and outside Africa with a view to harmonizing common position for the climate change talks. Meetings have been held in Naivasha-Kenya, Abuja-Nigeria, Dakar-Senegal, Bonn-Germany and Accra-Ghana with a view to presenting a common position at the Poznan talks in 2008. The group's position stressed the need for Adaptation Fund, technology transfer and mitigation.

In view of the challenges posed by climate change and environmental degradation, and against the background of crisis in the Niger Delta, Nigeria is likely to be overstretched in her institutional capacity to adapt quickly and effectively to climate change. However, proactive and planned options could help the peace efforts by enabling communities in the Niger Delta to increase their resilience to adapt to climate change. Proactive and planned adaptation strategies could help build the capacity of both the state and communities to prevent an overburdening on both the state and communities' coping mechanisms. Climate change impacts should not be allowed to become full blown before the state should respond as in the case of spontaneous adaptation. Adaptation efforts by the state could promote social justice, human rights by ensuring that the adaptation efforts are accessible and responsive to women and men in vulnerable in communities of the Niger Delta.

CONCLUSION

The paper has examined the issue of climate change and environmental degradation in the Niger Delta. It argued that problem of coastal floods and erosion, and many others, which are already a menace in the Niger Delta, is further being accelerated by the impact of climate change in the region such as acid rains, and sea rise. The paper notes that the activities of OMNCs in the region has led to oil spills, pipeline explosions and gas flaring, which further degrades the environment. Observers have argued that the crisis in the Niger Delta that began as local protest against environmental injustice in the region has gravitated into resistance and militancy (Obi, 2008). The Nigerian state, acting in collaboration with the OMNCs, has responded at various times with violence rather than engaging the people in dialogue. The government has also come up with initiatives in the past only to pay lip service to its own policies. The climate change situation could compound the problems in the Niger

Delta because most of the people depend for their survival on local ecologies and nature related trades such as farming, forestry and hunting. Environmental injustice such as unfair access to land and water can further contribute to poverty, marginalisation and violent conflict. As such, the just and equitable management of resources and the distribution of its benefits are vital to both sustainable development and a durable peace in the Niger Delta. In addition, state policies should include specific considerations for climate change adaptation, including an assessment of state capacities. Climate change should be integrated into poverty reduction and peace building frameworks for the region. Environmental impacts should also consider impacts bought about by climate changes.

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EX-SITU BIODIVERSITY CONSERVATION: POSSIBILITIES OF LOW-COST SEED GENE BANK OPERATIONS IN SOUTH WESTERN NIGERIA.

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Abstract

Ex-situ conservation of plant germplasm in gene banks constitutes a major security against genetic erosion of the world's food, fibre and medicinal plants and serves as genetic resources for crop improvement. This paper reports some studies on dry storage of seeds at the ambient high temperatures of the tropics for low-input gene bank operations. Previous studies had established the fact that seeds of various crop species deteriorated rapidly during storage under ambient seed store conditions at the South Western parts of Nigeria. However, results from the trials on maize seeds indicates that containerized dry-storage systems that allow manipulation of relative humidity at the prevailing high temperatures are capable of extending seed storage life for up to 1,149 days (about 4 years). Dry storage without cooling is less cost intensive than the conventional dry-cold storage which is energy-consuming, thus dry storage is a potentially effective low-cost gene bank method which should be considered for at least, short term seed conservation.

Keywords: Biodiversity conservation, seed storage, low-cost gene bank operation

INTRODUCTION

'…To keep seed alive upon the face of the earth' (Gen. 7: 3) was the Divine motive for building Noah's ark to forestall total erosion of genetic resources in view of a foreseen global environmental catastrophe. For the present day environmental issues, gene banks serve a similar purpose as the Noah's ark for preservation and reproduction of living samples of the world's biodiversity of crop varieties and their wild relatives. This biodiversity serves as genetic resources for food security and as the necessary raw materials for crop improvement and research (Fowler, 2008).

Since the last 2 decades, there are several reports of rapid erosion of genetic diversity due to climate change. For plants species, FAO (1998) estimated that over 75% crop diversity was lost in the last century and NACGRAB (2000) reported over 400 Nigerian plant species that are already in danger of extinction. Several human activities are known causes of a considerable portion of the erosion of the world's plant genetic resources. Intensive agriculture causes genetic erosion through the introduction of genetically improved crops which could elicit the loss of unselected genotypes. An example is the high rate of adoption of composite hybrid maize (over 90%) in place of traditional open pollinated landraces in south western Nigeria (Daniel and Adetumbi, 2006). High rates of urbanization also contribute to erosion of plant genetic resources. Germplasm conservation is therefore a priority issue to circumvent erosion of genetic diversity of crop plants and their wild relatives hence the idea of *ex-situ* conservation that is, preserving genes of plants outside their field environment.

Gene banks conserve plant genetic resources *ex-situ,* that is, outside their natural habitat. To conserve and regenerate genetic resources *ex-situ*, gene banks first must collect samples germplasm. Thereafter, the most fundamental activity in a gene bank is to treat samples of collections in a way that will prolong its viability as long as possible while ensuring its quality. The samples (or accessions as they are called) are monitored to ensure that they are not losing viability. Gene banks are also concerned with reproduction or regeneration of its plant material. Plant samples must periodically be grown out, regenerated, and new seed harvested. Gene banks also ensure the collections are properly characterized and documented; and that the documentation implemented as information systems that serves as important tools for researchers and breeders who need data on the samples. Finally, gene banks distribute healthy samples to the farmers, breeders, researchers and duplicate samples in other gene banks for security.

Seed gene banks

The ultimate aim of a gene bank is to maintain collections in reproducible forms *i.e.* with the highest possible physiological and genetic integrity in different forms e. g. as whole plants, seeds, pollen, embryos, tissue/cell cultures and DNA, but the easiest method for long-term genetic resources conservation is seed storage (Fowler, 2008). Seeds are miniature plants, carrying all the genetic complements for reproducing the next generation of plants. Seeds are also small and can have extremely long life depending on the species. Seed types that can tolerate desiccation and low temperatures, and indeed have enhanced longevity with dry-cold storage are known to have orthodox storage physiology. Such seeds are dried to low moisture content and stored at subzero temperatures in cold stores. This technique accounts for 90 percent of the 6 million accessions conserved in *ex-situ* gene banks globally (Boerner, 2006). However, this technique is only possible for that cannot survive under such conditions. For species with so-called 'recalcitrant' seeds or species that are vegetatively propagated, such as roots tubers and aroids, different conservation techniques are used. Though not all crops can be preserved by seeds, over 70% of plant species are known to possess the orthodox seed storage behaviour (Dickie, 1990). The abundance of species possessing seeds with orthodox storage behaviour means that seed gene banks has potential of holding the bulk of the earth’s plant genetic resources.

Storage of orthodox seeds in gene banks is operated within standardized regimes of storage environmental conditions of temperature and RH (since seed moisture content equilibrates with the prevailing RH of storage area). According to FAO (1975), the recommendation for seed storage standards were divided into preferred and acceptable standards. Preferred standards specify storage at -18°C or less in air tight containers with seed moisture content at 5±1% for long-term seed conservation. IPGRI (1994) also recommended the preferred standards for long-term seed storage installations but relaxed storage temperature to -10°C if the gene bank holds a few species with good storability attributes. Ng and Williams (1979) however believed that seed storage for plant genetic resources conservation can further be relaxed to >0°C to suit economic capacities of a gene bank if optimal storage RH conditions for enhanced seed longevity can be derived for individual species from experimental data. Hence, the research gap for seed storage experimentation (IPGRI, 2004).

Challenges for seed conservation in South-Western Nigeria

In South-Western Nigeria, implementing standardized seed gene bank operation faces considerable limitations. The first challenge is the ambient seed store conditions characterized by high temperature *i.e* ~33°C in day-time and ~26°C at night and RH ranging from 60% to 75% (Daniel & Badru, unpublished). These conditions were found extremely detrimental to seed viability retention in storage. Daniel & Ajala (2006) reported that the viability of maize and soybean seeds had dropped below 50% from 83% in 2 months of storage and they predicted that the best quality seed will reach its half-life (P_{50}) in 5 months. Similarly, P_{50} of just about 4 months was predicted for sesame seeds (Adebisi et al. 2008) under the prevailing ambient conditions in the South Western Nigeria. The second limitation for standardized gene bank implementation in South Western Nigeria is the problem of poor funding. The installation and operational costs of running a standardized gene bank is too exorbitant for Nigerian public institutions and not cost-effective for private profit-based seed companies. The challenge for scientific intervention is thus to investigate possibilities of implementing low-cost seed gene bank operations.

Two key factors affect seed storage life, the RH and invariably the seed moisture content and storage temperature. The classical Ellis and Roberts' (1980) seed viability model and results from other workers on other crop species indicate that the effects of seed moisture content on seed longevity is higher in magnitude than storage temperature (Table 1). Thus, reductions in seed moisture content yields more extension of seed storage life than reductions in storage temperature. Moreover, it is cheaper to reduce seed moisture by dry storage than to reduce temperature with cooling installations. Therefore, hermetic dry storage at ambient temperatures of South Western Nigeria is a promising idea for low-cost seed preservation. This paper reports some results from three separate experiments conducted on maize seeds under ambient tropical conditions at the University of Agriculture, Abeokuta, Nigeria (~5°3'N, 3°10'E).

Experiment 1: Conditioned storage over different saturated salt solutions at 32±2°C.

Seeds of commercial maize genotypes Oba-super and Suwan-1 harvested in 2004 from commercial seed production farms of Institute of Agricultural Research and Training (IAR&T), Ibadan were used in the storage experiments. The storage history of the seed lots was limited to processing and transportation periods, no previous warehouse storage was done on the seed lots. The seeds were stored in air-tight plastic containers that were conditioned to 7 different levels of RH inside an incubator set at 31±4°C (simulated ambient room conditions in the humid tropics). The RH levels were achieved by various saturated solutions of different salts (Table 2). The saturated salt solutions were prepared in glass petri-plates, placed at the bottom of each plastic container and wire gauze was placed on top of it to separate the container into lower (saturated salt solution) chamber from the upper (seeds) chamber. The seeds were packed in net bags and placed on the top of the wire gauze. The control treatment container did not have saturated salt solution in the lower chamber; seeds were placed in the container, closed and then stored in the incubator. The equilibrium seed moisture content with each treatment was estimated. Seed moisture content was expressed on wet basis as the percentage of seed moisture removed after oven-drying 5g of seeds at 130°C for at least 3 hours. Serial seed germination tests were conducted in sand culture before storage and at monthly intervals for 12 months in storage at the various RH regimes in the incubator. Seed germination counts were scored on daily basis for 8 days. Percentage seed germination was estimated as proportion of sprouted seeds from total cultured seeds. The serial seed germination data were analyzed with the PROBIT procedure of SAS (2001) to estimate the longevity parameters from the seed viability equation given below.

$$V = Ki - p\ (1/\sigma) \qquad (1)$$

Where V is the probit germination percentage after p days of storage, Ki is a constant equivalent to the probit value of seed viability before storage, and σ is the standard deviation of the frequency of seed mortality in time (Ellis and Roberts, 1980). The reciprocal of σ ($1/\sigma$) is the slope of a seed survival curve and an estimate of seed deterioration during storage. The μ of tolerance distribution is equivalent to 0.5 probability or half the viability period (P_{50}).

Results and discussions

From the laboratory seed storage experiment, the equilibrium seed moisture content under the imposed RH levels by each saturated salt solution at ~33°C after 12 months of storage are shown in table 2. RH environments created by the salts ranged between 15.6% and 80.5% in the containers with $ZnCl_2$ and KCl respectively. Under these different conditions, maize seeds showed average equilibrium seed moisture content that ranged from 5.5 to 8.6 (Table 2). RH achieved in open containers (control) containers was 56%.

Linear fits of survival data of the two seed lots to the probit model yielded negative slopes under all RH treatments signifying seed deterioration in both seed lots but at different rates under varying RH treatments (Fig. 1). Seeds stored in closed container with 15.6% RH showed much less steep survival curves than seeds stored 80% RH. Seed lots of the two maize varieties retained germination above 70% (probit 0.52) after 300 days when stored at low RH levels, whereas seeds stored at 80% RH already had less than 50% germinability (0 on probit scale) within the first 100 days of storage (Fig. 1).

Probit parameter estimates of the seed survival curves for both seed lots under all the RH treatments are shown in Table 3. Estimates of the negative slope of survival data fits *($1/\sigma$),* which correspond to the seed deterioration rates, were significantly high in the seeds equilibrated at 80.5% RH (equilibrium seed MC > 7.5% in Oba and > 8% in Suwan-1). Least estimates of $1/\sigma$ were observed in the seeds stored at 15.6% and 28.7% RH with equilibrium MC below 5% for both seed lots (Tables

3). Also, seeds of both lots stored at 15.6 and 28.7% RH had the highest estimates of longevity (σ and P_{50}) which were statistically different in comparison to the seeds stored at other RH treatments. Under these drying treatments, estimates of P_{50} of 'Oba Super' seedlots were over 600 days and 'Suwan-1' seedlots were over 500 days, which is approximately 10 times greater than the P_{50} values of seeds stored at >60 %RH. The absolute seed longevity ($P_{50}x2$) values derived for the seeds stored at 15% RH and ~4% equilibrium MC were 1,084 days for 'Oba Super' and 1,149 days for 'Suwan-1'.

Significant differences in longevity estimates of the two seed lots with lower RH and equilibrium seed moisture content are consistent with the concept of 'drier-the-better' that underlies ultra-dry seed storage under high temperature conditions (Zheng et al., 1998). The common explanation for enhanced seed longevity of dry seeds at high temperature is the low chemical potential of water in dry seeds that reduces seed damage at higher temperatures compared to seeds with high moisture content where weakly bound water is present (Ellis and Hong, 2006). Vertucci and Roos (1990) reasoned that drying can induce thermo-tolerance and enhance longevity by preventing thermal denaturation of seeds. The higher longevity of drier seeds under ambient tropical temperatures has implications for term defined seed storage in gene bank operations. Maximum absolute longevity of ~4 years estimated for dry maize seeds is consistent with the farmers' claims of prolonged seed longevity under low input storage systems (IPGRI, 2004). Although there was significant improvement in seed longevity for dry storage at 15% and 28% RH at ambient temperatures (~4.5% seed moisture content), it may be suitable only for maintaining seeds on short-term basis by gene bank standards (FAO/IPGRI, 1994).

Experiment 2: Containerized storage with silica gel at room temperature

Two containerized seed trials were carried out on 5 commercial varieties of maize seeds in 2005 and 2006. The varieties were DMR-ESR-Y (DM), Suwan1 (SU), ObaSuper-1 (OB), TZm (TZ), ART-Oloyin (AR). In 2005, 100g seeds of each variety was packed in net bags and placed in 2-litre capacity screw-caped containers with different weights of a commercial desiccant (silica gel) to achieve 4 different gel/seed ratios by weight namely: a) 100 g silica gel (1:1 gel/seed ratio), b) 40 g silica gel (1:2.5 gel/seed ratio), c) 5 g silica gel (1:20 gel/seed ratio), and d) 0 g silica gel (1:0 seed/gel ratio). In 2006, 200g of seeds were packed in net bags and placed in container each containing different weights of silica gel to achieve 5 different gel/seed ratios: a) 200g silica gel (1:1 gel/seed ratio), b) 80g silica gel (1:2.5 gel/seed ratio), c) 40g silica gel (1:5 gel/seed ratio), d) 10 g silica gel (1:20 gel/seed ratio), and e) 0g silica gel (1:0 gel/seed ratio). Control seed lots were stored in opened containers without silica gel. Once closed, containers were not opened and silica gel was not replaced throughout the storage period. The seeds were stored at ambient temperature of the seed store.

After 4 months of storage, the seeds were evaluated for viability and moisture content (mc). Seed mc was determined gravimetrically by drying 5 g of seeds at 130°C for >3 hours and expressed on a fresh weight basis. Seed germination tests were carried out in sand trays on 3 replicates of 10 seeds drawn from each of the storage treatments. Germination counts were taken at 3, 5 and 7 days after culture. After storage in the containers, the remaining seeds of each seed lot were subjected to controlled deterioration (CD) tests in an oven at 45°C and 90% RH for 72 hours. During the aging course, 3 replicates of 10 seeds of each treatment were removed from the aging chamber for germination tests at 3, 6, 24, 27, 48, 51 and 72 hours. The serial germination data of aging seeds were subjected to probit analysis (as in experiment 1) to estimate potential seed longevity under each containerized-dry storage treatment.

Results and discussion

Seed drying indicated by variations in seed MC of seed lots of the different varieties did not follow a regular pattern under the different treatments in the 2 experiments (Table 4). However, storage over 1:1 and 1:2.5 gel/seed ratios consistently resulted in the lowest mean seed MC (Table 4). The recommended standard for long-term seed conservation is 5% mc or less (FAO/IPGRI, 1994) and none of the gel/seed ratio treatments in the trials sufficiently dried seeds to this level. The observation in this study could be attributed to non replacement of silica gel during the experiment. With more frequent changes of silica gel, it should be possible to achieve standardized seed MC for maize germplasm conservation using containerized storage. Further studies should involve determination of optimal gel replacement frequency to achieve standardized seed moisture. It would be of research interest to estimate maximal longevity achievable for well dried seeds at high room temperatures. Another research interest would be to establish optimal drying for maximum longevity for different seed sizes and seed types.

Probit analysis of seed deterioration data from the CD tests of seeds stored over with various ratios of silica gel by weight showed that in the 2005 trial, *Ki* values was highest in seed lots that were containerized at 1:1 and 1:2.5 gel/seed ratios and least in seeds containerized at 1:20 and 0 gel/seed ratios (Table 5). In the 2006 experiments, *Ki* were significantly greater in all seed lots containerized with silica gel at 1:1, 1:2.5 and 1:5 gel/seed ratios than open and seed lots without silica gel (Table 6). The estimates of slope ($1/\sigma$) of the survival data by probit modeling was significantly higher in control seed lot and seed lots containerized without silica gel, indicating higher rate of seed deterioration in control seed lots. Also, estimates of σ and seed half-life (P_{50}) were highest in seeds containerized at higher gel/seed ratios than seeds containerized without silica gel and control seed lots in the 2 experiments.

The CD test provides data that can be subjected to probit analysis for estimating seed longevity parameters (Daniel et al., 1999; Davies and Probert, 2004) as well as for making conclusions on seed physiological quality (Kruse, 1999; Powell et al., 2000; Torres and Marcos, 2003). Overall, silica gel containerized seed lots exhibited significantly higher potential longevity than the control seed lots, supporting previous report of significant longevity extension through dry storage under ambient temperature in the humid tropics (Daniel, 2007). The results provide evidence estimates that containerized storage at 1:1 and 1:2.5 gel/seed ratios maximized storage life extension of maize seeds and elucidates the potential application of containerized-dry storage for low input seed preservation at high ambient tropical temperature without cooling.

Experiment 3: Containerized storage with dried sawdust at room temperature

In 2008, an experiment was initiated to investigate potentials of dried sawdust as low-cost desiccant for seed preservation. In the preliminary trial, weighed samples of the seeds were packed in net bags and then sealed in nylon sachets containing various quantities of sieved sawdust dried to 4.13% moisture content to serve as low-cost desiccant. The initial seed moisture content before sealing was 10.1%. Afterwards, 10g of seeds were packed in various ratios with sawdust desiccant as follows: (1) 10g, (2) 20g, (3) 50g and (4) 100g of desiccant *i.e.* 1:1, 1:2, 1:5, 1:10 desiccant/seed ratios by weight respectively and seed storage without desiccant served as control. The packs were stored at ambient laboratory temperature (~33°C) for 56 days. Seed viability was evaluated by germination tests in sand pots. Seed longevity was estimated by probit modelling of survival data (as in experiment 1) of seed lots stored with various desiccant/seed ratios.

Results and discussions

In this study, potential seed longevity in terms of estimates of seed half-life from probit modelling of seed survival data shows that seed longevity of seed lots stored with 100g of organic desiccant was highest (~300 days) followed by seeds stored with 50g of organic desiccant (Fig. 2). Control seed lots were also noted to have estimates of seed longevity above 200 days as compared to seed lots stored over 10g and 20g of organic desiccant (Fig. 2). The results of longevity estimates suggest that there may be merit in the use of organic desiccant for extending seed longevity. Nonetheless, further experimentations and comparison of seed quality results between sawdust and commercial desiccants are still underway; we hope to arrive at definite conclusions on the prospects of the use of low-cost desiccants like dry sawdust for dry seed storage.

CONCLUSIONS

The studies establishes the potential of seed longevity extension with dry storage at the ambient high temperatures of the humid tropics and thus the possibility of low –cost seed conservation since the cost of installation and operation of cold stores can be avoided. However, there are still some gray areas that more scientific investigations before deploying dry storage systems for low-cost gene bank operation in the humid tropics. Questions of research interest are 1). What gel/seed ratios would be capable of reducing seed moisture to near 5% within the shortest time? 2). What gel regeneration rate would optimize seed desiccation for dry storage? 3). Which level of seed moisture content will optimize seed longevity at tropical ambient temperatures? 4). Are there low-cost desiccants *e.g.* organic wastes that can infinitely reduce the cost of seed conservation? I am optimistic that further studies will answer these questions.

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Table 1: Estimates of seeds viability constants a cereal, legume, vegetable, tuber, and forestry crops

Crop	Viability constants				Source
	Ke	Cw	Ch	Cq	
Barley	9.98	5.86	0.040	0.0004	Ellis & Roberts (1980)
Cowpea	8.69	4.71	0.026	0.0004	Ellis *et al.* (1982)
Lettuce	8.21	4.79	0.048	0.0004	Kraak & Vos (1987)
White yam	2.16	1.58	0.009	0.0005	Daniel (2003)
Pine	3.62	0.26	0.006	0.0012	Bonner (1994)

Table 2. Relative humidity attained under different saturated salt solutions in closed containers at 31±4°C and the equilibrium moisture content of maize seeds after 12 months of storage.

Salt	% RH[1] (± S.E.)	Variety	Equilibrium seed moisture % ((± S.E.)
Zinc chloride [ZnCl2]	15.6 ± 0.95	'Oba Super'	4.05 ± 0.33
		'Suwan-1'	4.53 ± 0.23
Calcium chloride [CaCl2]	28.7 ± 1.51	'Oba Super'	4.62 ± 0.30
		'Suwan-1'	4.63 ± 0.31
Calcium nitrate [Ca(NO3)2]	52.5 ± 0.78	'Oba Super'	6.64 ± 0.37
		'Suwan-1'	5.95 ± 0 31
Sodium bromide [NaBr]	56 ± 0.43	'Oba Super'	7.38 ± 0.38
		'Suwan-1'	7.23 ± 0.43
Open	56.5 ± 1.18	'Oba Super'	6.16 ± 0.15
		'Suwan-1'	7.49 ± 1.43
Ammonium nitrate [NH4NO3]	60.0 ± 0.72	'Oba Super'	7.5 ± 0.24
		'Suwan-1'	8.46 ± 0.43
Ammonium chloride [NH4Cl]	75.4 ± 0.62	'Oba Super'	7.50 ± 0.22
		'Suwan-1'	8.84 ± 0.69
Potassium chloride [KCl]	80.5 ± 1.19	'Oba Super'	8.16 ± 0.37
		'Suwan-1'	9.58 ± 0.67

[1]Average of RH (%) from seven hygrometer readings; SE= standard error.

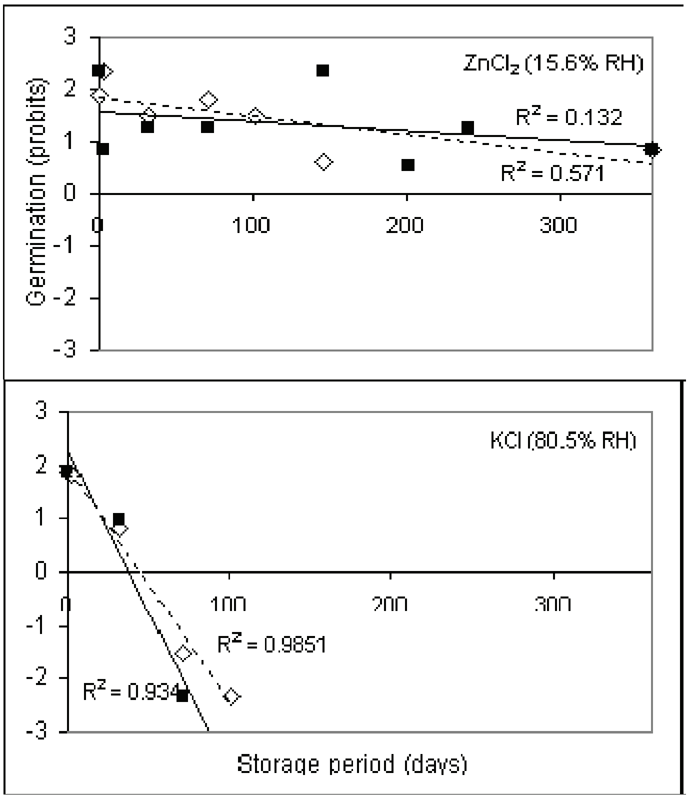

Figure 1. Survival curves based on plots of germination (probit scale) against time under low RH treatments (Upper box) and under high RH treatment (lower box) at 31±4°C. 'Oba Super' (bold lines with solid squares); 'Suwan-1' (dotted lines with hollow squares).

***Table 3*. Estimates of seed longevity (means of three replicates) parameters based on *Eqn. 1* during storage of two maize seed lots under various relative humidity conditions at 31±4°C in South Western Nigeria.**

RH%)	Seed variety					
	'Oba Super'			'Swan-1'		
	$1/\sigma^1$	σ	$P_{50}{}^3$ (days)	$1/\sigma^1$	σ	$P_{50}{}^3$ (days)
15.6	0.002	544.17	661.31	0.003	337.85	573.74
28.7	0.0034	361.32	595.83	0.003	301.74	531.16
52.5	0.007	149.05	348.02	0.004	239.90	398.82
56	0.009	116.51	308.84	0.005	218.17	340.31
56.5	0.006	177.82	339.94	0.005	213.58	296.57
60	0.029	37.36	76.58	0.031	33.30	73.09
75.4	0.034	37.14	66.33	0.038	32.95	65.78
80.5	0.066	15.11	42.10	0.056	18.31	43.53
LSD (*0.05 df = 14*)	0.013	205.57	299.1	0.014	65.13	5.38

[1]*Slope of probit model and estimate of rate of seed deterioration (1/s) probit viability loss per day;*
[2]*Standard deviation of seed death in time representing estimate of time taken to lose 1 probit viability;*
[3]*Estimate of μ of probit model representing time taken to lose 50% viability or the half viability period.*

Table 4. Equilibrium seed moisture content of various Nigerian commercial maize seed lots stored at different containerized dry storage regimes for 4 months (~120 days).

Treatment (gel/seed ratios)	Temperature* (°C)	% RH	%MC*** (varieties)				
			DM	SU	OB	TZ	AR
2005							
Open	30.3	73	10.7	12.5	10.5	10.7	10.5
0:1	30.2	70	14.5	15.2	9.7	8.3	13.4
1:20	30.3	67	14.4	12.5	8.6	9.2	12.5
1:2.5	30.2	64	11.8	12.4	7.7	8.4	11.9
1:1	30.2	50	10.0	10.4	6.6	8.2	9.4
2006							
Open	-**	-	10.2	11.3	10.5	7.1	7.9
0:1	29.3	70	11.6	14.62	10.0	12.2	21.6
1:20	29.3	69	10.9	12.1	9.6	13.2	0.9
1:5	29.2	64	9.6	11.7	8.4	13.5	18.6
1:2.5	29.3	62	8.6	11.2	8.3	11.4	13.9
1:1	29.3	54	9.1	11.4	9.2	10.6	11.7

*Temperature and %RH are average values recorded inside containers from hygrometer data.
**Hygrometer data not available.
***MC data taken after ~120 days of silica gel storage treatments.

Table 5. Effect of containerized dry storage treatments on estimates of parameters of potential seed longevity (2005).

Treatment (gel/seed ratio)	*Ki***	*1/σ*	σ	P_{50}
Control	5.22±0.173	2.36±0.213	13.71±2.970	8.37±2.155
0	4.39±0.480	1.89±0.559	10.18±5.251	1.56±0.769
1:20	5.14±0.217	0.14±0.083	25.45±6.832	7.69±2.100
1:2.5	6.02±0.447	0.03±0.003	36.20±3.598	23.13±6.000
1:1	5.99±0.274	0.04±0.016	32.40±6.699	22.55±4.715

SE, N = 9. Initial germination of probit survival data was below 50% for some of the treatments, thus the value of 5 was added to*
probit equivalent of initial percentage germination values of all seed lots to avoid negative Ki values.

Table 6. Effect of containerized dry storage treatments on estimates of parameters of potential seed longevity (2006).

Treatment (gel/seed ratio)	*Ki***	*1/σ*	σ	P_{50}
Control	4.91±0.040	0.19±0.021	7.18±1.375	0.99±0.251
0	5.15±0.078	0.08±0.021	20.61±2.735	7.18±2.059
1:20	5.46±0.102	0.11±0.032	24.69±4.295	14.70±2.996
1:5	5.68±0.105	0.08±0.025	23.57±3.616	18.88±3.904
1:2.5	5.62±0.813	0.03±0.002	32.95±2.024	19.48±2.355
1:1	5.62±0.125	0.04±0.003	24.79±1.470	16.74±3.472

**SE, N = 15.*
***Initial germination of probit survival data was below 50% for some of the treatments, thus the value of 5 was added to*
probit equivalent of initial percentage germination values of all seed lots to avoid negative Ki values.

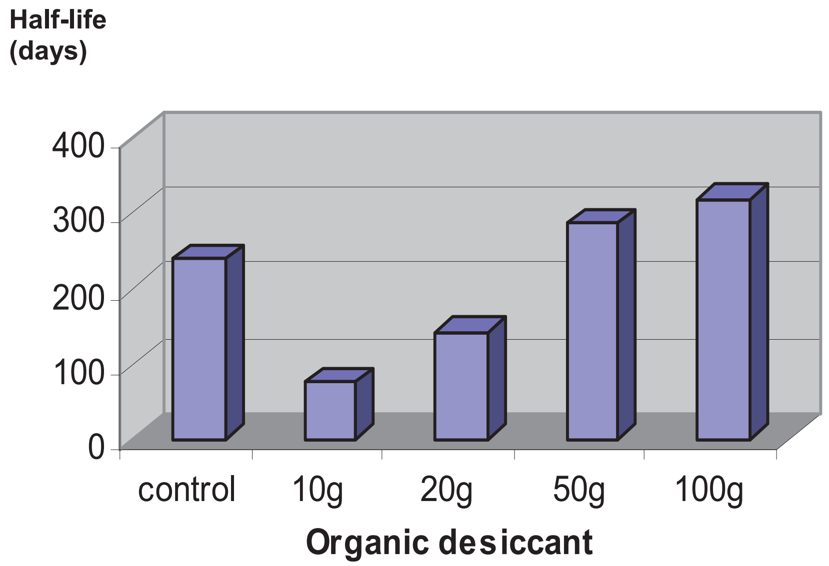

Fig. 2. Estimates of potential seed longevity in terms of half-life (p50) of maize seeds stored with organic desiccant

Determination of some Endocrine Disruptors in a Sewage Treatment Oxidation Pond and a Receiving Stream by High Performance Liquid Chromatography and Inductively Coupled Plasma-Mass Spectrometry

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Abstract

This paper reports a study on some endocrine disruptors in samples collected from a sewage treatment oxidation pond and a receiving stream that receives effluent regularly from the oxidation pond. Five phthalate esters; Dimethyphthalate, diethylphthalate, dibutylphthalate, bis(2-ethylhexyl)phthalate, diphenylphthalate, as well as arsenic, cadmium and lead which have been implicated as endocrine disruptors were determined. Phthalate esters were analysed using HPLC-MS after liquid-liquid extraction with CH_2Cl_2 and clean-up with ethyl acetate as eluting solvent for selective elution of phthalate esters from packed chromatographic column using alumina as adsorbent. The metals were analyzed using ICP-MS after acid digestion.

The results indicated that influents and effluents of the sewage treatment oxidation pond were grossly polluted as phthalate esters were found at a level higher than tolerance limits set for protection of aquatic life by USEPA. The levels of the esters in the sewage effluents also affected the receiving stream as the levels of the phthalates determined increased in the stream after the discharge of the sewage effluents into it. Characterization and structural elucidation of phthalate esters was achieved by combination of Infrared Spectrometry (IR); mass spectrometry and proton (**^{1}H)** and ^{13}C nuclear magnetic resonance (NMR). High mean levels of Pb, Cd, and As were recorded in both sewage and the receiving stream, and exceeded WHO guideline levels for drinking water and for protection of the aquatic ecosystem.

Keywords: phthalate Esters, Heavy metals, Endocrine disruptors, Clean-Up, Recovery

INTRODUCTION

A large number of environmental pollutants including phthalates, alkylphenolic compounds, polychlorinated biphenyls, organochlorine pesticides, bisphenol A, and heavy metals including lead, mercury, cadmium and arsenic have been shown to disrupt endocrine functions in animals (Susan and John, 2001; Wu et al., 2003; Lee et al., 2003). Because of their ability to interact with hormone transport proteins, as well as to disrupt hormone metabolism, these chemicals have the potential to mimic, or in some cases block, the effects of the endogenous hormone. They are therefore, described as endocrine disrupting chemicals, hormone disruptors or estrogen mimickers (Roberts, 1999; Colon et al., 2000).

There has been an increased concern about these pollutants because of their wide use in most personal care products, hence their wide distribution in the environment. For example Phthalates are components of many consumables, including personal- care, paints, industrial plastics, and certain medical devices and pharmaceuticals (ATSDR, 1993, David et al., 1999). They are moderately persistent and, as a consequence of their wide use, are the most abundant man-made chemicals in the environment (Jobling et al., 1995). Since phthalate plasticizers are not chemically bound to the polymer matrices of the products but are present as a mobile component, significant migration of them into the environment is inevitable.

Phthalate esters are chemicals with known endocrine disrupting properties (Siddiqui and Srivastava 1992; Imajima et al; 1997, Arcadi et al; 1998; Colonet at; 2000). There is significant concern for their ubiquitous presence in the environment, and scientists, clinician and regulatory agencies currently debate their potential for adverse health effects in humans, hence there is need to determine the levels of this class of compounds in the environment.

Lead is a ubiquitous environmental contaminant whose toxicity, including reproductive and developmental effects in humans, is well known. Lead is bio-accumulated by benthic bacteria, freshwater plants, invertebrates and fish (DWAF, 1996). For pregnant women, elevated Pb concentrations increase the risk of hypertension and birth defects (Rabinowitz, 1988).

On the other hand Cadmium is a very toxic metal (Friberg, et al., 1974). Natural waters contain only low concentrations of Cd usually less than 1μg/L, although values above 10mg/L have been reported both in natural and tap water. Cadmium has been found to be toxic to fish and other aquatic organisms (Rao and Saxena, 1988). Cd also has mutagenic, carcinogenic and teratogenic effects (Fischer, 1987; Friberg, et al., 1986; Heinrich, 1988).

Arsenic is a ubiquitous element whose primary route of human exposure is through ingestion of arsenic contaminated foods and water. Although, foods contain substantial levels of arsenic, it is primarily in organic forms, and of relatively low toxicity compared to the inorganic forms. In contrast, the predominant form in drinking water is inorganic arsenic, which is both highly toxic and readily bio-available. Chronic ingestion of arsenic-contaminated drinking water is therefore considered the major pathway behind the risk to human health (Bagla and Kaiser 1998; Lee et al., 2003).

Endocrine disrupting chemicals have been proposed as a potential cause of a numerous human health problems. Some examples of possible health effects reported in literature include; birth defects; alterations in sexual and functional development (Thomas and Colborn 1992); neurologic disorders, diabetes mellitus, immunologic disorder (Smoger et al,1993) early puberty in young girls (Colon et al., 2000; Zacharids et al.., 1970), breast cancer (Wolff et al., 1993, Steingraber et al.,1997), contribution to subfertility (Newbold, 1995), reduced physical stamina (Guillette,et al., 1998), reduced sperm counts (Toppari et al.,1996) and enlargement/reduction of prostate (vom Saal et al., 1997).

Endocrine disruption is a cause for concern because it is a means by which subtle effects from human actions can have species-and population-extinction outcomes. Small, but critical changes in the chemical makeup of an environment are enough to trigger outcomes that could lead to population decline and loss of bio-diversity. This study therefore, focused on the identification and quantification of some phthalate esters and heavy metals that have been implicated as endocrine disruptors in a sewage treatment oxidation pond; as a source and the impact on a receiving stream.

EXPERIMENTAL

Chemicals and Reagents

All reagents used in this study were of analytical grade. Ultra pure water was from a Milli-Q system supplied by Millipore (Bedford, MA, USA). N-hexane and ethyl acetate were from Ultrafine Limited, (Finchely,London). Acetonitrile was from Riedel-de Haën (Sigma-Aldrich, Laborchemikalien GmbH, Germany). Other reagents used were: sodium chloride from Associated Chemical Enterprises, (Glenvista, RSA), sodium carbonate from SAARCHEM, (Muldersdrift, RSA), anhydrous sodium sulphate and dichloromethane were obtained from Rochelle chemicals (Johannesburg, RSA) while aluminum oxide was from Fluka Chemica (Switzerland). HNO_3 and $HClO_4$ were obtained from BDH Chemicals (Poole, England).

Dimethyphthalate (DMP), diethylphthalate (DEP), dibutylphthalate (DBP), bis(2-ethylhexyl)phthalate (DEHP) and the internal standard (butyl benzoate) were GC grade by Fluka Chemica (Sigma-Aldrich, Switzerland), while diphenylphthalate (DPhP) was from Riedel-de Haën (Sigma-Aldrich, Seeize-Hannover, Germany).

Instrumental

Determination of phthalate esters was achieved after separation using a HP1100 series HPLC system, Agilent Technologies (Waldbronn, Germany), equipped with a diode array detector and thermostated column compartment. Chromatographic separation was carried out using a 250mm x 4.6mm i.d. Kromasil 100 C_{18} column with particle size of 10μm, from SUPELCO (Bellefonte, USA). Separation was performed under gradient elution conditions using acetonitrile and water as mobile phase, with an injection volume of 25 μl and flow rate of 1 ml/min, the column temperature was set at 40 °C. The elution gradient started with 50% acetonitrile, which was increased linearly to 75% over four minutes. This was afterwards changed to 100%, and the condition was maintained for twelve minutes before returning to initial percentage in four minutes. The identity of the pthalate esters was achieved using LCQ-Deca MS, Finnigana (San Jose, USA) and NMR spectrometer, Bruker Avance DPX 300MHz (Rheinstetten, Germany), respectively. Infrared spectrometry was used to determine and ascertain the functional groups found in the phthalates.

The metals As, Cd, and Pb were analyzed after acid digestion using a Finnigan MAT Element2 High Resolution Inductively Coupled Plasma - Mass Spectrophotometer Finnigan (Bremen, Germany). For ICP-MS analysis, the isotopes of the elements determined were; ^{111}Cd, ^{75}As and ^{208}Pb. The RF power was 1.158kW, nebulizer gas flow rate was 1.0L/min, and cooling gas flow rate was 14.89L/min, with a detector voltage 2398V.

Study area and sampling points

The study area and sampling sites had been described in our earlier study (Ogunfowokan et al. 2006). The sampling points were chosen to evaluate the environmental impact on the receiving river of point source pollution from the Obafemi Awolowo University's sewage treatment oxidation pond. Measurement points from the sampling sites were on the oxidation pond and the receiving stream. Samples were collected upstream and represent the reference point at points before the discharge of the effluent into the stream and serves as control.

Sample Handling

Samples for phthalate esters analysis and those for metals analysis were collected and preserved as earlier described and reported by Ogunfowokan et al. 2006 and 2008)

TRACE ORGANICS ANALYSIS

Extractions

Ultra pure water was used as the blank sample. 1000mL aliquot of ultra pure water was measured into a 2 L beaker and acidified with concentrated HCl to pH 2, then saturated with about 20g of NaCl. This was extracted three times with 15ml of CH_2Cl_2 each time. The CH_2Cl_2 extracts were combined and they contained phthalate esters and other organic contaminants. The free fatty acids (FFA) interferences were removed by further extraction with 3 x 10mL 0.1M Na_2CO_3. The organic extracts after alkali washing, were then dried over anhydrous Na_2SO_4. The dichloromethane was subsequently evaporated by purging with nitrogen gas. The same procedure was employed for real samples.

Sample clean-up

A 10 mL column was packed with about 12.5g of activated alumina prepared in a slurry form in n-hexane. The residue extracts were redissolved in 2ml CH_2Cl_2 and chromatographed through the packed column.

Hydrocarbons and phthalate esters were eluted successively from the column with 20mL of n-hexane and 30mL ethyl acetate. The ethyl acetate eluate was concentrated to 1ml by purging with nitrogen gas. This was diluted with 1mL acetonitrile for LC/MS analysis.

Response factor and quality assurance study

Quality assurance was carried out for recoveries of phthalates, in order to ascertain the efficiency of the analytical procedure. This was done by extracting a sample spiked with 10 mL of a mixture of five authentic phthalate esters at a concentration of 1 mg/mL. Using a spiked sample has the limitation that some analytes strongly retained on the particles may not be extracted. However, since no certified reference material was not available, this method was used.

The response factor (RF) of the authentic phthalates relative to the internal standard (butyl benzoate) was determined by analyzing 25µL of 1 mg/ml stock solution of the standard mixture containing the internal standard (I.S) on the HPLC. The response factors were obtained using the equation earlier stated by Ogunfowokan etal. (2003).

ANALYSES OF METALS

Digestion of water samples

The samples were digested using mixture of acids. The method adopted was already described by Carrondo et al. (1979).

RESULTS AND DISCUSSION

Our study provides an assessment of levels of certain endocrine disrupting chemicals in a sewage lagoon and its receiving steam over a period of six months (July-December). The study discusses the results obtained after monitoring for both metals and phthalate esters over the same period of time. To keep the discussions focused, results for the monthly analysis will be detailed and a summary will be outlined for each month of study.

Monitoring of cadmium in the influent and effluent

For the six month monitoring period the concentration of Cd ranged from 3.38 µg/L in September to 23.38 µg/L in October for untreated and treated sewage and from 2.23 µg/L in November to 25.75 µg/L in July for samples from the stream while the concentration at the reference point varied from 1.75µg/L in September to 5.38 µg/L in July. From Tables 1 to 3, the mean concentrations of Cd varied from 4.70µg/L in September to 19.05µg/L in July, in the influent and effluent; from 5.05µg/L in November to 19.57µg/L in October for the stream and from 1.75µg/L in September to 5.78µg/L in July for the reference point. These showed that the concentrations of Cd in influent and effluent of the sewage lagoon were much higher than concentrations in the stream, while the concentrations at the reference point were much lower than in either the stabilization pond or the stream. This confirmed the impact of the sewage lagoon on the receiving stream.

Levels of Cd in the sewage lagoon and the receiving stream were much higher than 0.15µg/L tolerance level set by WHO for aquatic system in soft water and 0.25mg/L in moderately soft water. Although the levels of Cd in the reference samples were higher than the set criteria, however they are below 5µg/L maximum allowable concentration in drinking water set by WHO. Given the fact that use of water from the receiving stream is domestic and agricultural irrigation high levels of Cd in the stream are of great concern because Cd is extremely toxic and the primary use of water with high concentrations of Cd could cause adverse health effects.

Monitoring of arsenic in the influent and effluent

The lowest arsenic concentration of <0.50µg/L was recorded at the reference point while the highest value of 64.14µg/L was recorded in the influent to the sewage lagoon. Mean concentrations of As in the pond ranged from 46.67µg/L in July to 104.67µg/L in November (Table 1). It also varied from 21.50µg/L in July to 98.88µg/L in September for the receiving stream (Table 2) while the mean concentrations of As in the reference samples ranged from < 0.50µg/L in July to 5.62µg/L in

December (Table 3). There is a wide variation in the concentrations of As in the pond, the receiving stream and the reference point for the period of this study. The sewage lagoon gave the highest concentrations of As followed by the receiving stream leaving the reference point with the least concentrations. This clearly showed that the receiving stream was grossly polluted by the sewage lagoon.

Levels of As in the sewage lagoon and the receiving stream are higher than 10µg/L minimum allowable threshold in water intended for human consumption indicating high level of pollution. The high levels of As in both the stabilization pond and its receiving stream should be a cause for concern.

Monitoring of lead in the influent and effluent

The levels of lead in the samples ranged from <0.5µg/L recorded for the reference point to 79.10µg/L recorded for the influent. The mean lead levels in the influent and effluent varied from 21.69µg/L to 65.55µg/L (Table 1), while in the receiving stream mean Pb levels ranged from 8.29µg/L to 51.75µg/L (Table 2) whereas the levels varied from <0.50µg/L to 7.20µg/L in the reference samples (Table 3), indicating that the high levels of Pb recorded in the receiving stream was as a result of the effects of effluent from the sewage lagoon, that has been discharge into it.

Levels of Pb obtained for the samples from the stream with the exception of the reference point were above the WHO limit of 10µg/L and maximum contaminant level of 15µg/L for drinking water (WHO, 1984). Consequently, the direct use of water from the stream for any domestic purposes without treatment could be detrimental to human health.

The overall means for the metals in Tables 1-3, revealed concentrations of 13.26µg/L, 82.69µg/ L and 48.24µg/ L for Cd, As and Pb respectively in the receiving stream, while in the influent and effluent, the overall means of 13.26 µg/ L, 82.69 µg/ L and 48.24 µg/ L were respectively obtained for Cd, As and Pb. The reference sample gave the least overall concentrations of 3.30 µg/ L, for Cd, 3.98 µg/ L for As and 5.11 µg/ L for Pb. Generally, the concentrations of the metals determined were lower between July and September than between October and December. This trend was attributed partly to the marked differences in the two seasons. The period between July and September was wet season while between October and December was dry. The lower concentrations in wet season may be due to dilution by rainwater. In contrast, dry season characterized by heavy sun intensity and high evaporation rates leading to reduction in the volume of water levels that may lead to pre-concentration of the metals, hence high levels recorded.

Monitoring of phthalate esters in the influent and effluent

As shown in Table 4, after optimizing the chromatographic separation conditions, the response factors and recoveries were evaluated for all the phthalates in the study. DPhP showed the lowest recovery of 46.36% and DEHP had the highest recovery of 106.34 %. The percentage coefficient of variation (% Cv) ranged between 2.42% for DBP and 3.91% for DPhP.

There is indeed a wide occurrence of phthalate esters in the sewage lagoon and the receiving stream as shown in Tables 5-7. Concentrations of phthalates in the study area ranged from ND to 114.38±22.52mg/L in July, from ND to 49.37± 11.75mg/L in August, from ND to 114.64±8.22 mg/L in September, from ND to 138.03±7.41mg/L in October, from ND to 400.19±4.07mg/L in November, and from ND to 377.55±14.89 mg/L in December. DEHP was the phthalate most frequently found during the study and tended to be present in the highest concentrations, followed closely by DBP and then DPhP. Generallr, DMP and DEP were rarely detected in the reference sample and the receiving stream and where present, they formed low percentage of the overall phthalate esters detected.

The average levels of phthalate esters in the sewage lagoon, receiving stream and the reference samples are shown in Tables 5-7, respectively. From the tables the overall mean concentrations of the esters were 24.80±23.85mg/L for DMP, 16.17±11.16mg/L for DEP, 31.64±24.71mg/L for DPhP, 46.25±19.63mg/L for DBP, and 161.50±156.43mg/Lfor DEHP detected in the sewage lagoon and its effluent as indicated in Table 5. The stream samples gave concentrations of 11.01±4.55mg/L, 6.18±1.86mg/L, 18.35±11.04mg/L, 22.41±12.91mg/L, and 97.97±111.20mg/L for DMP, DEP, DPhP, DBP, and DEHP respectively (Table 6). However, as shown in Table 7, the overall mean concentrations of 7.43±7.14mg/L, 8.92±7.18mg/L, 14.04±10.74mg/L for DPhP, DBP and DEHP respectively were found in the reference samples. DMP and DEP were not detected in the reference samples throughout the period of this study. Figures 1 and 2 respectively, show representative chromatogram for separated phthalate esters in wastewater sample and mass chromatogram of dibutyl phthalate. The molecular mass of DBP appeared as the base peak at m/z = 278.8. Further identification and confirmation of the compounds was done by infrared (IR) analysis of sample extracts using the diagnostic absorption bands for the identification of specific functional groups. All the diagnostic bands expected for standard phthalates were found in the samples (Table 8). These results indicated strong absorption band for C-H stretching vibrations for CH_3, CH_2, and CH in the region of 2840–2975 cm^{-1}. A medium absorption at 1190–1280 cm^{-1} may be associated with C – O stretching vibration of benzoate. A vibration band in the regions of 690–720 cm^{-1} has been assigned to a di-substituted aromatic compound, while vibration at 1110–1140 cm^{-1} is associated with C-O stretching vibration of ester and the band at 1650–1725 cm^{-1} may be associated with C=O stretching vibrations of an ester. The bands near 1500–1600cm^{-1} may be associated with C=C stretching vibration of aromatic ring. Generally, the IR results indicated the presence of all functional groups, which may be expected of a diester of phthalic acid. To further confirm the identity of the phthalate ester quantified in this study, NMR analysis of the samples was carried out. The results of nmr analysis of eluate after clean-up confirmed various protons and carbons that are expected in the model structure of any diester of phthalic acid. The interpretation of the proton and carbon 13 nmr spectra obtained are as presented in Table 9. The proton nmr signal at 7.55 ppm (d) was attributed to protons labeled H_a in the general structure shown, while signal at 7.73 ppm (d) was assigned to the protons labeled $H_{b.}$ Signal between 0.8-1.1 ppm were apportioned to CH_3- protons of alkyl group while signals from 1.2-1.7 ppm were of -CH_2- of alkyl group, R. From the ^{13}C nmr results, signal at 168.38 ppm (singlet) was ascribed to the carbonyl carbons of the ester while the one at 132.82 ppm (singlet) was assigned to the quaternary carbons of the aromatic ring. Signal at 132.69 ppm (d) was assigned to carbons bearing H_a while the signal at 132.14 ppm (d) was assigned to carbons bearing H_b. Signal between 11-18 ppm were apportioned to CH_3- carbon of alkyl group while signals from 19-28 ppm were of -CH_2- of alkyl group, R.These clearly indicated the presence of all the expected type of H and C in the model structure of phthalate esters. The use of combination of Nmr, IR and MS for the possible structural elucidation of the phthalates detected in the sewage oxidation pond and the receiving stream is this present study is an edge over the previous work in which only IR was used for the detection of the functional groups in the phthalate esters detected in environmental samples (Fatoki and Ogunfowokan 1993 a&b ; Ogunfowokan and Fatoki 2000; Ogunfowokan et al. 2006)

Generally in this study, the values of phthalate esters obtained are at least 10^3 much higher than the water criterion of 3µgL^{-1} recommended by the United States Environmental Protection Agency (USEPA) for the protection of fish and other aquatic life in water (USEPA 1994). The higher levels of Phthalate esters in the samples may not be unconnected with the chemicals discharges from research laboratories coupled with leaching of phthalates via surface runoff; sewage and waste water from the students' residential areas into the stabilization pond.

From the results obtained, concentration of DPhP, DBP and DEHP were significantly higher in sewage samples than in the stream and reference samples, and concentrations in the stream were significantly higher than in the reference samples indicating the pollution effects of the sewage from the stabilization pond on the stream. Concentrations of DMP and DEP were significantly higher in sewage than in stream and reference samples.

Given the trends shown in the data, the incidence of water borne diseases that is often on an epidemic scale in the rural area of developing countries evokes considerable concern. Some of the illness may be traced to the use of water grossly polluted by untreated or inadequately treated wastewater as already demonstrated by the detected high levels of phthalates. Among the reasons for high mortality rate in most of the rural area in developing countries is that water for domestic activities is collected directly from rivers cum streams and same is used without any treatment. The situation is worsened by the indiscriminate disposal of untreated wastewater into actively used streams. Burge and Marsh (1978) reviewed the public health implication of the manner of disposal of municipal waste and further confirmed the established principle that indiscriminate disposal of sewage waters could be seriously detrimental to public health.

Many stream and rivers especially in developing countries are victims of waste water from surrounding municipal and industrial dischargers. Hence information on the occurrence and the extent of pollution caused by toxic organic pollutants such as phthalate esters which are ubiquitous environmental contaminants is thus needed since rivers and steam are major sources of drinking water in many of the rural areas. Besides, the fact that these toxic organic compounds are included in various list of priority pollutants (Thuren, 1986) and the resulting adverse ecological effects these compounds may have on the aquatic biota the possible bioaccumulation of the compounds in food chains, make the monitoring program important.

CONCLUSION

In this study, metals were analysed with ICP-MS after acids digestion of the samples while phthalate esters were quantified using high – performance liquid chromatography and mass spectrometer after preconcentration and clean-up experiment on the water samples. As, Cd, and Pb were found in both sewage and stream samples at levels that give cause for concern. All phthalates studied were present at concentrations above the 3µg/L criterion set by USEPA for the protection of fish and other aquatic life. This is unfortunate because lives of fish and other aquatic biota in the receiving stream are at risk and the people that depend on the water from the receiving stream for various domestic purposes downstream are at risk of serious health effects due to pollution of the stream by these endocrine disruptors. There is therefore a need for urgent action by the authority in charge of the sewage lagoon to find a lasting solution to this problem.

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Table 1: Average levels of metals in the sewage treatment oxidation pond

Month	Metals		
	Cd µg/L	As µg/ L	Pb µg/ L
July	17.59 ± 3.02	46.67 ± 12.25	21.69 ± 10.88
August	15.61 ± 4.13	62.03 ± 11.00	42.18 ± 9.13
September	4.70 ± 0.52	92.30 ± 20.13	51.56 ± 10.25
October	19.05 ± 2.71	94.22 ± 23.69	43.84 ± 4.99
November	11.13 ± 1.43	104.67 ± 1.76	64.57 ± 7.00
December	11.17 ± 1.51	96.27 ± 2.92	65.55 ± 13.85
Overall mean	13.26 ± 5.27	82.69 ± 22.88	48.24 ± 16.36

Table 2: Average levels of metals in the receiving stream

Month	Metals		
	Cd µg/L	As µg/L	Pb µg/L
July	16.03 ± 10.62	21.50 ± 9.81	8.29 ± 3.98
August	5.52 ± 2.40	45.45 ± 14.46	31.28 ± 4.85

September	5.98 ± 3.07	98.88 ± 12.49	24.18 ± 6.27
October	19.57 ± 2.55	74.74 ± 22.50	42.78 ± 4.97
November	5.05 ± 3.18	74.88 ± 11.07	39.93 ± 6.80
December	10.98 ± 2.78	40.06 ± 14.95	51.75 ± 8.94
Overall mean	10.53 ± 6.12	59.42 ± 28.53	33.12 ± 15.23

Table 3: Average levels of metals in the reference samples

Month	Metals		
	Cd µg/L	**As µg/L**	**Pb µg/L**
July	5.78 ± 1.16	<0.5	<0.50
August	3.54 ± 0.16	3.02 ± 1.01	3.35 ± 0.02
September	1.75 ± 0.08	4.88 ± 0.85	2.83 ± 0.06
October	4.14 ± 0.72	5.30 ± 2.01	5.34 ± 0.18
November	2.32 ± 0.07	1.10 ± 0.76	6.81 ± 0.78
December	2.27 ± 0.03	5.62 ± 2.26	7.20 ± 1.20
Overall	3.30	3.98	5.11

mean	± 1.51	± 1.90	± 1.98

Table 4: Response factor and % Recovery of Phthalate Esters from Spiked Water Samples

Phthalate esters	*Response factor*	*Percentage recovery*	*Standard deviation*	*Coefficient of variation(Cv)%*
Dimethyl phthalate (DMP)	1.62	68.43	2.56	3.74
Diethyl phthalate (DEP)	1.48	72.35	2.40	3.32
Diphenyl phthalate (DPhP)	2.20	46.36	1.81	3.91
Dibutyl phthalate (DBP),	1.12	85.60	2.06	2.42
Bis(2-ethylhexyl) phthalate (DEHP)	0.81	106.34	4.11	3.87

Mean Value ± SD; %Cv for n=6

Table 5: Average levels of phthalate esters in the sewage lagoon

Phthalate Esters / Month	**DMP mg/L**	**DEP mg/L**	**DPhP mg/L**	**DBP mg/L**	**DEHP mg/L**
July	65.18 ± 38.02	11.19 ± 2.95	14.96 ± 2.36	30.08 ± 16.01	61.19 ± 37.63
August	32.58 ± 20.69	9.85 ± 5.85	11.43 ± 6.58	17.59 ± 7.39	22.75 ± 9.90
September	46.44 ± 37.10	38.06 ± 2.19	37.67 ± 6.33	34.16 ± 8.78	102.34 ± 36.46
October	4.08 ± 0.10	9.42 ± 1.29	89.48 ± 63.01	64.91 ± 50.44	75.31 ± 43.16

November	13.81 ± 3.02	16.60 ± 3.17	4.78 ± 1.63	67.40 ± 41.97	277.89 ± 206.40
December	7.72 ± 0.31	13.67 ± 11.31	88.90 ± 77.66	66.68 ± 23.96	277.88 ± 34.83
Overall Mean	24.80 ± 23.85	16.17 ± 11.16	31.64 ± 24.71	46.25 ± 19.63	161.50 ± 156.43

MEAN VALUE ± S.D

Table 6: Average levels of phthalate esters in the receiving stream

Phthalate Esters / Month	DMP mg/L	DEP mg/L	DPhP mg/L	DBP mg/L	DEHP mg/L
July	14.37 ± 6.80	6.18 ± 1.86	9.46 ± 6.73	21.67 ± 18.56	17.43 ± 2.60
August	10.61 ± 1.50	ND	ND	9.40 ± 0.29	19.51 ± 12.84
September	ND	ND	25.06 ± 8.73	14.26 ± 3.73	44.52 ± 9.92
October	ND	ND	34.47 ± 20.95	16.18 ± 7.07	23.07 ± 4.91
November	11.30 ± 7.12	ND	14.91 ± 13.36	45.49 ± 17.81	274.87 ± 165.79
December	20.28 ± 19.52	ND	9.58 ± 4.37	27.46 ± 15.69	239.64 ± 151.84

Overall Mean	11.01 ± 4.55	6.18 ± 1.86	18.35 ± 11.04	22.41 ± 12.91	97.97 ± 11.20

MEAN VALUE ± S.D

Table7: Average levels of phthalate esters in the reference sample (SR)

Phthalate Esters / Month	DMP mg/L	DEP mg/L	DPhP mg/L	DBP mg/L	DEHP Mg/L
July	ND	ND	ND	11.54 ± 4.54	12.24 ± 4.73
August	ND	ND	ND	8.40 ± 0.26	15.75 ± 5.44
September	ND	ND	5.97 ± 1.45	14.78 ± 2.10	69.24 ± 6.87
October	ND	ND	15.18 ± 9.63	38.35 ± 10.23	38.78 ± 1.57
November	ND	ND	5.28 ± 0.32	47.46 ± 5.14	416.38 ± 1.74
December	ND	ND	9.13 ± 0.08	38.00 ± 4.16	311.86 ± 13.70
Overall Mean	ND	ND	7.43 ± 7.14	8.92 ± 7.18	14.04 ± 10.74s

MEAN VALUE ± S.D, ND = NOT DETECTED

Table 8 : Interpretation of Infrared Spectrum of Phthalate Esters from the waste water Samples

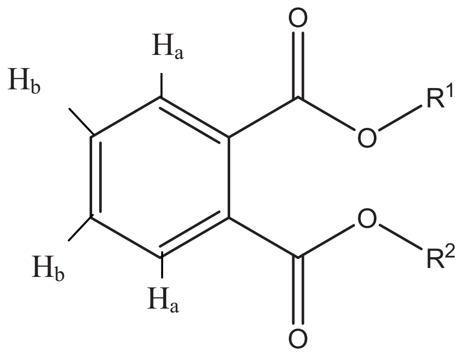
Wave number cm^{-1}	Assigned functional group
2,840 – 2975 (s)	C-H stretching vibration of CH_3, CH_2 and CH
1190 – 1280 (m)	C-O stretching vibration of benzoate
1650 – 1725 (m)	C=O stretching vibration of an ester
1500 – 1600 (m)	C=C stretching vibration of aromatic ring
1110 – 1140 (m)	C-O stretching vibration of ester
690 – 720 (w)	di-substituted aromatic compound

s = strong absorption

m = medium absorption

w = weak absorption

Table 9: Result of NMR Analysis of eluate after clean-up



General Structure of Phthalate Ester

Chemical Shift (ppm)	Multiplicity	Feature
^{1}H nmr		
7.55	doublet (d)	H_a
7.73	doublet (d)	H_b
^{13}C nmr		
168.38	singlet	carbonyl carbon of ester
132.82	singlet	quaternary carbon of the aromatic ring
132.69	doublet	carbon bearing H_a
132.14	doublet	carbon bearing H_b

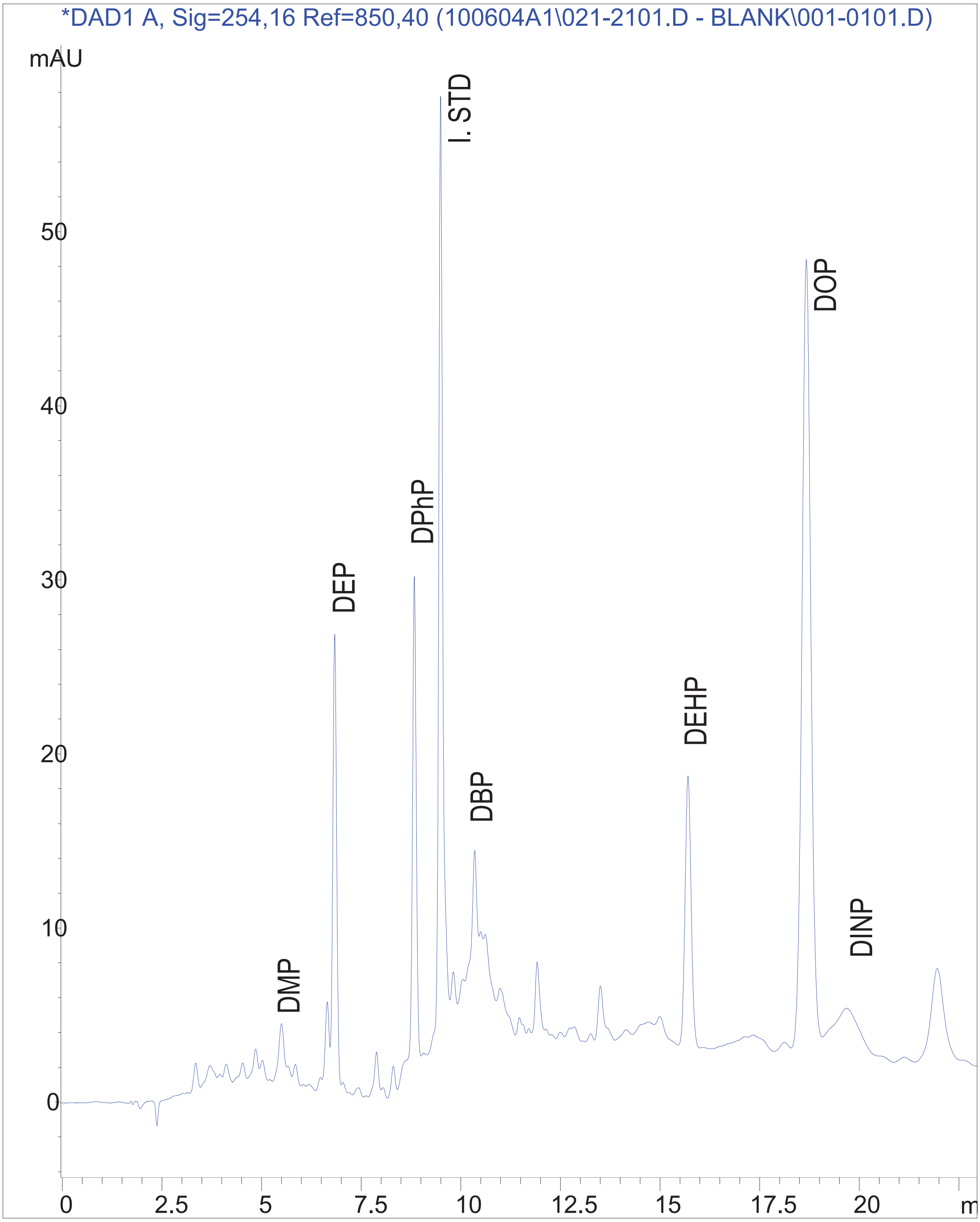


Figure 1: Representative Chromatograms of Phthalate Esters in Wastewater Sample Separated with HPLC at Optimum Conditions

Figure 2: Representative Mass Chromatogram of Dibutyl Phthalate Ester from the sewage treatment oxidation pond