ASSESSMENT, DEVELOPMENT AND CONSERVATION OF SOIL FERTILITY: KEY TO NATIONAL FOOD SECURITY

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Our almighty God and Jehovah, accept our gratitude for making this memorable day a reality in the life of this University and for all individuals here present to witness and grace this occasion. Holy Spirit of God, take absolute control of this meeting from the beginning to the end to the glory of your name, in Jesus name. Amen.

Opening remarks

Glory be to God Almighty for the privilege and great honour to deliver the Landmark University maiden lecture definitely on behalf of the College of Agricultural Sciences and specifically Department of Crop and Soil Sciences. It is an opportunity that comes sparingly in ones academic career.

When I was asked by the University Management to give this lecture, I initially felt hesitant and wondered what I could speak upon having delivered my inaugural lecture exactly six years ago on March 26, 2008. It would not be appropriate to repeat myself in an academic discourse like this. Then I remembered the scripture that says “I can do all things through Christ that strengthens me” Phil. 4:13. I also remembered that so much water has flowed under the bridge since that time in terms of teaching, research activities, seminars, workshops, conferences, commissioned work and community development in the field of soil science. Therefore based on recent lessons of experience, I settled for a title which I considered topical, fundamental and practically relevant to the achievement of soil fertility improvement, increased food production and food security particular in Nigeria and other nations in general. Thus, the title” **Assessment, Development and conservation of soil fertility: key to National food security”.**

A times, when I consider our natural endowment in this country, having transverse extensively throughout the length and breadth of the nation, from Port Harcourt and Lagos in the coastal zone to Dutse and Sokoto in the Sudan savannah, from Kebbi and Igbeti along the west boundary to Yola and Zaki Biam near the eastern border, we, as a people, have cause to thank God Almighty for such a blessing of land/soil resources. We can grow virtually any crop in Nigeria from swamp rice or sugar cane in the coastal areas, yam and other root crops in the rainforest zone, or potatoes and cucumber in the Mambilla and Jos plateau to the cultivation of cereal crops in the savannah agro-ecological zone of the north. We have clement weather to support the production of a diversity of crops, adequate water bodies and huge reservoir of human resources and common sense with which to put things together to achieve adequate food production, food sufficiency and eventually food security. Unfortunately, not all common commodities are common. Common sense may be one of the most uncommon commodities in Nigeria. Otherwise, why is the attainment of food security a mirage in Nigeria till date? Why is there poverty in the land? Why are Nigerians famished? We need knowledge so as not to perish. We need divine wisdom and fear of God so as to enjoy life. We need political will so as to become free and totally liberated from want and subjugation. May God help us. I have partitioned this lecture into the following areas:

- Introduction
- Forces militating against high productivity of Nigerian soils
- Impact of soil abuse on food security
- Recent efforts at upgrading soil fertility assessment, development and conservation to increase food production
- Conclusions and recommendations
- Acknowledgement
- References

1.0 INTRODUCTION

At the time of creation all living things – man, animals, vegetation – were formed from the dust (soil) of the ground; they were made to be fruitful and multiply, yielding seeds in their kind. God gave man the authority to dominate and use the herbs and the animals for food. Man was created from the soil and from that creation had depended on soil for prosperity and survival. Any departure from this divine arrangement usually incurs unpleasant consequences.

In essence, Mr. Vice-Chancellor sir, without soil there would be no vegetation – no crops for food, no forests, flowers, or grassland for cattle. To a great measure, life on Earth depends on soil. The soil was originally fertile and productive at its maximum capacity. Man was only required to till and weed the ground for high productivity. Once the man nurtured the soil, the natural resource, his survival and economic power were guaranteed; there was no food insecurity for man.

However, through man's carelessness and misuse of soil resources over time soil productivity has declined. Undoubtedly, the soil is growing old by the day with decreasing power to support man, plants and animals (Life), unless adequately managed.

In many countries of the world today, their people are suffering from acute hunger, widespread starvation, malnutrition and even death owing to the impoverishment of their soils which could no longer bring forth fruits in due season. What should we do here in Nigeria so that our soils would continue to support life and remain productive and sustainable for our future generations yet unborn? Or put in another form, how can we prosecute productive agriculture and food security but ignore the soil?

1.1 DISTRIBUTION OF LAND/SOIL RESOURCES IN NIGERIA

It is true that soil is an abundant everlasting gift to mankind but how much of it is given to Nigeria who constitutes a large proportion of the earth's mankind? Nigeria has a total land area of 91.2 million hectares with about 32 million hectares or 32% of it being used for cropping (Wudiri, 1988). Another 15 million hectares or 15% is used for grass land pasture and woodland. Forestry activities occupy about 9 million hectares or 10%. The remaining 38 million hectares or 40% consist of marches, swamps, hills, mountains and uncultivated marginal lands. Those of us concerned with food production cannot afford to exhibit *a laissez-faire* attitude to the unabated conversion of thousands of hectares of good farmlands into urban centres, roads and recreation areas.

Babalola (2000) gave a summary of the characteristics of seven main types of Nigerian soils with diverse physical, chemical and biological properties (Fig. 1).

These include:

- Entisols: these are loose sandy soils found on the coast and in the Chad basin.
- Inceptisols: these are the brown and reddish brown soils found commonly under sparsely vegetated northern parts of the Sudan savannah.
- Hydromorphic and Alluvial Soils: these are found in the river valleys and flood plains(Fadamas) and the coastal and deltaic swamps.
- Ferrallitic Soils: these are Alfisols and Ultisols which are intensely weathered, highly leached soils with high content of low-activity clay minerals.
- Ferrisoils: These are mainly alfisols.

- Highly ferruginous tropical soils: these are mainly alfisols and patches of ultisols which cover areas extending from the forest zone to the Sudan savannah.
- Vertisoils: these are highly clayey soils which have swelling and shrinking characteristics, dark coloured commonly associated with depression in the Chad Basin Area.

These soils, undoubtedly, have their problems, but are summon table. After all, they have, in the past, supported high yields of the major export crops, such as cocoa, rubber and oil palm and staples such as cassava with little or no external inputs. Indeed, with good soil management, adequate crop yields could be attained on the soils (Table 1). The soils have supported humanity for centuries through the peasant farming system even without soil amendments.

1.2 AGRO-ECOLOGY

Nigeria has six distinct agro ecological environments, each with its distinct climatic conditions. These include the Sahel and Sudan in the extreme North, the savannas, Northern and southern Guinea savannas and the derived savanna bordering on the humid rainforest zone followed by coastal swamps by the sea. The mean maximum temperatures vary from 38^0C in the uppermost northern part of Sudan and Sahel to a mean southern maximum of 30^0C. Minimum temperatures range from 13^0C in the North to 21^0C in the south.

Table 1: Yields (tones/ha) obtained under good management and farmer's field in Nigeria

CROP	GOOD MANAGEMENT	FARMER'S MANAGEMENT
Yams	11.7 – 17.6	11.0
Cassava	23.3 – 35.0	10.5
Sweet potato	13.1 – 25.3	8.0
Maize	4.1 – 5.2	1.25
Soyabean	1.98 – 3.03	1.00
Cowpea	1.58 – 1.82	0.5
Rice	2.6 – 3.8	2.82

Source: Adapted from Babalola et al. (1978) and Babalola & Zagal (2000).

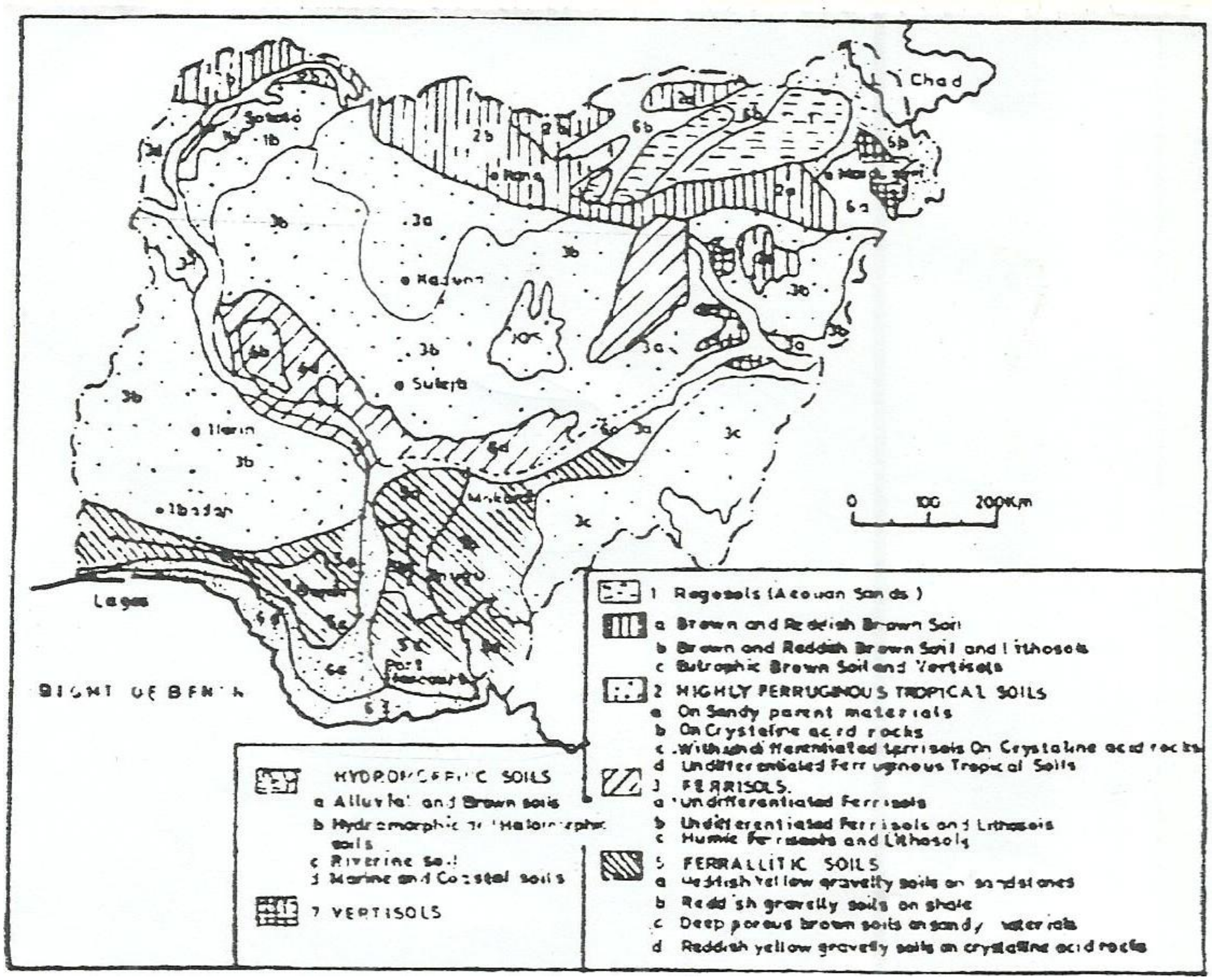


Fig. 1: The broad soil types of Nigeria (Source: Agboola, 1979)

Rainfall amount increases southwards with a mean annual of 200-500mm in the extreme north to about 1000mm in the middle belt savanna region to about 2000mm along the coast (Fig. 2).

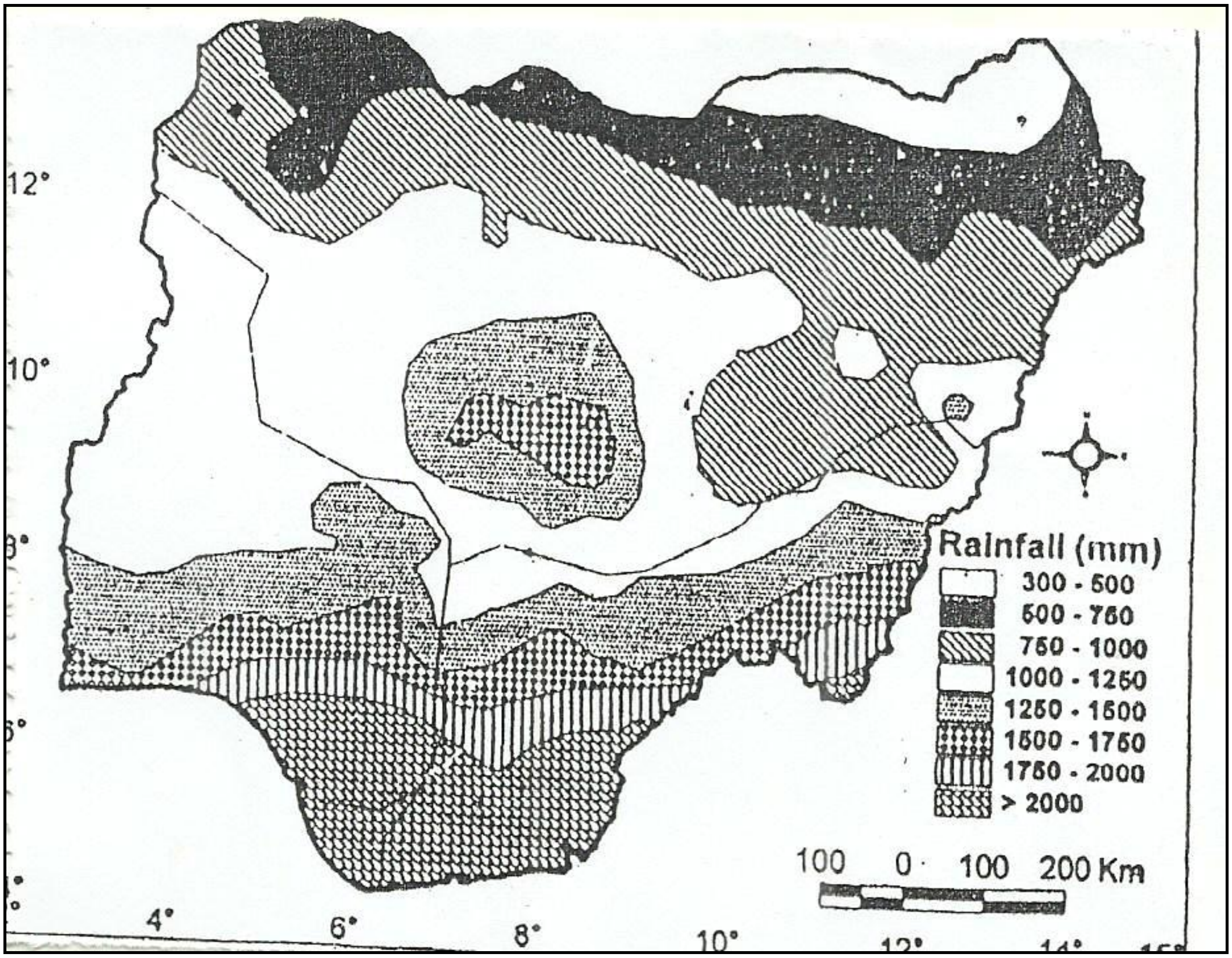


Fig. 2 Rainfall distribution in Nigeria (Source: Babalola 0., 2001).

1.3 Growing Seasons and Solar Radiation

With the exception of the arid and semi-arid regions of the North, there are two distinct growing seasons lasting from April to July in the early season and August to October in the late season. There is, therefore, a sufficient number of days to grow most arable crops. Many of the southern states witness between 110 and 185 rainy days.

Two growing seasons provide an opportunity to grow many crops twice a year and with irrigation practices, crop production becomes an all round the year activity. Although cloud cover in the southern parts reduces the receipt of solar radiation by crops, the single growing season in the north enjoys ample solar radiation. The significance of this productive potential can be realized as one compares the radiation levels and potential productivity in our environment with what obtains in the temperate environment (Table 2).

1.4 WATER RESOURCES AND CROPPING SYSTEM

Water, no doubt is the most important basic ingredient of agricultural production. In this regard, Nigeria is blessed with abundant water supply in terms of rainfall, rivers, ground water, lakes, dams and other surface water bodies.

The Federal Ministry of Water Resources estimated that the water resources potential of the country is 250 billion cubic meters made up of 190 billion cubic meters or 76% of surface water. Ground water constitutes only 24 percent (Babalola, 2001).

Table 2: A comparison of the receipt of solar radiation and potential dry matter production in Samaru, Northern Nigeria and Rothamsted in Britain

Samaru			Rothamsted		
Season	**Radiation (cal cm^2)**	**Dry matter (kg/ha)**	**Season**	**Radiation (cal cm^2)**	**Dry matter (kg/ha)**
6month rainy season May _October	88,000	22,000	7 month growing season Mar-Sep	64,000	16,000
6 month dry season Nov_ April	90,000	22,500	5 month winter Oct_ Mar	12,000	3,000
Annual total		44,500			16,000

Production limited by low temperature. Source: Kowal (1972)

Crops: The diversity in temperature, rainfall; solar radiation and soil makes it possible to grow a wide range of crops across Nigeria albeit to varying extents (Fig. 3).

The southern zone has predominantly tree and root crops. Here cocoa, cashew, rubber, coffee, kola, tea, oil palm, cassava and yam are the major crops. The middle belt zone is predominated by mixed root- crop and cereals and in the northern zone, by the grains: maize, sorghum, millet, and wheat, the pulses, groundnut and cowpea. Table 3 shows that we grow almost every crop in Nigeria. In the northern agro ecologies (Sudan and Sahel), a wide range of crops that can be grown under irrigation include maize, wheat, Irish potato and a wide range of exotic fruits and vegetables such as tomato, garlic and the greens (lettuce, cabbage and cauliflower). Successful cultivation of these crops can be attributed to the cool, dry season when low temperatures and low humidity do not allow pests and diseases to thrive beyond control measures.

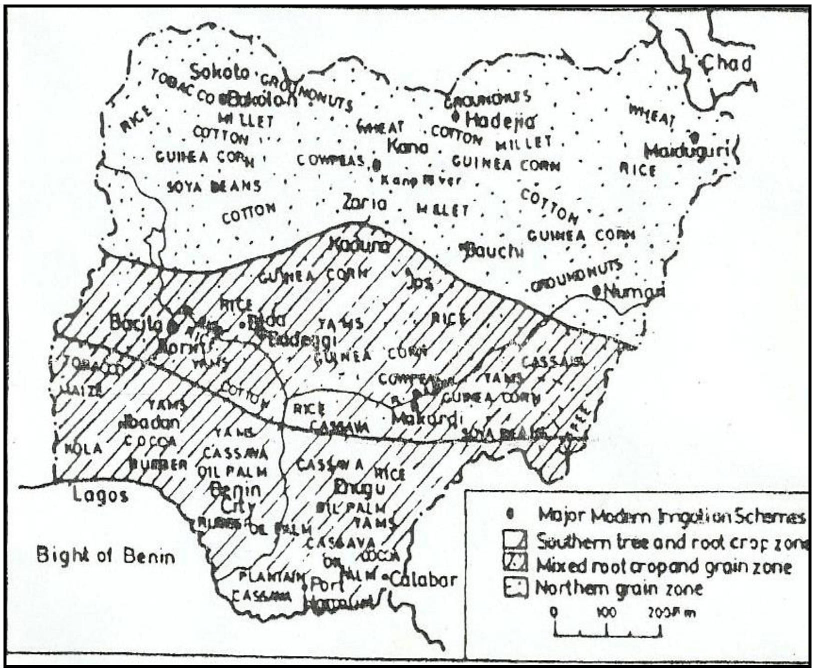


Fig. 3: Major crops and crop zones in Nigeria (Source: Babalola, 2001)

Table 3: The major groups of crops which are grown in Nigeria

Crop Groups	*Crop Types*
Cereals	Maize, millet, sorghum, rice, wheat etc.
Tubers	Cassava, yam, potatoes, cocoyam, sweet potato etc
Pulses and nuts	Cowpea, green grams, soybeans, groundnuts.
Vegetables Oils	Oil palm, groundnuts, beniseed, melon
Fruit and Sugars	Oranges, pineapple, plantain, bananas, okro, sugarcane
Vegetables and spices	Tomato, peppers, onion, garlic, leafy vegetables (Lettuce, cabbage, cauliflower, etc)
Forest foods	A large number of forest foods

2.0 FORCES MILITATING AGAINST HIGH PRODUCTIVITY OF NIGERIAN (TROPICAL) SOILS.

In the viewpoint of a soil scientist, the soil is a dynamic ecosystem covering the earths land surface that provides plant with support (anchorage), water, nutrient and air and supporting a large population of microorganisms that recycle the material of life (Singer and Munns, 1997). The soil supports all ecosystems on land and meets the needs of the entire human population for food, fibre, water, building materials and sites for construction and waste disposal. Ground water is safe for human consumption because the soil is able to filter toxic chemicals and wastewater that are poured on the land. We should note that the soil is able to perform human welfare functions if we understand its nature through sound scientific assessment procedures and manage it properly through the adoption of effective conservation strategies.

It suffices for us in this lecture to know that soil (unconsolidated or loose material) is formed from consolidated rock (parent rock and organic materials) through the process of weathering which, in turn is mediated by several factors such as climate, slope of the landscape, type of vegetation cover and man over a period of time. Soil takes hundreds of years to form but could be destroyed and lost within few months of mismanagement. Nigeria soils share similar properties with the global tropical soils in physical, chemical, biological and mineralogical composition.

Soil productivity which is a measure of the capacity of soil to respond to management for high yield is rather low in Nigeria just like the average yields of most crops in tropical Africa are similarly low.

Land remains prominent as the source of all the basic requirements for the majority of the population, accounting for about 97% of food and raw materials production, pasture and fishing. The country's land is very vulnerable and under increasing stress resulting from uncritical use and mismanagement with the attendant low productivity. What are the stress factors militating against Nigeria soils?

2.1 PHYSICAL CONSTRAINTS

In the Northern and Middle – belt areas of Nigeria, most of the soils are described as recent and moderately developed and are classified as *Entisols, inceptisoils and Alfisols.* Here, the soil and environmental conditions favour the raising of animals especially cattle and the production of annual crops mainly maize, sorghum, millet, cowpea, cotton, groundnut rice and soybeans. In the south, tree crops predominate, especially oil palm, cocoa, timber and cashew alongside food crops such as cassava, yam, rice, and maize which are generally cultivated on moderately and highly weathered soils classified under the soil order of Alfisols, ultisols, Oxisols and acid surface soils (Esu, 2005).

However, these soils are misused due to lack of systematic assessment and evaluation which could make us knowlegible about their potentialities and suitability for cropping. Erosion prone areas such as soil on sloppy lands are often cleared for farming without appropriate soil conservation measures. With high rainfall, the soils are easily eroded, lose their productivity and become severely degraded within short period of cultivation (Ofori and Santanna, 1985). The physical degradation processes that ravage our soils unabated include compaction, water and wind erosion, crusting and sealing, and water logging. Soil compaction and accelerated soil erosion are probably the most devastating soil physical constraints in Nigeria especially when intensive land use replaces traditional farming. That is, decline in yield is mostly caused by soil degradation particularly soil fertility depletion in addition to diseases. Lal (1985) emphasized the severity of soil compaction when large-scale farming is practiced through motorized farm operations. Humid and sub-humid agro-ecologies, such as in southern and middle belt regions of Nigeria, are particularly vulnerable to accelerated soil erosion and erosion-induced degradation of soil quality.

Erosion rates could range between 100 t Km^{-2} yr-1 in several watersheds with a delivery ratio of only 10 to 30 percent (Walling 1984). Rates of soil erosion, measured under experimental conditions could vary between 90 and 250 tons/ha/year (equivalent to an average loss of 1.2cm of topsoil per year) and run off as high as 42% of annual rainfall . Even in the gently sloping lowlands and savanna soils, losses as high as 20tons/ha and runoff amounting to 28% of annual rainfall have been observed. Drastic yield reductions for all crops are observed when the fertile top soil is preferentially removed by the overland flow leaving coarse sand and gravels behind (**Mbagwu et al**., 1984).

Splash erosion causes surface crusting and compaction and this often prevents plant germination, development and proliferation. Moreover, a compacted soil will have lower organic matter, reduced infiltration and less of plant available water (Ponzi, 1993).

2.2 CHEMICAL COMPOSITIONS CONSTRAINTS.

Nigerian soil scientists (Ojanuga, 1979; Agbede, 1984) had reported the dominance of kaolinitic clay mineral in all the well-drained soils of Nigeria tropical savanna, a property shared with the well-drained soils of humid tropical forests.

Montmorillonitic clay occurs in significant amounts in addition to kaolinite in the poorly-drained soils of Nigeria. In these soils where kaolinite, gibbsite, quartz, haematite and goethite predominate, leaching losses of nutrients are very high and rapid. Most proportion of soils in tropical Africa are described as low-activity-clay (LAC) soils with cation exchange capacity (CEC) usually less than 20cmol kg^{-1} and having very low plant nutrient reserves in the form of unweathered primary minerals. Nigerian soils are generally light textured and low in clay content with a range of 9 to 43%, in more than 60% of the area, clay content is less than 15%. Soil reaction (PH) ranges from 4.2 to 8.5, combined calcium (Ca) and magnesium (Mg) content varies from 0.5 to 5.55cmol Kg^{-1} organic matter content also varies from 1.0 to 2.55% (Agboola, 1986).

With the properties enumerated above, Nigerian soils are often referred to as fragile soils which require particular management cropping techniques. The thorough understanding and management of this fragile natural resource for food production at both sufficiency and security levels in Nigeria pose great challenge to all of us. The fact is that once the soil is destroyed, it is nearly impossible to bring it back to production. That should reminds us constantly the indispensability of soil fertility assessment, development and improvement in crop production.

2.3 ENVIRONMENTAL FACTORS AS CONSTRAINTS

Nigerian soils are inherently low in soil fertility. Due to poor handling and management of the land, decline in soil fertility is very rapid. Any attempt to drastically modify the soil environment always result in serious damage to the soil (Agboola, 1986). For example, if the vegetation cover is removed, the soil becomes vulnerable to intensive weathering and oxidation of organic matter, excessive leaching losses of plant nutrients, changes in soil physical properties which may lead to low water infiltrations, low buffering capacity and even acidification. The overall result is infertile soils and very abysmal low crop yields. The major agents of land degradation in Africa as a whole are water erosion, wind erosion, chemical degradation and others that affected soil loss by 47, 36, 12, and 3.5% respectively. Lack of soil knowledge gives people the impression that the soil could be used carelessly and in the process the soil gets damaged irreversibly in most cases. Some of the soil abuses were enumerated by Agboola (1986) as unsuitable land clearing methods, illegal mining operations of different minerals, unmitigated (uncontrolled) bush burning, overgrazing, exposure of water heads leading to severe flood and silting of rivers and lakes. The absence of initial pilot schemes to monitor environmental impact of the country's irrigation schemes has led to salinity, alkalinity, clay pan formation, water logging, etc.

Furthermore, lack of incomplete knowledge of soil resources by users and unavailability of improved farming and soil management practices that are compatible with the poor socio-economic conditions of most farmers hampers sustainable soil development and conservation. Many development schemes have either been only partially successfully or have failed due to lack of basic information on the natural resources available in a region.

3.0 IMPACT OF SOIL ABUSE ON FOOD SECURITY

The ***International Food Policy Research Institute (IFPRI)*** in 2002 described food security as "a situation in which all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life." In the Nigerian context, Idachaba (2006) described national food security as a "world in which the majority of households, communities and the Nigerian populace have economic and physical access to food that is adequate in quantity and quality for a healthy life at all times through agricultural growth, development and poverty eradication."

Food security is in three dimensions; food availability, food access and food adequacy. Food availability has to do with the supply of food which should be sufficient in quantity and quality and also provide variety. Other ramification of food security which are accessibility (power to purchase) and food adequacy (nutritional quality of food) are not part of this lecture.

The major challenge to food security in Nigeria is our underdeveloped farming systems characterized by low *soil fertility*, minimum use of external farm inputs especially manures, and environmental degradation. Like earlier mentioned, the soils continue to degrade leading to a reduction in the productivity of the farms. Some of the causes of soil fertility depletion include the limited adoption of fertilizer use for soil replenishment and lack of adequate water conservation measures. For centuries, rural farming communities had been able to sustain and feed the nation by adopting shifting cultivation (natural fallows) to restore soil fertility. Owing to rapid population growth and high pressure on agricultural lands, length of fallow periods has reduced drastically giving way to continuous cropping with its attendant problems such as low soil fertility. Often a time, increased food production is achieved by the expansion of agricultural production into marginal and fragile areas. The removal of vegetation through overgrazing, logging, development and domestic use are also brothers in crime in exposing the soils to forces of erosion and eventual decline in productivity.

Most of the land suitable for agriculture in Nigeria has low soil fertility. Yet the average fertilizer use intensity is in the range of 15-20 kilos per hectare (kg/ha), Africa average is 9 kilos per hectare (kg/ha) of harvest land, compare to 100kg/ha for south Asia, 125 kg/ha for East and south-East

Asia and 73 kg/ha for Latin America. The low use of fertilizers in African Agriculture results in the world's lowest crop yields.

4.0 RECENT EFFORTS AT UPGRADING SOIL FERTILITY ASSESSMENT, DEVELOPMENT AND CONSERVATION TO INCREASE FOOD PRODUCTION

4.1 DESKTOP WORK AND DIAGNOSTIC SURVEY OF AGRICULTURAL COMMUNITIES IN THE MIDDLE BELT

Medical experts usually carry out fact findings through laboratory tests, questionnaires and physical examination of patients before recommending drugs for ailments. In the same vein the initial exercise before putting a piece of land into cropping includes obtaining information from farmers about the production constraints they encounter in resource use and management to serve as platform for developing soil fertility strategies and management. In the last five years, our multi disciplinary team employed desktop study and diagnostic survey to articulate all existing information on the farmers' physical environment such as climate, soils, farm problems, farm production levels and the existing constraints to sustainable food production within the southern Guinea savannah states of Nigeria. The states studied were Nasarawa, Benue, Kogi, Niger and F.C.T within the North Central Nigeria. The information provided served as platform for the formation of research strategies that have practical relevance to the needs of farmers in terms of soil fertility development and conservation.

Soil, climate, geography and crop production are adequately documented holistically in two books as a precursors to the actual laboratory and field research trials for developing strategies for soil fertility improvement in southern Guinea Savannah of Nigeria.

Nigeria is richly endowed with natural resources which have to be harnessed for the production of various livestock and crops for the sustenance of its teeming human and animal population. Food insecurity and poverty that are prevalent in the country could be stemmed if we appreciate what we have and know how to tap the natural recourses and use them for the overall development of the country.

This project was embarked upon with the overall purpose of developing sustainable crop production strategies. On a long term basis, the strategies must be potentially capable of reversing the current trend of soil degradation, stabilize production processes and conserve soil fertility and improve farmers' income. Our multidisciplinary team carried out the desktop study and diagnostic survey of middle Belt states and F.C.T. in 2011.

The following facts emerged from the desktop and diagnostic survey:

- Production of document that articulates existing information on the physical and soil environment, cropping systems and production constraints of farming communities in North central states and Federal Capital Territory (FCT) of Nigeria (Agbede et al., 2011).
- Production of document that comprehensively report baseline data on climate, geography, economy, farmers' practice, production levels, problems and felt-needs in the northern Guinea savannah agro ecology of Nigeria; that is, the availability of data bank of farming practices, production and problems in the zone.
- Availability of massive soil data of over 500 samples collected on Local Government and soil unit basis that reveal diversity of land capability, extent and severity of deterioration and possible management measures for sustainable product

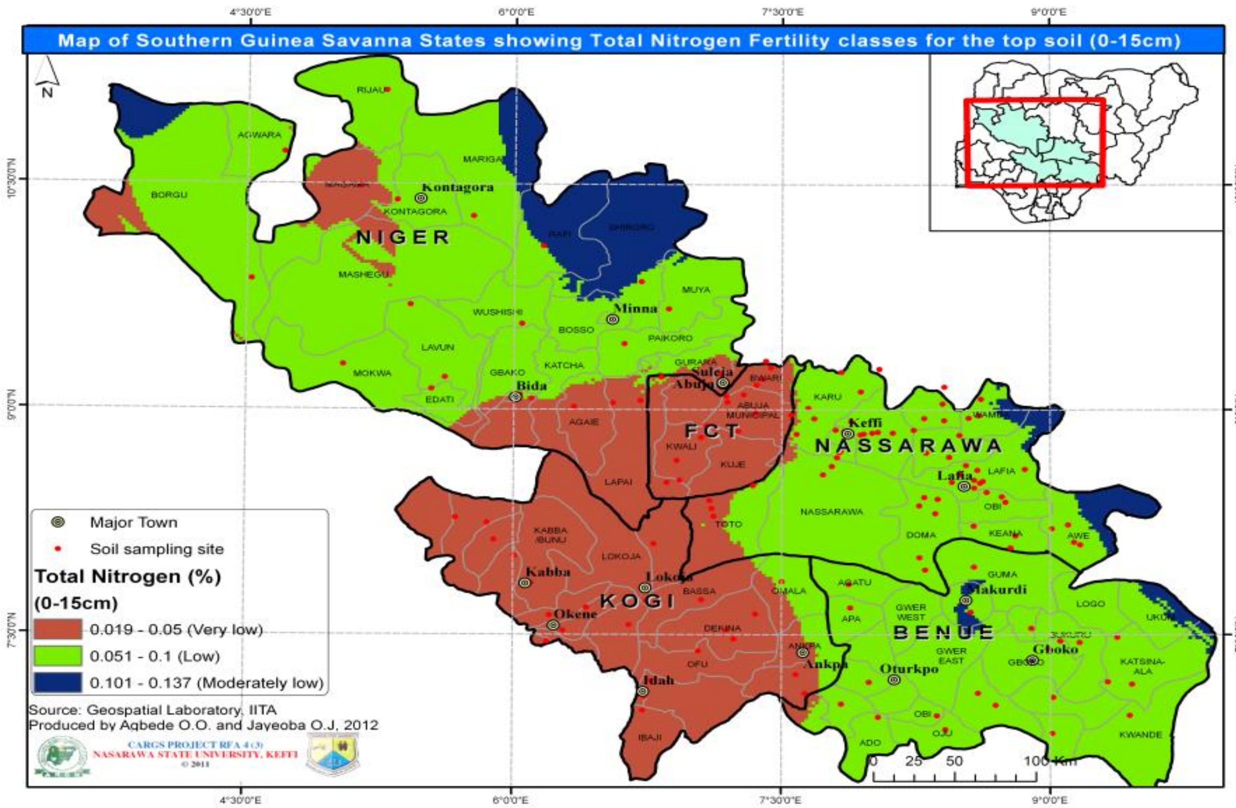
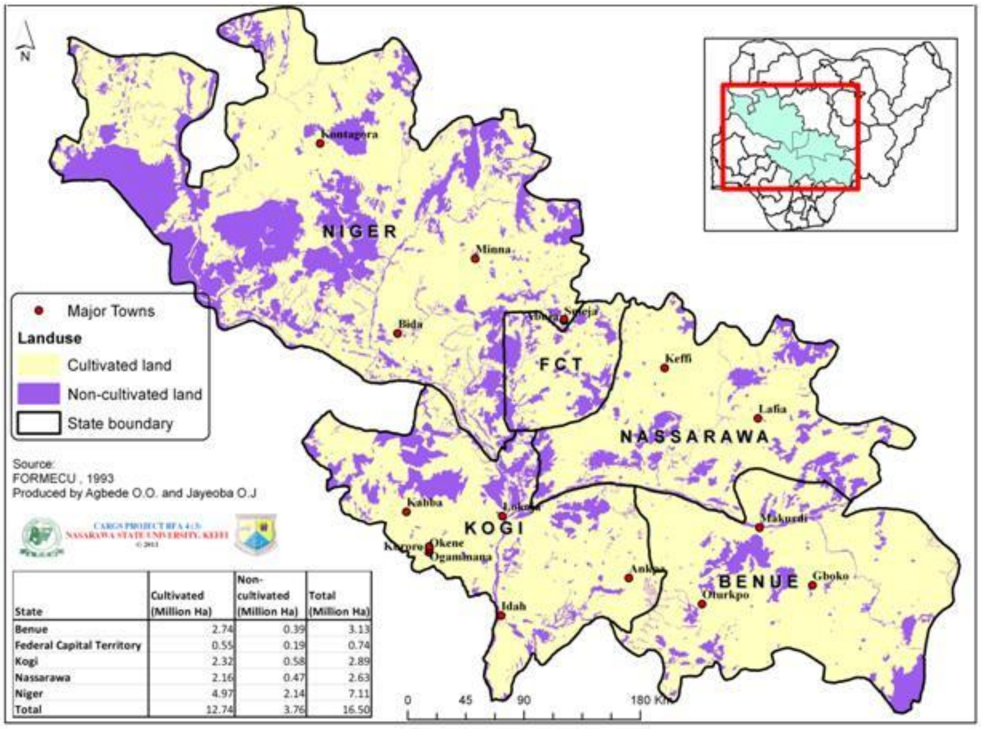


Fig. 4 Middle belt states and F C T of Nigeria showing soil total N

- Availability of spatial and geo-referenced maps for soil fertility (pH, micro and macro nutrients), soil organic matter as well as soil physical properties such as water holding capacities, aggregate stability etc. These maps would be useful for site-specific fertilizer and water management strategies for adoption by stakeholders (Agbede et al., 2013) .
- Site and field description , including physiographic (topography), drainage pattern, outcrops 0f rocks and stunners, climate (rainfall, temperature, relative

  Fig. 5 Land use pattern in the middle belt states and F. C. T of Nigeria
- humidity) vegetation (trees, weeds, grass cover etc) and soil description (such as colour, texture, structure) (Agbede et al., 2013)



State	Cultivated (Million Ha)	Non-cultivated (Million Ha)	Total (Million Ha)
Benue	2.74	0.39	3.13
Federal Capital Territory	0.55	0.19	0.74
Kogi	2.32	0.58	2.89
Nassarawa	2.16	0.47	2.63
Niger	4.97	2.14	7.11
Total	12.74	3.76	16.50

Fig. 5: Land use pattern in the middle states and F.C.T. of Nigeria (source: Agbede and Jayeoba, 2012)

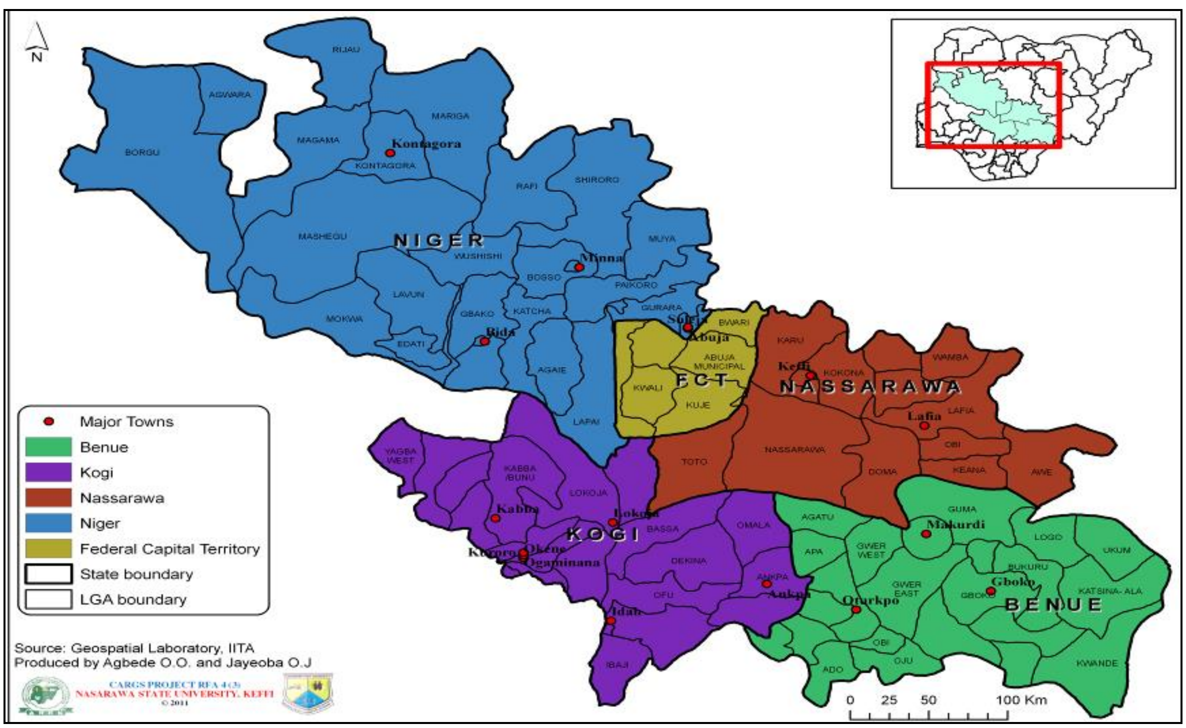


Fig. 6: Administrative map of southern Guineas Savanna States (Benue, Nasarawa, Kogi, Niger and FCT), Nigeria (source: Agbede and Jayeoba, 2013)

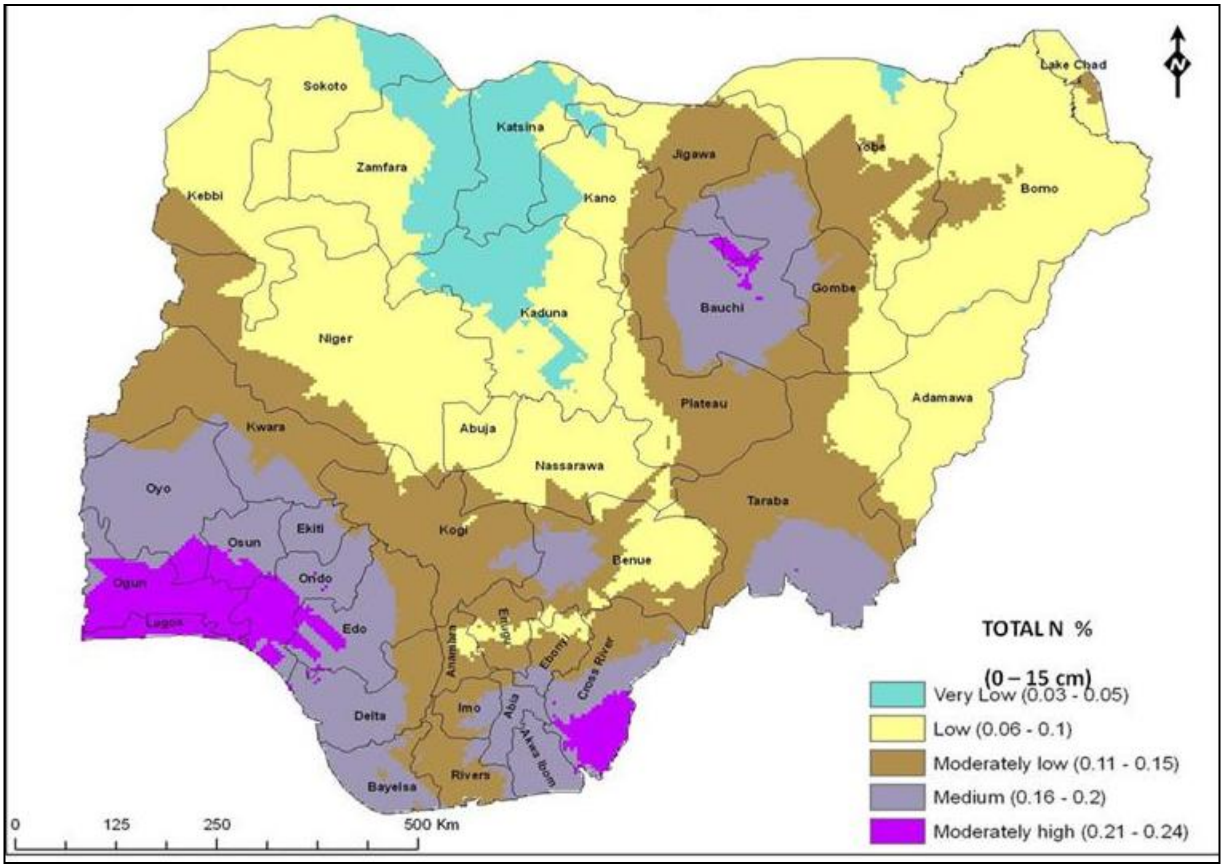


Fig. 7: Map of Nigeria showing different Total N fertility classes for the topsoil (source: Chude and Jayeoba, 2004)

4.2 GREEN HOUSE CORRELATION STUDY

Massive and intensive soil samples from selected locations on Local Government and soil unit basis in over five hundred sites in four states and FCT were collected. The soils were analyzed and subjected to comparative productivity study in the green house. This exercise was embarked upon to known the soil fertility levels and productivity regimes of the diversity of soil types in the zone. The results were very revealing. Crop growth reflected the nature and the initial fertility status of the various soil types. Results could be used to predict site-specific fertilizer recommendations after carrying out appropriate correlation and regression of plant growth with soil nutrients. Plate 1 shows a few examples of crop performance in the unamended soils. The performance of crops in soils of different locations enables us to group the soils into soil fertility classes and productivity domains as a guide for fertilizer recommendations.

Plate 1. Correlation studies on different potted soil types of farming communities in the southern Guinea savanna.

4.1.1 Integrated Soil Fertility Management

Apart from the fact that fertilizer use by farmers is pitiably low, the nutrients supplied are not usually available to crops due to leaching losses, run-off losses, volatilization and soil mineral adsorption losses.

The key to sustainable soil fertility management is integrated application of organic and inorganic fertilizers. Efforts in this direction will ensure carbon build-up of soil and its quality on a long term basis. Table 4 shows maize response to integrated nutrient management in Nasarawa state location during 2012 planting season. Different combinations of N P K , green legume, cow dung, rice bran, compost plus, soybean residue and poultry manure were test d on farmers' field. Poultry manure and compost plus, with or without inorganic fertilizer gave the highest yield of maize. This trend is an apparent increased efficiency in N P K utilization possibly due to a combination of increased biological activity and the fresh supply of nutrients when the organic matter is incorporated into the soil.

The data indicated that compared with the control, other treatments significantly increased maize yield in Nasarawa state indicating the indispensability of soil fertility improvement of the farm lands.

Table 4: Maize Response to Integrated Nutrient Management in Nasarawa State.

Treatment	Date to 50% Tasseling				Days to 50% Maturity				Grain Weight (100 Seed) (Kg)				Grain yield/Plot (Kg)			
	I	II	III	mean	I	II	III	mean	I	II	III	mean	I	II	III	mean
A. Compost plus B. (25kg/plot)	40	40	40	40.0	64	64	65	64.3	0.2	0.3	0.4	0.30	4.5	5.7	5.4	5.20
F. Soybean/cowpea/G-nut residue(75kg/plot)	40	40	40	40.0	64	64	65	64.3	0.2	0.3	0.4	0.30	3.2	6.2	5.2	4.87
C. Poultry dropping (75kg/plot)	40	40	40	40.0	64	64	65	64.3	0.2	0.4	0.5	0.37	6.2	6.5	6.4	6.37
I – ½ dose poultry manure + ½ dose NPK (250g/plot)	42	40	40	40.7	64	64	65	64.3	0.4	0.4	0.5	0.43	6.5	4.4	6	5.63
E. Green legume (75kg/plot)	42	40	42	41.3	64	64	65	64.3	0.2	0.3	0.4	0.30	3.5	4	5	4.17
J– ½ dose cowdung manure + ½ dose NPK (250g/plot)	40	40	40	40.0	64	64	65	64.3	0.4	0.3	0.3	0.33	4.5	4	4.4	4.30
G. NPK (500g/plot)	40	40	42	40.7	64	64	65	64.3	0.3	0.3	0.3	0.30	3.5	5	5	4.50
D. Cowdung (75kg/plot)	42	40	42	41.3	64	64	65	64.3	0.4	0.3	0.3	0.33	4.2	5.3	4.6	4.70
H – ½ dose rice bran + ½ dose NPK (250g/plot)	42	40	42	41.3	64	64	65	64.3	0.3	0.3	0.2	0.27	4.4	4.2	4.6	4.40
B. Rice bran(75kg/plot)	42	40	45	42.3	64	64	65	64.3	0.4	0.3	0.3	0.33	3.3	4.2	4.2	3.90
K– ½ dose compost plus + ½ dose NPK (250g/plot)	42	40	42	41.3	64	64	65	64.3	0.4	0.4	0.4	0.40	4.4	5	4.5	4.63
L. Control	42	40	45	42.3	64	64	65	64.3	0.1	0.2	0.2	0.17	3	3.5	3.4	3.30

4.3 ESTABLISHMENT OF PILOT DEMONSTRATION PLOTS IN PROBLEM SOILS (ACID AND SALTY SOILS)

4.3.1 Combating soil acidity.

Available information indicates that about twenty three (23) states cutting across six geopolitical zones of the country have one form of acid soil problem or the other.

Reclaiming such acid soils had become a necessity if yield per unit area is to increase since the attainment of higher and sustainable crop yield is predicated on soil conditions under which crops grow, such as occasioned by soil acidity problems.

In Nigeria, acid soils mostly occur in the humid regions where rainfall appreciably exceeds evapo - transpiration mostly in the southern Guinea savannah. Repeated use of acidifying inputs such as ammonium – containing fertilizers (urea and ammonium sulphate) usually result in acidic condition especially in intensively cultivated irrigation schemes in the northern Guinea savannah and Sudan zone.

Causes, effect and extent of soil acidity.

Soil acidity reduces the value of production in the affected areas in Nigeria. Soil acidification is a natural result of agricultural land use and affects or puts at risk more than 14.5million hectares of arable soils.

Soil acidity is defined as the soil that has a pH less than the threshold that restricts plant growth. Sub-surface acidity is a bigger problem than top soil acidity. Identification of the problems and profitable treatment with ameliorative soil amendments often leads to increase crop yield.

Acid tropical soils, oxisols and ultisols with a pH lower than 5.5, cover the larger block of potentially arable land in Nigeria (Ibia and Udo, 2009: obiara, 1961: Ayeni and Adeleye, 2011). They represent over 25.0% of Southern, Eastern, Western and Central part of the Country. These soils are either covered with forest or savannah, but they are increasingly being cleared in order to open new land for agriculture, thereby creating national concern for the environment. Consequently, attainment of good yield of many crops is contingent on increasing the pH of acid soils which then improve plant availability of macronutrients while reducing the solubility of elements such as aluminum (Al) and manganese (Mn). Soil acidity is commonly corrected by applying limestone. However, liming soil is not a common practice in the traditional subsistence farming system due to lack of awareness of the importance of lime and unavailability of the products at critical period. There is, therefore the need to look for cheap alternative sources of liming materials which can reduce the concentration of exchangeable Al and increase that of Ca to bring about high yield of arable crops.

Some major target areas have been identified in some states as specified below. The constraints are generally excessive leaching of bases and replacement of the cation with H^+ and Al^{3+}. The project entails settings up demonstration plots on farmer's field to show –case technologies for solving problems concerned with soil acidity. The demonstration plots were to include farmers practice for comparison. The emphasis was to find locally sourced low-input materials for correcting soil acidity using crops that are popularly cultivated within the community.

Cattle dung is common in all the ecological zones of Nigeria. Its adoption by farmers may not be a problem as it is cheap and readily available. The main objective of this study was to determine and demonstrate to the farmers the effect of organic manure and lime on soil pH and cat ions in Akwa Ibom, Anambra, Enugu and Ogun States of Nigeria.

4.3.2 Use of different ameliorative amendments to combat soil acidity

Benchmark sites of soil acidity were selected in Akwa Ibom, Anambra , Enugu and Ogun States for amelioration using chemical and organic amendments. Geo-referenced locations of the sites are stated below. Fig. 8 shows the states studied while Table 5 shows the soil parameters of the locations.

- **Akwa Ibom state**
  Site: Ekamba, nsukara village Uyo LGA
  Long: 007^0 58.954E
  Lat: 05^0 01.212
  Elevations: 62m

- **Anambra state**
  Site: Igbariam farm settlement Village 1
  Long: 006^0 57.870E
  Lat: 06^0 18. 757N
  Elevation 72m

- **Enugu State**
  Location: Edem Community in Nsukka LGA
  Long: 007^0: 20.546E
  Lat: 06^0 50.266N
  Elevation: 427m

- **Ogun State**
  Location: Ajegunle farm settlement Odeda LGA
  Long: 003 25.905E
  Lat: 07^0 09.04
  Elevation: 151m

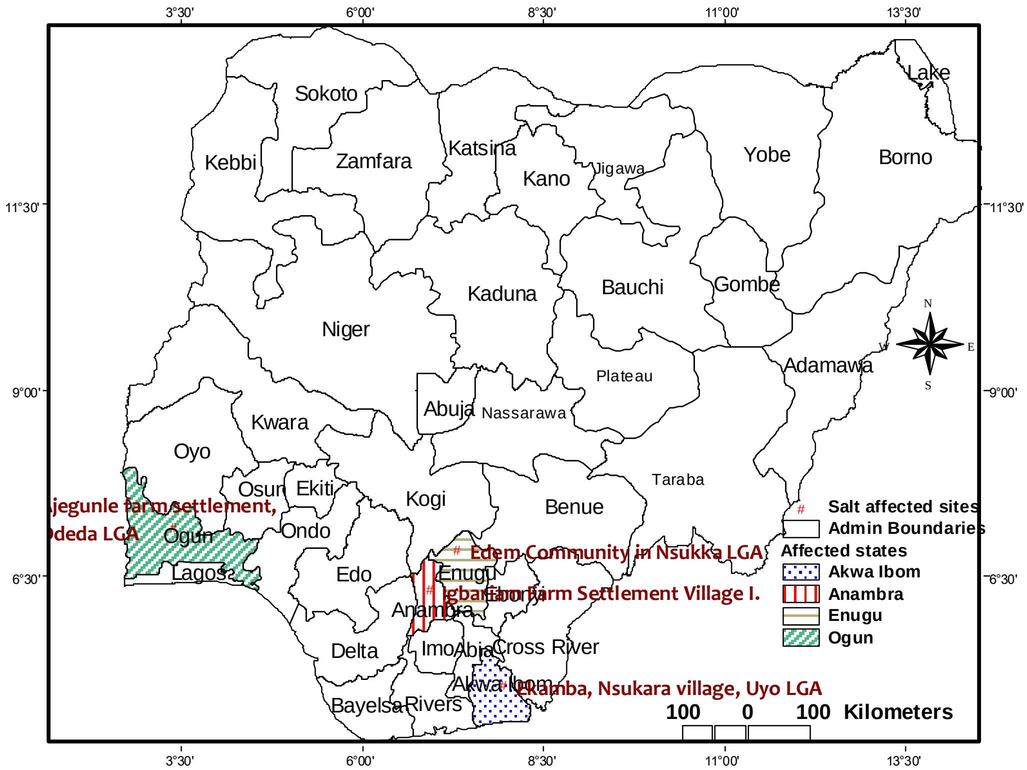


Fig. 8: Map of Nigeria showing plot demonstration plots in acid-affected states.

Table 5: Physical and chemical properties of surface soil samples of acid-affected areas in Akwa Ibom, Anambra, Enugu and Ogun States.

S/No	Particle size distribution					pH		Org. C & N			PPM Exp	Exch. Cat ions Cmol kg-[1]				CEC	Base salt%
	Location	Sand %	Silt %	Clay %	Textural class	H_2O 1:1	KCl 1:1	C %	O.M %	N %	Bray P	Ca	Mg	K	Na		
												Centimol Kg-1 Soil					
1	Nsukura Village Akwa Ibom	84.8	1.4	13.8	SL	5.66	5.06	0.81	1.40	0.06	3.9	3.46	1.58	0.33	0.46	6.10	97.5
2	Igbariam (Anambra State)	73.1	12.3	14.6	SL	6.5	5.8	0.92	1.59	0.10	4.5	3.80	1.77	0.37	0.53	7.00	92.4
3	Nsukka Edem (Enugu State)	85.6	3.4	12.0	LS	5.8	5.10	0.55	0.95	0.06	2.7	2.88	1.10	0.22	0.40	5.06	96.0
4	Ajegunleodeda (Ogun State)	83.1	7.3	9.5	LS	5.92	5.18	0.65	1.12	0.07	3.07	2.69	1.40	0.51	0.31	6.80	72.0

4.3.3 Site and soil characteristics of study areas

At Akwa Ibom state the trial was sited at Nsukura Offot, Uyo LGA in the Southeastern rainforest zone of Nigeria (Lat $4^0.30^1$ and 5^1 30 N and Long 7 5 and 8^0 20^1 ^{E} , 100m altitude).

The site has mean annual rainfall of about 2500mm during the rainy season which is from March to November. Main relative humidity of 78%, mean annual minimum and maximum temperature of 22. 5^0 C and 30.7^0 C (Ibia and Udo, 1993).

The soil is acidic and belongs to broad soil classification group Altisol, with well drained coaster plain sands of Benin formation, low in organic matter, nitrogen, potassium, and other nutrients (Peter et al., 1989).

The site had been under a two-year fallow prior to use for the study. Pre fallow crops were cassava, maize, and cocoyam planted in the traditional mixed cropping system and without the application of inorganic fertilizer.

The study area in Enugu state is located at latitude 06^0 50.266N and longitude 007^0 20. 546E, with mean elevation of 427m above sea level. The area is characterized by a humid tropical climate with wet and dry seasons (Obi,1982). The rainfall is bimodal distributed with annual total of about 1750mm. The area experiences long wet season (April- July) interrupted by short dry period (July – August). The August break is followed by short wet period (August/ September- October). and finally, by long dry season (November – March). The mean daily maximum temperature is usually above 27^0 C throughout the year.

The highest values (up to 35^0C) are usually recorded between February and April. The mean annual temperature is 27^0 C with minimum and maximum of 21^0 C and 31^0 C respectively (UNN metrological station). The soil is an Ultisol (Acrisol FAO; sol ferrallitique, French system) belonging to the Nkpologu series. It is deep porous, and red to brownish red and derived from sandy deposit of false-bedded sand stones, classified as typic paleustult (Nwadialo 1989). Generally the soils are moderately drained, have low cation exchange capacity (CEC) due to high leaching as a result of intense rainfall. The surface soil reaction is very strongly to strongly acid and with low organic matter and are structurally weak as laterite and lateritic gravel soils, the top layer is predominantly sandy loamy.

The relative humidity ranges from about 65% to 100%. The lowest values are obtained during the dry season, whereas the very high values (96%-100%) are recorded in the rainy months of April/ May to October.

This mapping unit is composed of soils on flood plain lands along the tributaries of river Anambra and on the depression or swamps that occur on the upland mapping unit. Well drained and textures are generally fine sandy quantity of fine sand fraction.The soil reaction is very strongly acid. Exchangeable bases are low except Na and Mg the CEC varies from low to moderate. The fertility level is low to medium.

Land use for the floodplain is usually rice and cultivation and for the soil on the depression. Vegetables are cultivated during the dry season while rice is planted during the rainy season.

In Anambra state, the Igbarian upland area is composed of soil on relatively elevated land with elevations ranging between 41m and 87m. The area is intensively cultivated to yam, cassava .upland rice, fruit tree such as oranges, mangoes, oil palm and guava. Oil palm plantation is extensive while a few Daniellia ssp and Neeem trees also occur.

In Ogun state the research plots were established at Ajegunle farm settlement in Odeda local government area with coordinates of Lat 07 09.048N and Long 003^0 25.905E and elevation of 151m above sea level. The area is within the rain forest agroecological zone of the country where over 60% of the populations are predominantly farmers. The annual rainfall ranges between 1,500-3,500mm.

The soils are low in pH, cat ion exchange capacity and nutrient contents such as nitrogen and phosphorus. Table 6 shows the physical and chemical properties of soils collected from the four states studied. To improve the productivity of these soils, lime application and increasing the organic matter content are the main solutions. However, liming should be limited or not beyond pH 6-7 especially soils with high amount of aluminium and iron oxides.

4.3.4 CROP RESPONSE IN AMENDED ACID SOILS

Figure 9 and Table 6 show crop response to the different amendments in the four states studied. The following observations stand out from the results.

- In all the states, amendments gave better performance in crop growth parameters compared to zero levels (farmers practice)
- Lime and poultry manure application were superior to other treatments and farmers practice (zero level).
- Farmers were delighted to observe the efficacy of lime and poultry manure to combat soil acidity and improve crop growth
- The effect of compost plus generally manifest under adequate watering regime which was limited during the dry season.
- Farmers discovered that poultry manure might become a better alternative to lime in ameliorating acid soils of their farmlands.

  Figures 5- 6 shows that liming and application of organic manure improved crop growth. Increase in plant height and leaf area of okro is above 20% and 40% respectively with addition of lime and poultry manure to acid soils of Nsukura, Uyo LGA. Farmers indicated great interest in the use of lime if available due to the demonstration plots. Akwa Ibom state is one of the densely populated states in Nigeria with predominant acid soils. Improvement of the productivity of these acid soils would definitely bring more cultivatable areas into use by farmers. (Plate 1&2)

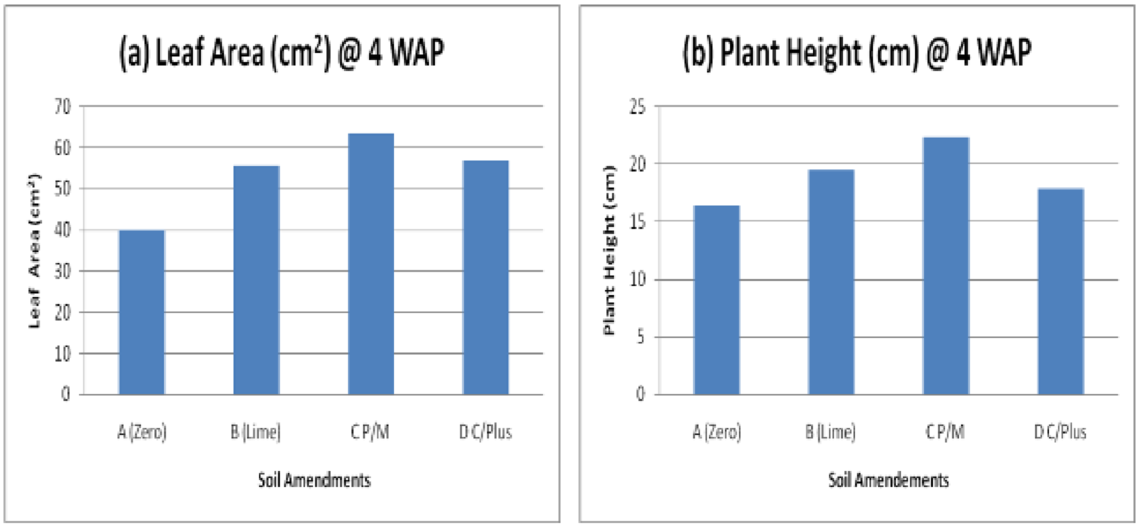


Fig. 9: Effect of organic and inorganic amendments of acid soil on crop performance in Akwa Ibom State (a) Leaf area of okra (b) Height of okra (PM = poultry manure, CP = Compost plus)

Plate 2. Okra crop under different soil amendments (compost Plus and poultry manure) at Nsukura, Uyo LGA, Akwa Ibom state

Table 6: Yield of okra in amended acid soil, Akwa-Ibom State

(a) Number of fresh okra fruits(pods)

S/N	Treatment	2WAP					4WAP				
		I	II	III	T	M	I	II	III	T	M
1	A			1	1	1	8	3	6	17	5.67
2	B	2	2	2	6	2	4	7	6	17	5.67
3	C	1	2	2	5	1.67	8	14	15	37	12.33
4	D	5	4	2	11	3.67	8	4	10	22	7.33

S/N	Treatment	6WAP				
		I	II	III	T	M
1	A	68	44	66	178	59.33
2	B	90	67	38	195	65
3	C	84	66	104	254	84.67
4	D	57	58	58	173	57.67

(b) Total yield of fresh fruits (pods) (kg/ha)

S/N	Treatment	I	II	III	T	M
1	A	1.21	0.83	1.09	3.13	1.04
2	B	1.87	1.5	0.63	4	1.33
3	C	1.69	1.39	1.92	5	1.67
4	D	1.54	1.08	1.23	3.85	1.28

Crop performance in Enugu State

At Edem community near Nsukka in Enugu State where the demonstration plots were sited, the effect of lime and the organic amendments (poultry manure and compost plus) on yellow pepper was very highly noticed especially on plant height and leaf area. Lime came top in improving growth parameters measured followed by poultry manure. The two amendments increased performance by over 20% compared to zero (control) treatment. Under the current intensification and pressure on land, the benefits of lime and organic fertilizer for sustainable crop production cannot be over emphasized in the pilot area studied. There is however the need to follow a planned rotation using suitable integration of chemical and organic fertilizers that are capable of enriching the soil and improve nutrient uptake by crops.

The amendments gave over 36% increases in leaf area and 25% in plant height compared to control. Plant height, leaf area and number of leaves are known to have high correlation with fruit yield in pepper. The limitation of abundance of water during the dry season production might have reduced the rate of compost plus mineralization and hence delay nutrient release compared to poultry manure which could decompose under limited amount of water.

Pictures of crop response to application of organic and inorganic soil amendment and farmers' field day are presented in plate 2.

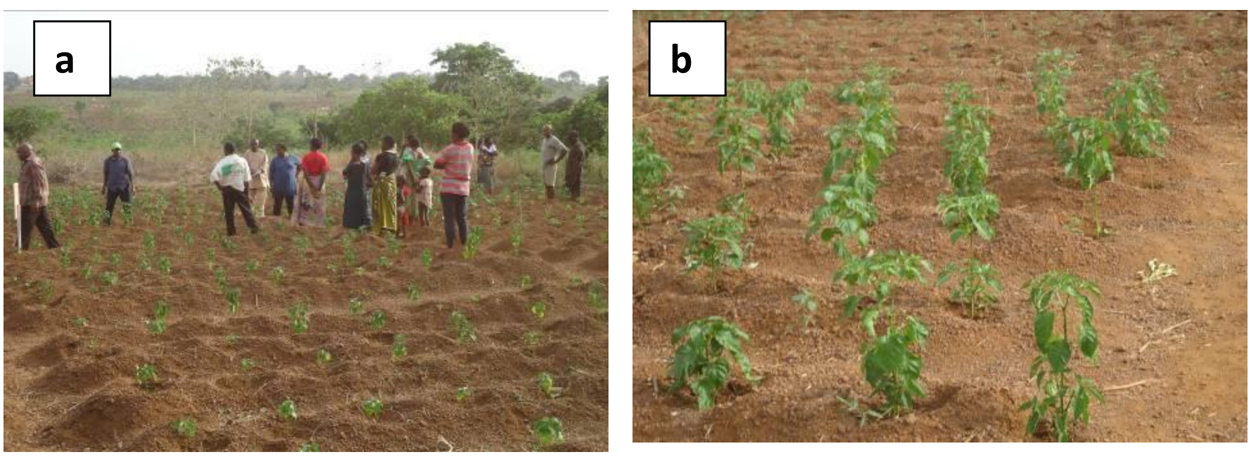


Plate 3. Yellow pepper on plots treated with: a. lime and b. poultry manure at Nsukka, Enugu State

In Ogun State both organic and chemical (inorganic) amendments positively affect the growth of amarantus vegetable. Plant height improved with amendments especially lime and compost plus which gave above 54% over zero level or farmers practice. During the duration of the study, plant height increased progressively with weeks after planting (plate) and fig.

Performance of Crop (*Amarantus olitorus* and okra) in Ogun State.

The superiority of amended acid soils over non-amended acid soils was also revealed in other growth parameters measured viz: leave count, stem diameter and leave area. In all cases improvement was 20 – 40 % in amended soils over non-amended soils.

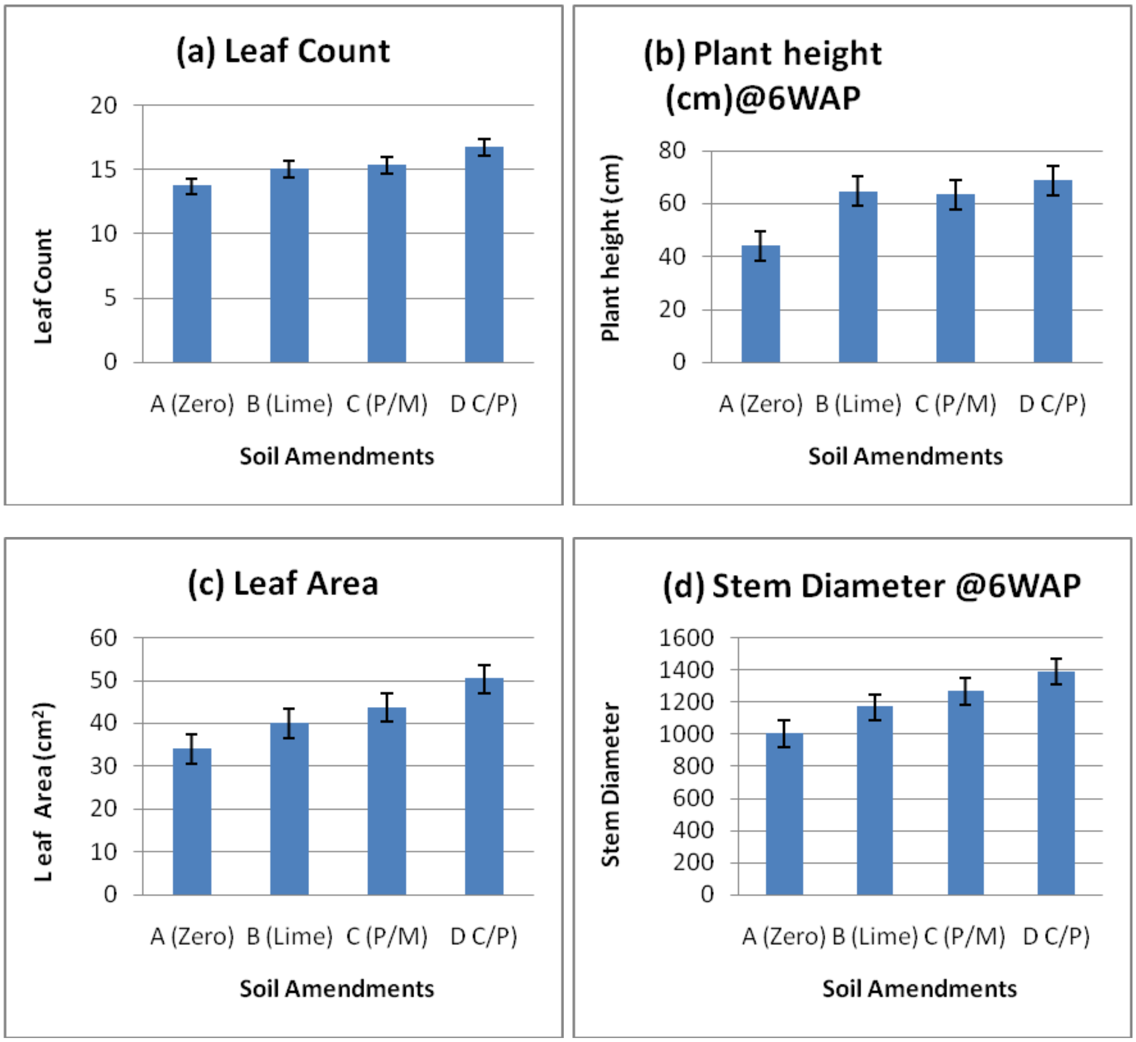


Fig 10: Response of *Amarantus olitorus* to amended acid soils in Ogun State (a) Leaf count (b) Plant height (c) Leave area (d) Stem diameter (PM = poultry manure, CP = Compost plus)

Plate 4. Response of vegetable crop to soil amendments in acid soil in Ogun state

Table 7: Growth parameters of maize grown in amended acid soil in Anambra State (I, II, III replicates, T = Total, M = mean)

(a) Plant stand count

Treatment	2WAP					4WAP					6WAP				
	I	II	III	T	M	I	II	III	T	M	I	II	III	T	M
A-Zero	79	80	80	239	79.7	72	79	80	231	77	72	73	80	225	75
B-Lime	81	81	81	243	81	73	81	75	229	76	73	80	75	228	76
C-Poultry	81	76	80	237	79	80	73	77	230	76.6	80	71	72	223	74
D-Compost Plus	81	81	81	243	81	77	80	79	236	78.7	77	78	78	233	77.7

(b) Stem Diameter (cm)

Treatment	2WAP					4WAP					6WAP				
	I	II	III	T	M	I	II	III	T	M	I	II	III	T	M
A-Zero	0.68	0.7	0.78	2.16	0.72	1.23	1.63	1.85	166	55.4	1.6	2.28	2.13	6.01	2
B-Lime	0.77	0.82	0.75	2.34	0.78	1.32	1.35	1.78	4.45	1.48	1.93	1.97	2.17	0.7	2.02
C-Poultry	0.83	0.73	0.77	2.33	0.78	1.68	1.25	1.88	4.81	1.6	2.25	1.9	2.22	6.37	2.12
D-Compost Plus	0.73	0.63	0.7	2.11	0.7	1.37	1.47	1.98	4.82	1.61	2.03	1.98	2.17	6.18	2.06

(f) Fresh yield at 10wks (tonnes/ ha)

Treatment	I	II	III	T	M
A-Zero	5.4	6.5	5.7	16.7	5.57
B-Lime	13.5	13.8	9.9	37.2	12.4
C-Poultry	15.3	11.7	17.1	44.1	14.7
D-Compost Plus	17.1	14.4	13.95	45.45	15.15

Crop performance in amended acid soils in Anambra State

Table 10 shows the performance of maize crop (plant stand count, stem diameter, plant height, leaf area, fresh yield at 10weeks) grown in amended acid soils of Anambra state. Like other states, there were general increases in the agronomic traits of crops with time (weeks after planting). However, treatments (especially lime, poultry manure and compost plus) enhanced crop performance (stem diameter and number of leaves) over the control plots. There was no consistent trend in the plant height and leaf area of maize grown in acid soils treated with lime and poultry manure. But compost plus improved plant height of maize over other treatments.

There were significant difference in maize yields as a result of application of soil amendments (Lime, poultry manure and compost plus) over the control (farmers practice) in Anambra State. Application of these soils ameliorative chemical and organic manures gave over 100% yield increase (Table 10). The differences in yield among the amendments were not significant. Hence any of lime, poultry manure or compost plus could be applied to ameliorate acid soils for increased crop production and sustainable soil productivity.

Farmers' Comments

Some farmers are aware of the effect of lime and poultry manure and had even tried them on their farms previously but lime has been scarce and inaccessible to them. Compost plus was completely new to them and they were delighted on the information that lime is being supplied to states by the Federal Ministry of Agriculture and Rural Development especially when the effect of lime on their acid soil has been practically demonstrated to them. They would buy and use lime readily to supplement their locally sourced poultry manure.

The desirability of this demonstration plots whereby lime use is included could have preceded the supply of lime to states by the Federal Ministry of Agriculture and Rural Development. The results of the trials would enable farmers know the package of lime recommendation to improve soil fertility of their farms.

4.4. RESTORATION OF SALT AFFECTED SOILS

The necessity to restore salt – affected soils for soil fertility improvement is understood by the fact that they are widespread in Nigeria. Both saline and sodic soils affect plant growth adversely through the effect of excess salts on the osmotic presence of soil solution resulting in reduced availability of water. Improvement of saline and sodic soils essentially requires the replacement of excess salt in the exchange complex through the use of soil amendments and leaching of excess salts into the sub-soil layer below the feeding zone of plant roots. Field trials were plastered in salt –

affected soils in Kano, zamfara, sokoto, kebbi, Nasarawa, Taraba, Jigawa and Taraba states during Janurary to May 2013, that is, purely dry season farming. Already tried and tested soil ameliorative materials were used to correct soil salinity through the establishment of pilot demonstration farms (Fig. 6).

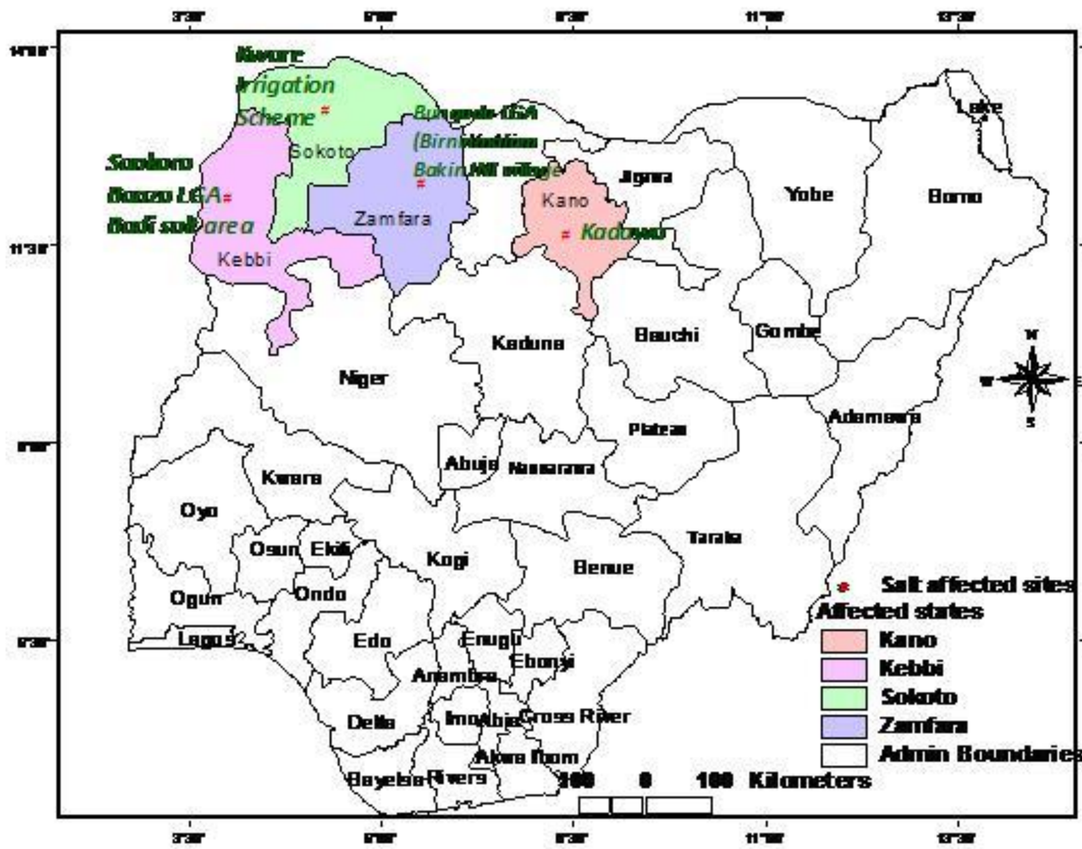


Figure 11. **Geo-referenced map of salt affected sites in Kano, Zamfara, Sokoto and Kebbi States**.

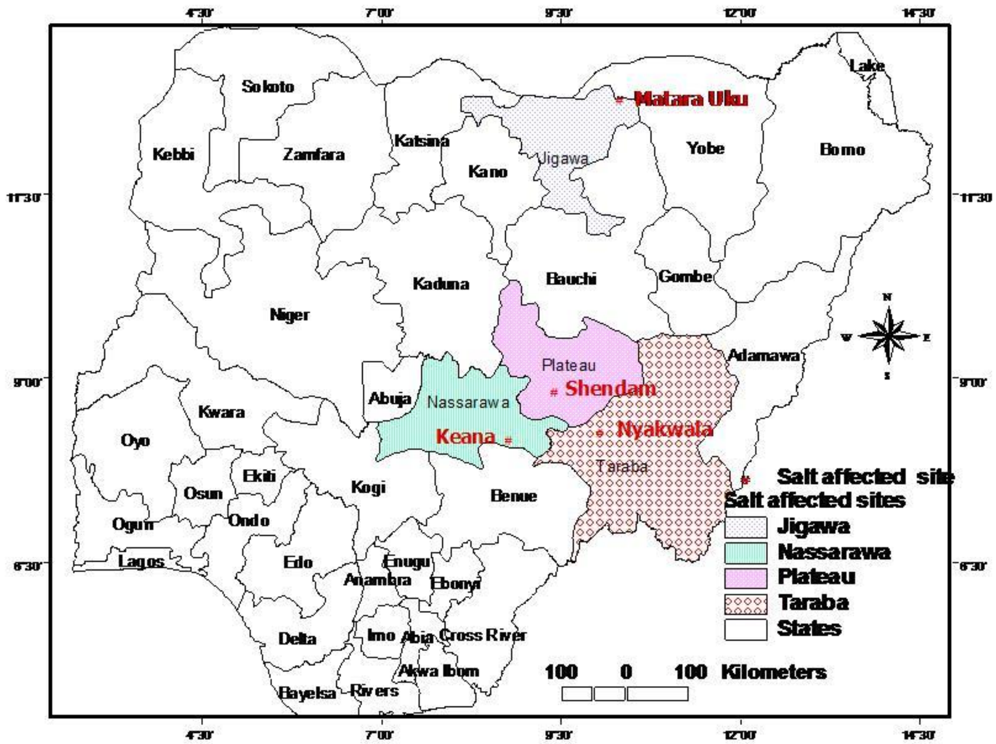


Figure 12. Geo -referenced Map of salt- affected Demonstration sites in Nasarawa, Plateau, Taraba and Jigawa States

4.4.1 PHYSICAL AND CHEMICAL PROPERTIES OF SAMPLED LOCATIONS

Surface soil samples (0 – 25cm) were collected from all the experimental sites in all eight(8) states where salty soil is endemic, treated and analyzed (as presented in Table 8) with the aim of evaluating their fertility status. The soils were evaluated both in the field and laboratory. Results of the analysis showed that the top soils in Kano and Zamfara are sandy loam, while Sokoto and Kebbi top soils are sandy clay. The analysis also showed that sandy, clay loam soils dominated the surface layers of Kaena, Nasarawa state, loam sand at Birni-Kogi in plateau, sandy loam at Nyakwalu-wukari in Taraba state and loamy sand at Matara-uku in Hadejia Local Government Area of Jigawa state. Soil reaction ranged from neutral to alkaline in the eight sites studied (pH 7.2 – 8.5).

The organic carbon and total nitrogen contents of the soils in all the states were generally low to moderately low, while available phosphorus values where also low. Exchangeable bases ranged from medium to high in all the states. Similarly the effective cation exchange capacity (ECEC) and percent base saturation (PBS) of the soils range from medium to high. The results of soil analysis as a whole suggest that sustainable productivity of the soils requires careful management, application of fertilizer containing micronutrient elements to these savannah soils will definitely enhance their fertility and productivity levels. Hence agrolyzer and crystallizer which contain some micronutrients were selected along with some organic manures (compost plus and poultry manure) as rectifiable amendments in the establishment of demonstration plots for farmers.

Table 8: Physical and chemical properties of surface soil samples of salt-affected areas in Kano, Zamfara, Sokoto and Kebbi Nasarawa Plateau, Taraba and Jigawa states.

S/NO	PARTICLE SIZE DISTRIBUTION					pH		Org. C & N			PPM EXP.	Exch. Cations				CEC	Base salt %
	Location	Sand %	Silt %	Clay %	Textural class	H_2O 1:1	KCl 1:1	C %	O.M %	N %	Bray P	Ca	Mg	K	Na		
1.	Kano	78.4	10.2	11.4	SL	8.28	7.47	0.78	1.35	0.091	3.2	3.66	1.52	0.32	0.59	6.50	96.9
2.	Zamfara	80.1	9.1	10.8	SL	7.84	7.11	0.70	1.21	0.077	3.6	3.10	1.48	0.41	0.60	5.80	96.6
3.	Sokoto	57.2	19.5	23.3	SCL	8.47	7.76	0.88	1.52	0.112	3.7	4.95	2.44	0.66	0.69	9.00	97.7
4.	Kebbi	75.3	14.0	20.7	SCL	8.36	7.58	0.82	1.42	0.085	4.0	4.75	2.31	0.56	0.48	8.30	98.8
5.	Keana (Nasarawa)	59.3	18.4	21.3	SCL	7.5	6.5	0.98	1.70	0.08	5.60	4.86	2.1	0.33	0.65	8.10	98.6
6.	Birni-Kogi (Plateau)	80.2	10.6	9.2	LS	7.3	6.3	0.85	1.47	0.07	4.1	3.20	1.66	0.26	0.32	5.70	96.5
7.	Nyakwala-wukari (Taraba)	67.2	14.2	18.6	SL	7.2	6.5	0.71	1.23	0.09	2.8	4.48	2.27	0.57	0.63	7.80	97.5
8.	Mataran-Uku (Jigawa)	84	1.4	13.8	LS	7.8	6.9	0.63	1.09	0.08	5.3	3.91	1.84	0.38	0.50	7.20	97.5

Plate 5. Plasmolysed weeds on salty soils at Matara uku Jigawa State

Plate 6. Farmers and ADP staff collecting soil samples with Scientists at Wukari site, Taraba State

4.4.2: FIELD TRIALS TO RESTORE SALT-AFFECTED SOILS

Six proven technologies for the amelioration of salt-affected soils viz: poultry manure, compost plus, elemental sulphur, agrolyzer, crystallizer and farmers practice (zero amendment) were introduced in each farm.

Tables 9-12 show crop response to the different amendments in all the states studied. The following trends emanate from the results;

- In all the states, amendments gave better performance in crop growth parameters compared to zero levels (farmers practice).
- Agrolyzer, compost plus and poultry manure tended to alternate in positively affecting crop performance; that is, the performance of these soil amendments on crop growth in salt-affected soils depends on the particular crop parameter and soil type or location.
- Results in Tables 9-12 reveal that the use of agrolyzer as soil amendment in salt-affected soils would serve to supply the much needed micro-nutrient elements which are usually deficient in these soils. Poultry manure also contain substantial amount of micro-nutrients in addition to its moderating effect on soil pH.
- Compost plus and poultry manure are organic soil amendments which are generally accessible to farmers and could be incorporated into farmers practice
- Farmers were delighted to observe the efficacy of agrolyzer and poultry manure to combat salty soils and improve crop growth.
- Adequate watering regime during the dry season farming would make crops to utilize nutrients in organic manure through adequate mineralization and nutrient release.

The yield response of tomatoes to application of organic and inorganic soil amendment on a salt affected soil at Kware irrigation scheme, Sokoto is presented in Table 5. Application of crystallizer at the rate of 300kg/ha produced the highest significant yield of 3.7kg/plot followed by poultry manure with a yield of 3.54kg/plot. Compost plus however produced a higher yield of 2.13kg compared with 1.7kg and 1.08kg recorded for agrolyzer and elemental sulphur respectively despite its initial slow growth.

Meanwhile, untreated plot had the lowest yield of just 0.57kg. These results clearly showed that application of organic and inorganic soil amendment in the

Table 9:Response of leaf area, leaf production and yield of tomatoes to application of organic amendments on a salt affected soil at Kwara irrigation scheme. Sokoto.

[x] significant at P>0.05, [xx]Significant at P>0.01, ns = not significant, WAP = weeks after planting.

	Leaf area (cm^2)			**Leaf Production**			**Yield**
Treatment	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	**(kg/plot)**
Zero	4.67	8.67	12.33	8.7	11.31	13.3	0.577
Sulphur	5.33	9.00	12.33	14.7	16.0	18.0	1.08
Crstallizer	12.33	19.33	23.00	16.0	17.77	19.3	3.71
Poultry Manure	11.33	17.67	22.3	16.8	18.7	20.0	3.54
Agrolizer	8.00	14.33	17.33	16.8	18.0	19.3	1.71
Compost plus	6.67	10.67	14.33	11.33	12.7	13.7	2.13
Mean	8.06	13.28	16.94	14.0	15.7	17.28	2.12
Significance	0.0007[x]	0.001[XX]	0.003[xxx]	0.01[xxx]	0.017[xxx]	0.027[xxx]	<0.001[xxx]
Se +	1.272	1.459	1.682	1.39	1.39	1.47	0.156
LSD	4.009	4.598	5.301	4.39	4.37	4.65	0.49

The yield response of okra to application of organic and inorganic soil amendment on a salt affected soil at Sunkuru, Kebbi State is presented in Table n7. Application of crystallizer at the rate of 300kg/ha produced the highest significant okra yield of 11.28kg/plot followed by poultry manure with a yield of 10.43kg/plot. Element sulphur however produced a higher yield of 9.8kg compared with 8.17kg and 8.13kg recorded for compost plus and Agrolizer. Untreated plot had the lowest yield of just 4.3kg.

Pictures of okra response to application of organic and inorganic soil amendments and farmers field day are present in plates 15- 17

Yield response of the different crops tested (maize, okra, tomato's and maize) to soil amendments especially crystallizer, poultry manure, Agrolyzer and compost plus in all the states studied were highly significant (Tables 9-12) for Kano, Zamfara, Nasarawa and Kebbi.

Response of leaf area of okra to organic and inorganic amendment on a salt-affected soil is presented in Table 7. Application of Agrolizer produced the widest significant leaf area of 12.67cm^2 followed by crystailzer (11.33cm^2) at 2 weeks after planting. Okra growth on untreated plot had the leaf area of 10.0cm^2 while compost plus had the lowest leaf area of 9.33cm^2. At twelve weeks after planting sulphur has the widest leaf area of 101.0cm^2 observed in plots treated with crystallizer, while the untreated plots had the smallest leaf area of 81.3cm^2.

Table 10: Response of leaf area (cm^2), leaf production and yield of Okra to application of organic and inorganic amendments on a salt affected soil at Sunkuru, Bunza, Kebbi.

***significant at p=< 0.5, **significant at p<0.01, ***significant at p<0.001,**

	Leaf area (cm^2)				Leaf count				
Treatment	2WAP	4WAP	6WAP	12WAP	2WAP	4WAP	6WAP	12WAP	Yield (kg/plot
Zero	10.00	27.0	70.0	91.0	6.0	10.0	13	18	4.30
Sulphur	10.33	30.3	71.7	101.0	7.0	15.0	18	18	9.80
Crstallizer	11.33	31.0	61.7	100.0	7.0	10.0	13	22	11.23
Poultry Manure	9.00	35.0	61.7	87.0	8.0	10.0	14	20	10.43
Agrolzer	12.67	33.3	58.3	85.3	8.0	10.0	21	24	8.13
Compost plus	9.33	35.7	58.3	81.3	8.0	11.0	24	29	8.17
Mean	10.44	32.1	63.6	91.0	7.0	11.0	18	26	8.68
Significance	0.639	0.348	0.348	0.566	0.679	0.227	0.332	0.564	<0.001***
Se+	1.632	5.96	5.16	8.99	1.2	1.608	4.08	4.30	0.492
LSD	Ns	ns	ns	ns	Ns	Ns	ns	Ns	1.551

Table 11 shows the response of number of branches of Tomato to organic and inorganic amendments in salt affected soil at kadawa, Kano State. At harvest application of crystallizer produced the highest number of plant branches of 13.7 followed by poultry manure (9.3). Application of elemental sulphur, Agrolizer and compost plus produced number of branches of 7.3, 6.3 and 5.3 respectively, while the untreated plot had only 3.0 number of branches.

The Table also shows the performance of tomato height growth to the application of organic and inorganic soil amendments at the time of harvest. Crystallizer equally had the highest height growth of 39.3cm followed by poultry manure (37.9cm). Other amendments, compost plus, Agrolizer, and Sulphur had plant height of 35.0cm, and 30.9cm respectively. The untreated plot however had the least height growth of 24cm.Leaf production of tomato in response to the application of organic and inorganic soil amendments is presented in Table 8. At harvest, application of Crystallizer also had the highest leaf production of 38 leaves followed by poultry manure (34 leaves). The lowest leaf count of 17 leaves was observed in untreated plot. The yield response of tomato to application of organic and inorganic soil amendment on a salt affected soil at kadawa Irrigation scheme, Kano State is presented in table 8. Application of poultry manure at the rate of 10kg /plot of 25m2 (4.0ton/ha) produced the highest significant tomato yield of 5.24kg/plot followed by compost plus with a yield of 3.44kg compared with 2.5kg and 1.43kg recorded for Agrolizer and sulphur. Untreated plot had the lowest yield of just 0.83kg/plot. Application of poultry manure gave over 500% yield increase relative to un amended plots. The trial also showed that organic based amendments (poultry manure and compost plus) demonstrated higher effectiveness in amelioration of salt affected soils.

Pictures of capacity building of farmers on amelioration of salt affected soil and farmers' field day are presented in plates 18-21

Table 11: Yield and Growth response of tomato to organic and inorganic soil amendment in salt soil affected at Kadawa irrigation station, Kano state

***significant at p<0.05, **significant at p<0.01, *** significant at p<0.001, ns =not significant**

Treatment	No of branches	No of leaves	Plant height (cm)	Yield (kg/plot)	% increase over control
Zero	3.0	17	24.0	0.83	-
Sulphur	7.3	29	30.9	1.43	72.2
Crystallizer	13.7	38	39.3	3.44	314.3
Poultry manure	9.3	34	37.9	5.24	531.3
Agrolizer	6.3	30	31.8	2.54	206.02
Compost plus	5.3	31	35.0	4.65	460.24
Mean	7.5	30	0.037	3.02	
Significance	0.172	0.305	2.89	<0.001***	
Se+	2.64	5.81	9.10	0.156	
LSD	Ns	Ns	Ns	0.49	

The yield response of okra to application of organic and inorganic soil amendment on a salt affected soil at BIrnin malam Bakin JNI village, Zamfara State is presented in Table 12. Application of Agrolizer at the rate of 0.3g/plot +NPK (0. 25kg.plot of 25m2) produced the highest significant okra yield of 3.67kg/plot followed by poultry manure with a yield of 3.17kg/plot. Elemental sulphur however gave a higher yield of 3.1kg compared with 3.03kg and 2.93kg recorded for crystallizer and compost respectively, while the untreated plot had the lowest yield of 2.83kg. Cross section of farmers at field demonstration is presented in plate 7.

Table 12: Yield and Growth response of okra to organic and inorganic soil amendments in salt affected soil at Birninmalam Bakin JNI village, Zamfara state

	Plant Heath(cm)	Stem Diameter	Leaf Area (cm^2)	Yield (kg/plot)
Zero	38.67	2.4	29.6	2.83
Surphur	55.33	2.8	44.3	3.10
Crystallizer	57.33	2.9	40.2	3.03
Poultry manure	56.00	2.93	50.2	3.17
Agrolizer	75.0	3.2	51.5	3.67
Compost plus	57.0	2.77	50.2	2.93
Mean	56.56	2.83	44.3	3.072
Significance	<0.001***	0.002***	0.041	0.003
Se+	2.18	0.088	4.47	0.066
LSD	6.86	0.276	14.08	0.21

Plate 7. Some farmers after field demonstration on management of affected soils at Zamfara State

Observations

Some farmers are aware of the effect of agrolyzer and poultry manure and had even tried them sparingly on their farms but agrolyzer has been scarce and inaccessible to them. Compost plus seems completely new to them. Farmers were delighted on the information that agrolyzer could make their salty soils productive. It was observed that even though amendments used gave higher crop performance over the zero level, farmers practice nowadays is no longer at zero level of soil amendment. Where and when available they use inorganic fertilizers and animal manure but at very low levels which may not be enough for soil amelioration.

The desirability of this demonstration farm is that it practically educates the farmers on the efficiency of these amendments in improving crop yield and make their soil productive if properly adopted. The results of the trials if adopted would enable farmers know the package of recommendation for crops in terms of quality to apply, method of application and time of application to crops.

The demonstration plots show that salt-affected soils could be made productive in Nigeria as it is done in other countries of similar problems. This is the first effort at using wide range of amendments to demonstrate to farmers that their salt-affected soils could be made productive. This effort should be validated on site-and crop-specific basis and repeated over some years

Application of poultry manure gave over 500% yield increase relative to unamended plots. Organic based amendments (poultry manure and compost plus) demonstrated higher effectiveness in the amelioration of salt affected soils. The good news is that these materials can easily be sourced locally by farmers for direct application to their farms. Government on the other hand can make chemical amendments such as Crystallizer, Agrolyzer, Elemental sulphur, Gypsum and lime available to farmers at a subsidized rate. The Federal Ministry of Agriculture and Rural Development is therefore implored to make adequate supply of these ameliorative amendments available to farmers in the country.

These projects underscored the benefits of the reclamation of salt affected soils, in order to achieve Agricultural growth and to ensure food security in Nigeria.

Conclusions and Recommendations

Mr. Vice-chancellor Sir, Ladies and Gentlemen, during the Summit on food Security in Africa held in December, 2006 at Abuja, Nigeria, the Director-General, Food and Agriculture Organization (FAO) opined that "No civilization, no continent, no self-respecting country can allow the food security of its people to be ensured or decided by others.'' This statement emphasized succinctly the importance and imperativeness of achieving national food security. Soil fertility and sustainable productivity of our farm lands will ensure high crop yields which are precursor to food security in addition to the improvement in the value chain of staple food crops in the Country. There is no reason why our national yield average should continue to be low. In the recent past, several summits, workshops, seminars, conferences etc. have been held on food security in Africa such as Lagos Plan of Action (1980), the Harare Declaration of African Ministers of Agriculture, the International Conference on Nutrition (1993), the common African Agriculture Programme (CAAP), the FAO Agenda for the world food and Agricultural Development, 1996 and 2001 World Food Summits, in Rome, African Union Summits at Maputo (July 2003) and at Sirte (February 2004).The NEPAD fish for All Summit of 2005, Cocoa and Fertilizer Summit Abuja in 2006 and the FAO and AUO Ministerial Meeting on Rural Infrastructure and Water Resources in Libreville.

I hold the opinion, like millions of concerned Nigerians, that talk shops towards the achievement of food security in Nigeria have been more than enough. Let us start to take decisive actions to implement recommendations of talk shops; otherwise we may become fishless fishermen. Other areas requiring concerted efforts and urgent attention are as follows:

- Conflicts and civil strives can severely undermine poor people's access to food and their livelihoods, and can result in acute hunger. Conflicts in the country must therefore be speedily brought to end.
- **Institutional support for soil research**
  There is urgent need for the establishment of National Institute for Soil Research. This Institute would concentrate on soil resource assessment and monitoring, provide information technologies through the innovative use of Geographic Information systems and remote sensing, demonstrate the integral roles of soil in ecosystems, and carry out basic research that would generate baseline data applicable at the farmer's level. Such Institute would have the mandate of finding solutions to our soil and land problems in Nigeria.

- Students in agriculture especially farmers' children in tertiary institutions should be encouraged to study soil science through special concessions and fees subsidy. Genuine efforts should be made by governments at all levels to upgrade and empower soil research laboratories and other facilities. All Faculties of Agriculture in Nigeria Universities, crop-related research institutes and Polytechnic should be empowered and mandated to embark on soil characterization and suitability assessment of agricultural lands within the area of their jurisdiction. Availability of baseline data for soil and crop selection before embarking on any farming enterprise would limit the extent of soil degradation and crop failure.

- **Soil Testing for sustainable crop production:** Embarking on any profitable crop production enterprise without soil testing is like treating a sick person without adequate diagnosis of the ailment. Just like proper diagnosis of a patient enables the doctor make effective prescriptions soil testing enhances valid fertilizer application for sustainable soil productivity and management. It is through soil testing that nutrient loss by erosion in crop mining could be replaced. The judicious and careful use of farmlands in the country demands that soil Testing be upgraded to a National Programme that is highly subsidized for accessibility and affordability by resource poor farmers who of course produce the bulk of our food. Failure on the part of this group of the populace to integrate soil testing in their farming systems would make the attainment of food security to remain a mirage.

- Reducing vulnerability to seasonal variations in climate is an essential ingredient of sustainable crop production. In the context of largely rain-fed agricultural production, extending the areas of land under irrigation will provide significant agricultural productivity gains. The large expanse of farmland in the northern areas of Jigawa state, for example, is usually abandoned as waste salty land during the dry season due to lack of irrigation scheme that could make the area agriculturally productive.

- Increasing fertilizer use especially incorporating organic manures and legumes into the cropping system, water management and the adoption of appropriate tillage during land preparation is an imperative in actualizing the commitments made at the Africa Fertilizer Summits (2006). The current efforts by the Federal Ministry of Agriculture and Rural Development at making fertilizer available to farmers at farm gate prices is desirable. The programme should continue and must not die with the exit of current government. The emphasis should concentrate on the complementary use of inorganic fertilizers and organic fertilizers to sustain soil fertility and enhance crop production thereby facilitating the achievement of food security.

- Nigeria should focus on education, research and development in soil resource base as an intervention to food security. A major challenge here is the formation and maintenance of capacity for agricultural Research and Development (R&D), This will require extensive investment in science and agricultural education at a higher level and the creation of an incentives structure for scientists, particularly in biotechnology.

- Enhance access to new crop technologies and seeds to small farmers through innovative institutional structures such as the African Agricultural Technology Foundation (AATF), whose mission is to link the needs of smallholder farmers with potential technological solution, is a major step forward. Ensuring sustainability of agricultural productivity through serious attention to environment and natural resources especially soil watersheds and biodiversity; in addition land tenure issues need to be addressed.

In Landmark University, through the instrumentality and vision of the Proprietor, Dr. David O. Oyedepo, we have embarked on Agricultural revolution that would, in due course, turn things around in the country. The goal is to produce sufficient food to feed our students and staff, our immediate environment, the entire nation and for export. Landmark University as the first and only private University of Agriculture in Nigeria is setting the pace in the running of functional, efficient and productive agriculture model ; we lead, others follow.

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Since I joined Landmark University I have always enjoyed Management especially the Pro-Chancellor, the Vice-Chancellor the Registrar inspirational leadership, encouragement and favourable working environment in terms of good human relations, prompt payment of workers' salaries, funds for research, attendance of conferences, provision of modern facilities for teaching and research, and setting good examples for hard work and personal discipline.

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Mr. Vice-chancellor Sir, The Academia, Distinguished Guests, Distinguished Kings and Queens, Ladies and Gentlemen,. I thank you all for your patience in listening to this lecture. God bless you all.

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