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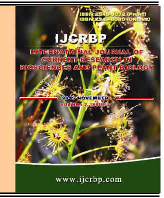

Review Article

Management Strategies for Sustainable Rice Production in Nigeria

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Abstract

Soil resources serve as a basis for food security. The international community advocates for its management for the achievement of higher crop productivity and its sustainability across the world. As the world population is increasing and land is limited and immobile, the challenge to farmers to is adopt soil management options that could enable the populace being kept on land. Therefore, the use of traditional practices e.g. shifting cultivation, mono cropping, bush burning and fallowing, and crude soil management practices such as excessive use of inorganic fertilizer; machineries, over grazing etc cannot be tolerated as they lead to soil degradation. Research results has however, revealed that scientific management of soil resources could greatly increase crop production. Thus, this reviewed paper is tailored towards Integrated Soil Fertility Management (ISFM) which is an embodiment of Soil and Water conservation.

Keywords

Productivity
Rice yield
Soil
Sustainability

Introduction

Rice is one of the most important cereal crops in Nigeria. Rice consumption is increasing rapidly in Nigeria because of urbanization, relative ease of Preparation and convenience in storage. Nigeria is the largest rice producing country in West African region (Ezedinma, 2005). As at 1980, rice production in Nigeria was estimated at 2 billion kilograms (kg), while the world was producing 300 billion kg (Omaliko and Agbim, 1983). By 2002, Nigeria alone accounted for 57% of the total rice producing area in West African (WARDA, 2005). With the population boost of over 88 million people in 1991 to over 140 million in 2006 (NBS, 2007) her rice demand is projected to increase up to 8 million tonnes in the next decades (Osagie, 2009).

However, rice production falls short of the demand; the country depends heavily on rice importation of over 5million tonnes annually, equivalent to over US $800million a scarce foreign exchange. Recently, the Federal Government of Nigeria raised the tariff on rice importation to 75% to protect local producers against massive importation of rice. This policy is stimulating interest in the domestic production of rice.

Currently, most of the farmers producing rice rely on traditional technology with low use of improved inputs. Average rice yields in the country are low and ranges between 1- 2.5t ha^{1}. Among the reasons frequently given for such low production capacity include decline in soil fertility, excessive soil wash and other adverse effects on the soil physical and chemical properties after the protective vegetation had been removed (Omideji et al., 1985).

The problem of soil fertility in Nigeria is driven by a wide range of bio physical, chemical and socio-economic factor. Firstly, geological origin of the parent material of the soils of this region, upon which the soil developed consists of old and weathered materials, which probably do not contain many nutrient bearing materials. Secondly, nutrient depletion, i.e., the soils are generally over mined. Stoorvogal and Smaling (1990) advocated in 1983 that, for a total of 32.8million hectares of land cultivated in Nigeria, soil mining amounted to a total of 111,000 tonnes of nitrogen (N) 317,000 tonnes of P_2O_5 (P) and 946,000 tonnes of K_2O (K), this is equivalent to over US $800million of N, P and K fertilizers. Thirdly, restoring these nutrients has been a very hard task to peasant farmers because of their socio-economic conditions. Macro-economic policies also play a leading role in influencing accessibility, availability and the type of input a farmer can use. Unfortunately, exchange rate, poor producers prices, high inflation among others contribute to low fertilizer use in Nigeria.

Consequent upon these limitations, it will be logical and justifiable that several technological and institutional innovations are put in place to manage soil fertility decline to enhance sustainability of rice production in Nigeria.

Soil management options and recommended domains for maintaining soil health and sustainability

Soil management involves all operations, practices and manipulations of soil properties to protect the soil and enhance its performance. A range of improved soil management technologies/approaches and best – bets available for the soils of west central Africa (FAO, 2006). Best – bets are selected technologies that, according to “expert opinion” have good chances of adoption and a positive impact on the livelihood. Thus these approaches/strategies aimed, to differing extents, at improving/maintaining soil chemical and physical properties, arresting or minimizing degradation in terms of declining soil organic matter content, nutrient loss; toxicities, compactions, sealing and crusting; poor infiltration of rain and loss of top soil by erosion consequently, all these will increase agricultural productivity, alleviate poverty and improved food security while protecting the environment.

Integrated soil fertility management (ISFM)

This is also referred to as integrated nutrient management (INM) in some cases. This approach involves combining different soil fertility technologies with soil and water conversation. It is based on the principle of maximizing use of organic materials, minimizing loss of nutrients and judicious use of mineral fertilizer. Thus, Lombin et al. (1991) postulates that complimentary use of organic and mineral fertilizer has proved to be a sound fertility management in many countries of the world. However, ISFM include the use of animal manure, crop residues, green manuring, composting, application of ground phosphate rocks, integration of nitrogen fixing crops into the cropping system and seed priming.

These concept/strategies are two way traffic i.e., practices that add nutrient to the farm land and those that save nutrients from being lost e.g. crop residue restoration and soil erosion control (Rhodes et al., 1996) Some best–bet component integrated soil fertility management (ISFM) are as follows:

Practices that add nutrient to the rice farm land mineral fertilization

This is the practice of using inorganic/chemical synthetic fertilizer. FAO (1989) reported positive responses to NPK in several African countries from trials and demonstration conducted from 1961 to 1986.

However, fertilizer procurement and distribution is an animal ritual by various strata of government in Nigeria. Average of about 500, 000 metric tonnes of fertilizers are procured by FGN mainly urea, NPK and SSP, resulting in an expenditure of more than one hundred billion naira (N100, 000, 000, 000) during the period under reviews but inspite of this colossal amount of money spent, fertilizer used in Nigeria has not gone beyond 15kg/ha against the background of 50kg/ha of Abuja declaration of 2006 during the Africa fertilizer summit of 2006. Several factors are responsible for poor fertilizer culture in Nigeria among which are inefficient distribution of the product, distribution don’t often synchronized with peak period of needs and completely more worrisome, is the pervasive sense of chest beating and accomplishment in Government circles when in essence one bag each of urea and NPK given can at best supply not more than 35kg NPK enough for just one acre of rice field (Bala, 2015).

Use of phosphate rock (PR)

Rock phosphate is a local rock mineral (Akande et al., 1998) is reported to be deposited in Nigeria in fine sedimentary basins found in Sokoto, Ogun, Delta, Imo and Anambara states. However, only Sokoto and Ogun rock phosphate has been confirmed in commercial quantities and with a very high content of elemental P (Akintokun et al., 2003).

Most tropical soils are reported to be low in phosphorus (P) due to it geological and mineralogical constituent in addition, Sanchez (1976) observed that low P content may be due to nutrient mining among other reasons. Sokoto rock phosphate is one of the medium to high reactive rock mineral that do not need any further modifications apart from fire grinding. It is known to be good source of P due to its high P2O5 (33.9%) and citrate soluble (3.1%), with proper management it could be sustainable source of P for increase crop production (Audu et al., 2013).

Seed priming and microfertilization

Seed priming consists of soaking seeds of crops (rice, sorghum, cowpea, groundnut, sesame) in water for8 to 18 hours (depending upon the crop) and drying the seeds prior to planting. It should be carried out after a shower sufficient for sowing when the rains have stabilized. It results in improved germination, establishment and rooting leading to better crop growth and yields (Liniger et al., 2011).

Priming upland rice seeds with water can give yield increases of 15 to 25% and about 30% if priming is with zinc micronutrient solution (RARC, 2011). On average, yield increases of up to 50% can be expected if micro fertilization is combined with seed priming. Micro fertilization has been mechanized in Mali. The technology is applicable across the Nigeria on flat to gentle slopes on small farms of 2 to 20 ha. A major problem is that complete dependence on micro fertilization will induce nutrient depletion and soil degradation.

Green manuring

Green manuring is the growing of herbaceous plants for the purpose of application to the soil surface or incorporation for the benefit of a food crop. Green manuring in West and Central Africa has taken several forms. The green manure plant may be sown into the food crop at varying intervals after the latter has emerged and incorporated before the planting of the next crop - a practice known as under sowing. Plant materials may be cut from outside the cropped plot and brought to the plot for application, as in the 'cut and carry agroforestry system'. In lowland rice production, the water fern *Azolla* species (which grows in association with the N fixing *Anabaena azollae*) has been used by the Rice Research Station, Rokupr, in Sierra Leone for green manuring. Liniger et al. (2011) proposed the production of green manure using *Tithona diversifolia* in Cameroon as a best-bet for soil fertility management. Hedges of this plant grow along roadsides or farm boundaries. Its biomass has a high nitrogen and phosphorus content and decomposes quickly after application. Fresh leaves and stems are cut, chopped and applied on cropland after the first ridging. The material is spread over the half-made ridge at the rate of 2 kg/m2 and then covered with 5 to 10 cm of soil to finish the ridge. Sowing of seeds is done not sooner than a week later. A limitation of green manuring is that, except when the green manure is a leguminous crop and can fix nitrogen, it does not add nutrients to soils at the plot level. Rather it helps to save nutrients from being lost from the farming system. If the green manure crop is from a soil of poor fertility, its quality will be low and its contribution to soil fertility therefore also low. Rice straw could also be applied to the soil. It is reported that 500kg ha^{-1} of rice straw contains approximately 36kg N, 4.5kg P and 112kg K. recycling rice straw is a good way of balancing the negative nutrient balance. Cyril (2015) screened a number of leguminous green manure such as *Sesbania rostrata*, *Sesbania sesban*, *Sesbania aculeata* and *Crotalaria juncea* and *Crotalaria caricia*. He discovered *Sesbania rostrata* proved outstanding. He observed that 60 plants per square meter of *Sesbania rostrata* was capable of providing 4000kg of dry matter, 100kg of N ha^{-1} in just 45 days of growth. *Sesbania rostrata* could be planted into rice field during fallow period; theses could be incorporated into the soil after 40–50 days after germination to enhance nutrient composition of the soil.

Composting

Composting is the process of producing partially decomposed organic materials from materials high in carbon such as maize or rice straw mixed with small amounts of additives of higher nitrogen content such as excreta from farm animals, or mineral fertilizers.

Composting narrows the C/N ratio of the materials and the nitrogen contained becomes more easily available to crops. FAO (2003) described a number of on-farm composting options as follows: pits 3 m x 1.5 m and 20 cm deep are dug in the dry season. After harvesting, layers of chopped crop residues, animal dung and ash are heaped as they become available up to 1.5 m high and watered. The pile is covered with straw and left to heat up and decompose. After 15 to 20 days the compost is turned over into a second pile and watered again. This is repeated up to three times or as long as water is available. Composts can also be produced in pits of up to 1 m depth; in this situation, the pit captures water. The compost may be applied immediately to irrigate rice and vegetable gardens or kept in dry shaded places for the next season's cereal, like sorghum. Concerning the latter, one handful of compost is mixed with soil in each planting hole. It is targeted at farm sizes of less than 1 to 2 ha. Market orientation is mainly subsistence but in urban and peri-urban areas composting is suitable for commercial vegetable production. Composting mainly saves certain nutrients from being lost from the farming system.

Practices that saves soil nutrient from being lost (soil conservation)

Cross slope barriers/*Ridges* are measures for reducing runoff speed on sloping land thereby conserving soil and water.

Anti erosive soil bunds

This is also referred to as earth bunds. It's mostly constructed on the ferruginous soils; it takes the form of strips of soil measuring 80 cm to 1m at the base and tapering upwards to between 30 and 50 cm. The bunds retain water and facilitate infiltration. They are particularly useful in situations where construction of stone works is difficult (lack of stones, long distance from stone sites, transportation problems). Earth bunds are not suitable for very wet areas unless graded, as they can be washed away.

Stone lines slow down the speed of runoff water, improve infiltration of water and permit the sedimentation of sand, finely textured materials and organic materials (Hien et al., 1996). Yield increases of up to 20 to 30% have been reported. In general, cross slope barriers are applicable on gentle to steep slopes in the semi-arid, sub-humid and humid zones. However, though they are used for control of erosion, water conservation and harvesting in the semi-arid zone, in the humid and sub-humid zones their main use is in the control of soil erosion.

Tillage

The word tillage is derived from 'Anglo-Saxon' words *Tilian* and *Teolian*, meaning 'to plough and prepare soil for seed to sow, to cultivate and to raise crops'. **Jethrotull,** who is considered as father of tillage suggested that thorough ploughing is necessary so as to make the soil into fine particles is the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops.

Tilth is the physical condition of soil obtained out of tillage (or) it is the result of tillage. The tilth may be a coarse tilth, fine tilth or moderate tilth.

Objectives of tillage

The main objectives of tillage are,

- To prepare a good seed bed which helps the germination of seeds.
- To create conditions in the soil suited for better growth of crops.
- To control the weeds effectively.
- To make the soil capable for absorbing more rain water.
- To mix up the manure and fertilizers uniformly in the soil.
- To aerate the soil.
- To provide adequate seed-soil contact to permit water flow to seed and seedling roots.
- To remove the hard pan and to increase the soil depth.

To achieve these objectives, the soil is disturbed / opened up and turned over.

Minimum tillage and direct seed planting

In the promoted minimum tillage and direct planting system, land is prepared by slashing the original vegetation and allowing regrowth up to a height of 30 cm. A glyphosate-based herbicide is sprayed on the vegetation and the residue is left on the soil surface. Seven to ten days later, rice is planted with the aid of planting sticks or a jab planter, directly in rows through the mulch. The mulch increases stored water, reduces erosion, helps to control weeds and improves soil fertility in subsequent seasons after the residue has decomposed. The benefits of minimum tillage and mulching have been well documented for soils in south western Nigeria (Lal,1981) The technology described is promoted in Ghana, and is applicable to the sub-humid zone on well drained soils of medium to high fertility on smallholder farms of 1 to 5 hectares. It can be used for both subsistence and commercial systems.

Wet tillage or puddling

Ghildyal (1978) defined puddling as mixing soil and water to render it impervious. The tillage operation that is done in a land with standing water is called wet tillage or puddling. Puddling operation consists of ploughing repeatedly in standing water until the soil becomes soft and muddy. Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seed bed for planting rice. Puddling is done in both the directions for the incorporation of green manures and weeds. Wet tillage destroys the soil structure and the soil particles that are separated during puddling settle later. Wet tillage is the only means of land preparation for transplanting semi-aquatic crop plant such as rice. Planking after wet tillage makes the soil level and compact. Puddling hastens transplanting operation as well as establishment of seedlings. Wet land ploughs or worn out dry land ploughs are normally used for wet tillage.

Effects of puddling on soil properties

1. Coarse aggregates are broken down
2. Non-capillary pore space is destroyed
3. Apparent specific volume decreases
4. Water-holding capacity increases
5. Hydraulic conductivity and permeability decreases
6. Evaporation decreases
7. Soil reduction is favored

This research has demonstrated that a wide range of technologies is available for soil fertility improvement in Nigeria. However, a complete redress of soil fertility in Nigeria cannot be achieved without commitments from local, state and federal Govt. Government should articulate the views and concerns of all stake holders; identify gaps in knowledge and information and outline procedures to fill them.

Conclusion

This research has demonstrated that a wide range of technologies is available for soil fertility improvement in Nigeria. However, a complete redress of soil fertility in Nigeria cannot be achieved without commitments from local, state and federal Government. Government should articulate the views and concerns of all stake holders; identify gaps in knowledge and information and outline procedures to fill them.

The integrated soil fertility management (ISFM) is a new research approach that seeks to overcome short comings of the past conventional approaches. It limits the development of resource conserving technologies, support to institutions and farm groups and provision of enabling policy environment for agricultural investment. The strategy advocates for the participatory farmers research, a holistic approach to address many and complex farming systems problems so as to achieve wide validity as adoption of agroeco-systems that operate with dynamic natural and economic environment.

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