International Journal of Manures and Fertilizers Vol. 2 (7), pp. 344-348, July, 2013. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Economic evaluation of fertilizer utilization and integrated practices for environmental sustainability and agricultural productivity in Sudan savannah zone, Nigeria

Micheal E. kelechukwu

Department of Crop Science, Faculty of Agriculture,Unversity of Uyo, Uyo state, Nigeria. E-mail: Mkel@yahoo.com.

Accepted 4 June, 2013

An assessment of fertilizer use and other integrated practices was carried out with two hundred farmers selected by stratified random sampling from twenty villages in Kano and Katsina States of Nigeria. The farming system was mixed farming (legume-cereal-livestock mixture), as a strategy both to address nutrient management as well as their livelihoods (both food and income security). The major crops comprised maize, sorghum, millet, rice, soybean, groundnut and cowpea. The average farm size was 7.4 ha and livestock comprised an average of 14 goats, 15 poultry birds, 7 sheep and 9 cattle. An average of 63 kg fertilizer was applied per ha of land relative to about 649 kg of fertilizer requirement per hectare of the crops grown, very low relative to Asia and some other African countries such as South Africa, Malawi, Benin and Ethiopia. The livestock mix provided substantial farmyard manure for fertilizing the soils and supplemented farm drought animals / animal traction while the crop residues (legumes and cereals) provided feeds for the livestock. It was found that fertilizer use multiplies the returns on farmers' output by a factor of 2.1-14.6, which was relatively higher than previous findings (IFDC, 2002) for the same crops in Nigeria, but crop yields were comparatively less for other Sub-Saharan and Asian countries. The observed higher response coefficient could be explained by the use of organic/farmyard manures and other soil conservation practices. Farmers exploit land and the natural fertility of the soil through continuous cropping and poor fertilization (organic and inorganic). Critical environmental issues emanating from these are soil nutrient depletion, soil degradation by erosion, weed and pest invasion, all culminating in sustained low productivity. It was therefore concluded that sustained growth in agricultural productivity without environmental exploitation and degradation cannot be achieved unless efforts to enhance farmers' fertilizer use and organic fertilization are taken seriously. Efforts should be put in place to correct fertilizer market inadequacies, particularly to monitor the quality standard and guarantee farmers' access to fertilizers, as well as encourage National research and extension programs to emphasize economic use of basic local materials for effective fertilization of farmers' fields, reduced vulnerability to nutrient loss and drought, and increased agricultural productivity.

Key words: Organic, inorganic, fertilizer, nutrient loss, environmental, exploitation, degradation, soil conservation, agricultural productivity.

INTRODUCTION

Agriculture currently contributes about 41% of the Nigerian gross domestic product (GDP) and employs about 70% of the active population (Eboh, 2008). The agricultural GDP is contributed by crops (85%), livestock (10%), fisheries (4%) and forestry (1%). It is estimated that about 75% (68 million ha) of the total land area has potential for agricultural activities with about 33 million ha under cultivation (about 50% of cultivable agricultural land). With this massive agricultural land area, good weather conditions consistent with sustainable farming systems and practices, Nigeria has a comparative advantage to feed the world taking a cue from countries

like China and United States of America. Wide divergence of technical change exists in Asia and Africa. Adesina (2008) alluded these to factors which include the use of high-yielding varieties by Asia policies, technologies and institutional environment that were conducive for green revolution. On the other hand, Nigerian agriculture is dominated by smallholder and traditional farmers who use rudimentary production techniques. Agricultural systems in Nigeria include rotational fallow agriculture, semi permanent or permanent agriculture and mixed agriculture (Agboola, 1979). Agricultural subsystems are dominated by the rotational bush and grass fallow systems in both the forest and savanna environments. This was attributable to the lack of a suitable alternative that ensures soil fertility maintenance and crop production, as well as higher frequency of cultivation. As a result, the average yields of major staple crops remain far below most of other developing countries.

Despite the variations in soil types, productivity and potentialities, the problems of soil fertility maintenance are similar in many parts of Nigeria. The critical elements are the organic matter and mineral nutrient contents that decline during cropping and increase under fallow. Three or four years of cropping deplete the soil of its fertility to such a critical point that crop yields are static or decline, and weed invasion becomes serious, during which restorative intervention modes become imperative. Of course, the incidence of high population growth rate in the last three decades has generated enormous pressure on land and its resources leading to the failure of the fallow systems (FFD, 2002).

Past policy process comprise series of agricultural projects, some of which include Agricultural development projects (ADPs) (1972 to date), National accelerated food production project (NAFPP) 1974-1996, Fertilizer subsidy program/ fertilizer procurement and distribution (1976-1997, 1999 to date), Operation feed the nation (1976-1979) as well as the Green Revolution program (1980-1984). In spite of past policy efforts, Nigeria's food balance sheet is repleted with food insecurity, poverty, hunger, disease, and environmental degradation that has necessitated increasing dependence on food imports. The agricultural policy focus is to protect and improve agricultural land resources as well as preserve the environment for sustainable agricultural production. Particularly, the fertilizer sector is undergoing a systematic reform toward liberalization and competitiveness in order for fertilizers to play a sound and significant role in increasing agricultural production.

Eboh (2008) observed the fact that much of the increase in agricultural growth in Nigeria come from expansion in cultivated area, thus calling into question our agricultural growth strategies. Fertilizer use in Nigeria decreased from over 500,000 nutrient tones in 1993/94 to approximately 100,000 nutrient tons in 1999/2000; because fertilizer market is not functioning properly, transaction cost is high, fertilizer is not readily available and quality is poor (IFDC et al, 2001). The fertilizer map of Nigeria (IFDC et al, 2000) shows that the Sudan Savannah zone (Katsina and Kano States) has relatively low nitrogen level (less than 0.1%), medium to high phosphorous level (>10ppm) and 0.15-0.25 meq of potassium. Based on the status of soil fertility and other factors including amount of nutrients required by specific crop, yield potential of a crop and pattern of rainfall, the recommended fertilizer rates for maize, sorghum, millet, upland rice, groundnut and soybeans in Sudan Savanna range from 63-210 kg/ha. Inability to meet these nutrient requirements over the years is consistently resulting in nutrient mining of the soil, and subsequently, declining agricultural productivity and environmental sustainability. Adesina (2008) observed that soil nutrient mining is killing Africa, particularly in Nigeria where more than 60 kg/ha of nutrient loss was recorded in 1995- 1997, and 30-60 kg/ha in 2002-2004. A major reason for the high soil nutrient deficiency is the low level of fertilizer use in Africa compared to the rest of the world. Adesina (2008) viewed fertilizer as a "golden bullet" to rapid agricultural growth. Two critical issues are associated with fertilizer use: high level of use as in the case of developed economies, which may create environmental challenges from 'over use'; and lack of use by African countries, which creates another kind of environmental problem from 'no use'. Therefore, this paper examines the extent to which the nutrient requirement for the major crops grown in the Sudan Savannah zone is met and the yield response of the crops, soil conservation and improvement practices being employed, and the implications for agricultural productivity and sustainable environment.

METHODOLOGY

Data collection

The methodology involved the use of primary and secondary data. The primary data were sourced from farmers selected from Sudan Savannah zone of Nigeria. Community selection was stratified random. Five villages were selected from each of four local government areas (LGAs), namely Shanono and Bunkure LGAs from Kano State, as well as Safana and Musawa LGAs from Katsina State. The techniques employed for the study included a combination of focus group discussion (FGD) and semi-structured interview (SSI). The sampling for the FGD was purposive and by convenience results in the selection of an average of one hundred and fifty participants, including one hundred male and fifty female for the focus group discussion in each community. The semi-structured interview involved an average of ten farmers from each community using cluster sampling technique.

Analytical technique

Analysis of the data was done using descriptive statistics including percentages, mean and ratios while matrices were used to summarize and present the results. The ratio of crop yield response (kg) to fertilizer use (kg) served as an indicative measure of return to use of inorganic fertilizer.

Table 1. Socio-economic characteristics of respondents.

Parameter	Female	Male	Total
Average age (yrs)	37.8	44.25	44.12
Average Experience (yrs)	13	28.32	22.21
Average farm size (ha)	1.57	11.56	7.43
Average quantity of fertilizer use (kg)	241.5	537	445
Average fertilizer use per ha	153.82	46.45	59.89
% respondents married	94.3	96.8	95.02
% respondents not member of organization	80	59.5	46.51
% Respondents with formal Education	26	42.86	32.56
Number of Respondents	35	132	167

Source: Field survey in Kano and Kaduna States, Nigeria, April, 2008.

Table 2. Major crops, farm size and outputs by gender category.

Crop	Gender Distribution				Average farm size (ha)	Average quantity (kg)	Crop yield (kg/ha)
	Women		Men				
	Farm size (ha)	Quantity (kg)	Farm size (ha)	Quantity (kg)			
Cowpea	1.84	355	6.04	1114	3.94	734.5	186.42
G/nut	1.96	558	6.64	3248	4.3	1903	442.56
Soybean	0.28	162	5.67	575	2.98	368.5	123.87
Maize	1.24	508	21.29	4610	11.27	2559	227.16
Sorghum	1.04	511	3.75	1322	2.40	916.5	382.67
Rice	0.50	477	3.1	2667	1.8	1572	873.33
Millet	3	575	11.51	1957	7.26	1266	174.50

Sources: Field survey in Kano and Kaduna States, Nigeria, April, 2008. *Singh (2002). The role of manures and fertilizers on crop production.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The focus group discussants comprised 150 farmers in each community, 67% of them were male and 33% female. The respondents for the semi-structure interview comprised about 20% female and 80% male (Table 1). The average age of the respondents was forty-four years, only 26% of the female respondents had formal education while about 43% male went to formal school. About 60% of the male and 80% of the female respondents did not belong to any community group.

Most of the farmers grow mixed grains-legumes crops comprising maize, sorghum, millet, rice, soybean, groundnut and cowpea. The average farm size for male and female farmers was about 11.6 and 1.6 ha, respectively. The farm size of women was lowest for soybean (0.28 ha) and highest for millet (3 ha), while the men have highest farm size for maize (about 21 ha) and lowest for rice (about 3 ha). However, the output level was generally low for all crops. Subsequently, crop yield was low in all the communities and the yield from women's plots was generally less than for men. Comparative analysis was drawn from Eboh (2008), who submitted that in 2006, many states recorded less than 1.8 mt/ha of maize, compared to 4.2 mt/ha in Thailand, 3.2 mt/ha in Malaysia and 3.5 mt/ha in Indonesia. He also stated that only Kaduna and Plateau States had sorghum yields that compared well with those of South-east Asia (1.898 mt/ha). Many states recorded less than 2.4 mt/ha of rice, compared to China (6.2 mt/ha), Indonesia (4.7 mt/ha), Malaysia (3.3 mt/ha) and Thailand (2.9 mt/ha). All states, except Benue, achieved yields less than 1.5 mt/ha of millet, the national average yield in Argentina. Only two states recorded more than 1.6 mt/ha of groundnut, compared to South-east Asia which recorded 9.3 mt/ha. Eboh (2008) concluded that much of the increase in agricultural growth in Nigeria came from expansion in cultivated area rather than increased yield.

Fertilizer use and other soil-enhancing practices

On the average, farmers consume about 445 kg of mixed fertilizer such as NPK (Nitrogen, phosphorus, potassium) on an average of 7.4 ha land (Table 1), implying that about 63 kg fertilizer was being applied per ha of land relative to the requirement of about 4800 kg (about 649 kg/ha) for the crops mixture (Table 3). It was found that fertilizer use multiplies the returns on farmers' investment by a factor of 2.1-14.6 relative to the findings of IFDC (2002) where average crop yield response was 3-5 on the same set of crops (Table 3). Problems associated

Table 3. Estimate of yield response due to fertilizer use in Sudan Savannah, Nigeria.

Crop	Recommended fertilizer rates (NPK in kg/ha)*	Response coefficient yield (kg) / fertilizer use per ha (kg)	Farm size (ha)	Fertilizer requirement per crop (kg)	Nutrient content of crop residue** (% NPK)
Maize	210	3.80	11.27	2366.7	2.28
Sorghum	126	6.39	2.40	302.4	2.28
groundnut	79	7.39	4.3	339.7	3.99
Soybean	85	2.07	2.98	253.3	3.75
Cowpea	85	3.11	3.94	334.9	3.75
Upland Rice	160	14.58	1.8	288	2.21
Millet	126	2.91	7.26	914.76	1.75
Total	871			4799.76	
Average			7.4		

Sources: *FPDD (2002), **Singh (2002). Field survey in Kano and Kaduna States, Nigeria, April, 2008.

Table 4. Livestock size by type and nutrient content of wastes.

Livestock	Average holding by sex of respondents		Average total	Nutrient content of farmyard manures – dry weight basis* (%NPK)
	Women	Men		
Goat	6.33	35.25	13.86	
Sheep	4.67	9.75	7.21	
Poultry	18	25.5	14.5	8.12
Cattle		18.25	9.13	1.45
Bull	2	5.5	3.75	

Sources: Field survey in Kano and Kaduna States, Nigeria, April, 2008.*Singh (2002).

with low crop response to fertilizers were production malpractice and irregularities such as nutrient deficiency in fertilizer samples, underweight bags, poor physical properties and alteration of fertilizer formulations. Although FPDD (2002) found that there has been a high potential demand for fertilizer use in agriculture attributable to the fact that more farmers have become aware of the need to use mineral fertilizers in recent years, level of fertilizer use is still relatively low. According to Ayoola (2008), this could be due to inefficient fertilizer market derived from policy inconsistency and market regulation. It would appear that NPK 15-15- 15 was being applied indiscriminately, regardless of the type of soil and crop, with possibilities of generating sub-optimal production and substantial wastage of the input as well as depletion of soil nutrients. Thus, the need to provide necessary guide to farmers in the use of other grades like calcium ammonium nitrate (CAN), urea, muriate of potash (MOP), basic slag phosphate (BSP), and single super phosphate (SSP) based on the major deficiencies of the soil in the savanna zones which was identified as phosphorus (FPDD, 2002) and the peculiar characteristics of different crops grown.

The average response coefficient to fertilizer use in the study area ranged from 2.1 for soybean and cowpea to 14.6 for rice compared to the national average reported by FFD (2002) as 3-5 for the same crops. The observed higher response coefficient could be explained by factors including other practices such as use of organic/farmyard manures and other soil conservation practices. As a complement to inorganic fertilizer, the use of organic fertilizers has assumed significant importance in the agricultural system. A large quantity of crop residues are produced from maize, sorghum, and pulses (cowpea, groundnut and soybean) which can be converted into organic manures by composting, mulching or direct incorporation into the soil to generate nutrient; which according to FPDD (2002) may yield nutrient ranging from 1.75 to 3.99% of NPK.

Mixed farming system (legume-cereal-livestock mixture) is most often practiced by both men and women, with slight changes in the combination of preferred legume or cereal intercrop, as a strategy both to address nutrient management as well as the livelihood (both food and income security) of the communities. Farmers keep an average of 14 goats, 15 poultry birds, 7 sheep and 9 cattle (Table 4). The livestock mix provided substantial farm-yard manure for fertilizing the soils, and supplemented farm drought animals /animal traction while the crop residues (legumes and cereals) provided feeds for the livestock. There is opportunity for promoting organic agriculture in the Sudan Savannah zone, which will not

only sustain the soil nutrient but also provide an avenue for tapping on the global market for organic products.

Soil types and farmers' assessment of fertility status varied with location across all communities. The various types of soil included sandy loam, clay, stony, loamy, sandy, and clay loam. Farmers' evaluation indicated that in most cases, the clay, loamy and stony soils were relatively more fertile than the sandy loam and sandy soils, but that the fertility status of most of the soils is rather poor, resulting in very low yield even sometimes in spite of fertilizer application. The problem of weed and striga especially *Striga hemonthica, Striga gesneroides* and *Alectra* was found to be endemic in all the selected communities and was also associated with poor soil fertility. Most of the soils also had problem of water logging (mostly clay and loam soils) and erosion and progressive decline in soil fertility a real challenge to agriculture. Application of more inorganic fertilizers alone may not yield expected results due to leaching and other sources of nutrient loss. Integrated soil improvement and conservation techniques including more intensive use of organic manures may be necessary.

Farmers' practice for managing soil fertility included use of homestead refuse, fertilizer application, fallow and application of clay to sandy soil. Fallow rotation is rarely used. Tillage conservation practices included planting of grass to control erosion, planting on ridges, field drainage and use of sand bags.

Economic and environmental implications

Agricultural soils in the study area lose their fertility by plant nutrient depletion (due to erosion, intensive cropping, inadequate fertilization, and low organic matter content) and this constitutes a real and immediate threat to food security and the livelihood of the people. The loss of fertility reduces yields and affects water holding capacity, leading to greater vulnerability to drought. This confirms FAO's report (1994) that the loss of soil fertility in many developing countries poses an immediate threat to food production and could result in a catastrophe no less serious than from other forms of environmental degradation.

Agricultural growth helps the economy in the sense that when agricultural producers' income rises, they spend money on non-agricultural items, creating jobs for others through out the whole economy. IFPRI (1997) found that for every US$ 1 increase in agricultural outputs in developing countries, the overall economy grows by US$ 2.3. In addition, productive agriculture helps to alleviate rural poverty, since more than 75% of the poor in many Sub- Saharan and Asian countries are made up of the rural poor who depend directly or indirectly on agriculture, and are often forced to overuse or misuse the natural resource base in order to meet their basic needs. Therefore, the situation of low agricultural productivity would tend to retard national economy, increase rural poverty and deplete natural resource base thereby undermining sustainable development.

The inadequate access of farmers to adequate inorganic fertilizer represents an incentive to the rational use of organic wastes. Recycling plant and animal wastes in agriculture is associated with a lot of benefits including improvements in soil fertility, the premium paid on organic vegetables and conversion of waste materials into useful resources. However, because of transportation costs, use of animal wastes as fertilizer is economically feasible only if on-farm or nearby sources exists from intensive livestock units. And since most farmers own substantial livestock units in semi-intensive or free range management, strategies to intensify management of livestock to provide wastes directly on-farm or close enough to farmland would be necessary to reduce cost of fertilization.

CONCLUSION AND RECOMMENDATIONS

Critical environmental issues emanating from the findings are soil nutrient depletion, soil degradation by erosion, weed and pest invasion, all culminating in sustained low productivity. The level of inorganic fertilizer use is very low relative to Asia and some other African countries such as South Africa, Malawi, Benin and Ethiopia. Adverse soil conditions due to wide spread erosion and weed/pest invasion would reduce the efficiency of applied fertilizers. Farmers exploit the land and the natural fertility of the soil through continuous cropping and deplete the soil nutrient. These constitute major concerns with respect to the long-term adverse effects on soil productivity.

Thus, sustained growth in agricultural productivity without environmental exploitation and degradation cannot be achieved unless efforts to enhance farmers' fertilizer use and organic fertilization are taken seriously. These suggest the need for government to establish a functional regulatory system for fertilizer sector specifically to correct the market inadequacies, particularly to monitor the quality standard of all fertilizers to guarantee that certified products reach the farmers. Fertilizer policies should emphasize provision of direct smart subsidies to farmers and develop a network of agro-dealers across rural areas. Farmer participation and private-public partnership in the fertilizer policy process should be encouraged. National research and extension programs should emphasize economic use of basic local materials to control depletion of nutrients from the soil through erosion as well as increase the fertility of farmers' fields through effective combination of organic manures, biologically fixed nitrogen and inorganic fertilizers.

REFERENCES

Adesina A. (2008). Achieving the African Green Revolution: Lessons

for transforming Nigerian agriculture. Paper presented at the International Conference on Food Security, 23-24 July 2008, Abuja pp. 4-6.
Agboola SA (1979). “An Agricultural Atlas of Nigeria”. London: Oxford University Press.
Ayoola GB (2002). “Fertilizer Production, Imports and Use in Nigeria”. Pp. 10-12.
Eboh E (2008). State level strategies to achieve sustained agricultural productivity, growth and development. Paper presented at the International Conference on Food Security, 23-24 July 2008, Abuja pp. 7-8.
Food Agriculture Organization (1994). “Cherish the earth: Soil management for sustainable agriculture and environmental protection in the tropics”. FAO, Land and Water Division, Rome.
Federal Fertilizer Department (2002). “Toward a Fertilizer Regulatory System for Nigeria: An Inventorization of the Fertilizer Sector” pp. 10-15.
Fertilizer Procurement and Distribution Division (2002). “Agricultural Policy of Nigeria”. Federal Ministry of Agriculture and Rural Development pp.13-16.
IFPRI (1997). Pinstrup-Andersen P, Pandya-Lorch R, Rosegrant MW, The World Food Situation: Recent Developments, Emerging Issues, and Long-Term Prospects. IFPRI, Washington, December 1997.
International Fertilizer Development Centre (2000). “Agricultural Input Markets in Nigeria: An Assessment and a Strategy for Development” pp. 4-16.
International Fertilizer Development Centre (1985). “Fertilizer Efficiency and Technology Transfer Workshop for Africa” pp. 5-7.
Singh HB (2002). “The Role of Manures and Fertilizers in Crop Production”. International Fertilizer Development Centre, United States Agency for International Development and Federal Government of Nigeria, in Developing Agri-input Markets in Nigeria pp. 68-71.