Journal of Agriculture and Social Research (JASR) Vol. 11, No. 2, 2011

APPLICATION OF INTEGRATED SOIL FERTILITY APPROACH IN THE IMPROVEMENT OF SOIL FERTILITY IN SEMI ARID ECOLOGY

UGBOH O. AND ULEBOR J.U
Department of Agricultural Science,
College of Education, Agbor, Nigeria

ABSTRACT

Nutrient level and moisture status are low in major soils of the tropical and semi arid ecology. This ecological region, to buttress the facts of its inadequacy in soil fertility and crop production, and do to these results, the soil suffers from inherent soil or land degradation, overgrazing, lack of adequate use of modern facing technologies, continuous cultivation, annual bush burning, moistures stress, and related erosion problems. Innovational practices in the management of organic matters in semi-arid soil, emphasizes, that farmers should engage in the act of recycling of organic matters, ensure that conservative tillage is operated, practice of irrigation, mulching and Alley farming are encouraged. Additionally, the use of organic and inorganic fertilizer in an integrated programme will play a major role in the solving of low nutrient level associated problems, improvement of soil texture and structure, thus boosters food production in the ecological region.

Key Words: Integrated Soil Fertility Approach, Soil Fertility

INTRODUCTION

The levels of nutrients in major soils of the tropics and semi-arid ecology are negatively low. It is a known fact that plant production in natural ecosystems primarily depends on nutrient recycling and biological fixation of atmospheric nitrogen. Thus, sustainable crop production on these soils must strongly emphasize inorganic and organic recycling. The choice of nutrient management strategies depends not only upon environmentally suitable crops and cropping system, but also upon the available resources at the farm (Strainer 1984, Nicholaida et al 1985, Juo 1987, Renand et al 1997, Franzluebbers et al 1998).

It has been observed that moisture stress affect over two thirds of all soils in semi arid areas while soil fertility degradation has been described as the second most important constraint to food security in African. Despite proposals for a diversity of solutions and the investment of time and resources by a wide range of institutions, it continues to prove and substantially intransigent problem. Inadequate management has exacerbated these problems to an alarming extent. The population is thus trapped in a vicious poverty cycle between land degradation, and the lack of resources of knowledge to generate adequate income and opportunities to overcome the degradation.

The needs for soil fertility improvement in Semi Arid Ecology

The semi-arid ecology of African suffers from inherent soil or land degradation, caused by overgrazing, lack of adoption of modern farming technologies, limitation of the farmers in ability to replenish nutrients lost in the continuous cultivation, annual bush burring, soil and wind erosion among others. In view of the above constraints to soil improvement in the arid regions in Africa, the following reasons further create the need for semi-arid soil improvement. The rural poor farmers cannot expand land holdings because the frontier is limited and the availability of arable land has skunk dramatically per capital.

Compared to other areas, a large proportion of soil in semi-arid areas has low inherent fertility and exhibits a variety of constraints, among them; nutrient deficiency, low organic matter, moisture stress, and high erodibility. Millions of hectares of land are physically degraded each year, due principally to water and wind erosion. These processes have led to the semi-arid areas being characterized by declining per capital food production.

Causes of loss of soil nutrients in Semi-Arid Ecology

It is a known fact that the following factors accounts for the causes of soil infertility – these are shortage of manure, tillage practices, continuous cropping practices, limited crop rotation, indiscriminate cutting of trees, burning of crop residues and bush fires. Physical or chemical composition of the semi-arid regions affect the fertility of the soil. Similarly, Hanson (1992) reported that of the three billion hectares of arable land in tropical Africa, where semi-arid is available only 14.7% is considered to be free of physical or chemical constraints. One third (32.2%) has physical constrains, 13.2% has limited nutrient capacity, 16.9% has high soil acidity, and 6.8% has high P. fixation. The nature of the soil and it's properties in terms of its compactness, sticky characteristics, micro and macro-pores spaces, the soil structure and texture as it is in clay soil in the semi-arid region, are determinants of the soil fertility. This soil types are generally very sticky if in a wet condition and when they are wet, they are not easily permeable to water. They contain very little air thus not well aerated, due to the very narrowpores spaces, which reduces drainage and encourage capillary uptake and water retention. The soil type is highly rich in nutrients but in some cases not available to plants due to the physical constraints.

While sandy soil which is remarkably available in the semi arid region, is made up of coarse large soil particles which are mainly composed of the mineral quarts (SIO3). Sand soil particles are loosely packed and they create large pore spaces which encourage the easy circulation of air in the soil, hence the soil type is said to be well aerated. It is gritty to touch and glassy in appearance due to the presence of the mineral quarts in the soil. The soil type due to the inherent large pore spaces allows easy movement of water though the soil and as a result, it is said to be porous. This soil is liable to excessive leaching of plant nutrients due to the action of percolating water obeying the force of gravity; otherwise called gravitational water.(Ulebor 1999). Thus the leached plant nutrients may no longer be available for the plants to absorb. It has low capillarity force due to the large pore space. It is as a result of this that the soil is incapable of allowing soil water to rise up to the subsoil level, where it could be available for crop plants to absorb during the dry season. Thus, this accounts for the wilting of leaves of shallow rooted crops in the semi-arid regions. Sandy soil is said to have good physical properties which are constraints to the soil fertility (Ulebor 1999).

Continuous cropping of semi-arid soil has resulted in a rapid decline in soil organic matter in the surface soil during the first few years following land clearing (Brams 1971, Juo et al 1995). Continuous cropping cause significant decline in soil PH and exchangeable Ca and Mg levels. According to (Cunningham 1963, Adepetu et al 1979, Jou Kang and Balasubramanian 1990, Pichot et al 1989, Juo et all 1995a), this is more pronounced when acidifying fertilizers are used. Research findings accounted for the decline of crop yields under continuous cropping as having been attributed to factors such as acidification, soil compaction and loss of soil organic matter (Juo et al 1995). It is recommended that the application of organic materials is needed, not only to replenish soil nutrients but also to improve the physical, chemical and biological properties of soil (Juo et al 1995a). To a large extent, this may be achieved by managing the agro ecosystem in such a way that nutrient sources are generated, recycled and maintained. The act of slashing and burning of farmland and the usual annual bush firing immensely contribute to the decline of soil nutrients in the semi arid regions. Naturally, the rainfall level and distribution accounts for the existence of grassland and stunted trees vegetation. In the drought period, this area is highly exposed to wild bush burning. Thus, this leads to the burning of the underlying organic residues, the combustible grasses and the short trees where available. Under such conditions the major portion of all of these compounds undergoes essentially a "burning" or Oxidation process. The Oxidizable fractions of organic materials are composed largely of carbon and hydrogen, which make up more than one half of the dry weight (Brady 1974). Consequently, the complete Oxidation of most of the organic compounds in the soil may be expressed as follows:

$$- \quad \underset{\substack{\text{Carbon and hydrogen} \\ \text{Containing compounds}}}{[CH_4]} + 2O_2 \xrightarrow[\text{Oxidation}]{\text{enzymic}} CO + 2H2O + \text{Energy}$$

In the above over-all reaction, there are many intermediate steps and also there are important side reactions, which involve elements other than carbon and hydrogen, which are occurring simultaneously. Neither of these facts, how ever detracts from the importance of this basic reaction in accounting for most of the organic matter decomposition in the soil. Some of the elements produced in the above reaction such as hydrogen are loss by way of evaporation while some of the carbon are loss by erosion process. The energy generated tend to reduce the fertility of the soil by killing some of the micro organisms and the earth worms in the soil which in their various activities increase the fertility of the soil.

Integrated Nutrient Management Approach

Integrated nutrient management aiming at sustainable and enhancing good soil nutrient level for higher crop productivity, adopts the wise use and management of inorganic and organic sources in ecologically sound production systems (Janssen 1993). The underlining basic principles of integrated soil nutrient management in semi-arid soil is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way so as to maximize crop production and maintained soil conditions. This veritable and highly scientific soil nutrient management approach optimizes all aspects of nutrient cycling aim at achieving optimum good soil condition. Thus enabling high crop yield. Furthermore, the nutrient recycling ensuring the fulfillment of the syndrome of plants nutrient demands and nutrient release and availability in the semi-arid regions of the world. This practices is highly advantageous as it helps in checking surface run-..., which could lead to soil nutrient loss, prevents leaching process, corrects nutrients immobilization and volatilization which are characteristically features of semi-arid soil conditions. Integrated soil fertility management measures in the semi-arid soils, accommodate wide differences in terms of what farmers can do depending on their access to land, labour, livestock, capital and knowledge.

MEASURES OF INTEGRATED NUTRIENT MANAGEMENT

The act of crop residue management enhances nutrient availability, sufficiency in the semi-arid ecology. Crop residue, which is a form of organic nutrient source, include other plant residues such as leguminous cover crops, mulches, household wastes; animal manure, green manure and others. Organic matters addition in the soil are known to have remarkable effects in the improvement of the physical structure of the soil and increases water holding capacity of sandy soil in particular, and encourages water percolation significantly in the clay soil. The additional benefits of organic matter, are that, chemically, it increases the capacity of the soil to buffer changes in PH, increases the caution exchange capacity (CEC), reduces phosphate fixation, and serves as a reservoir of secondary nutrients and micro nutrients. Furthermore, organic matter is the energy source for soil fauna and micro organanisms, which are the primary agents that manipulate the decomposition and release of mineral nutrients in soil ecosystem.

Crop residue management in semiarid regions is an effective practice for soil fertility maintenance, only if crop residues are harvested and stored for use as mulch for the cropping season in the following year. In humid and sub humid regions, where cropping seasons are separated by a relatively short day season, the usual practice is to leave crop residues in the field after each harvest.

INNOVATIONAL PRACTICES IN THE MANAGEMENT OF ORGANIC MATTERS REQUIRED IN SEMI ARID SOILS

Farmers are advised to adopt return or recycle of organic materials to the soil, so as to replenish soil organic carbon lost and other nutrients through decomposition. The recycling of organic matters entails the return of the residues of plants, animals, green manures, cover crops to the soil. It is advisable for farmers to ensure minimum disturbance of the soil surface through conservative tillage, use of mulch residues so as to have controlled rate of decomposition of organ matters in the semi arid soils. The control of soil temperature and water evaporation by mulching the soil with plant residues, or alternatively where convenient by the use of cover crops.

Through the integration of multipurpose trees and perennials into cropping systems to increase the production of organic materials; Integration of cover crop and multiple purpose, woody and herbaceous legumes in existing cropping system to increase the availability of organic resources and consequently to improve crop yields. It is worthy to note that as an innovation in the management of organic matter in semi-arid soils that soil fertility is built up by rural communities through progressive and steady modification of the natural resource base (soils, vegetation, slopes, water flows) by fallowing, grazing, selecting crop species, deep ploughing to break the plough pan, sub-soiling, organic fertilizing, transferring crop residues and fodder. Soil fertility is also strongly influenced by the accumulation of organic wastes, ashes and various by-products close to living areas and by the long term rotations of these living areas. Farmers need to be empowered through farmers organizations and networks which can contribute to the planning and implementation of improved practices, and which are fully involved in biding for funds and in managing them towards more beneficial land management.

Green Manure Crops And Intercrossing

Applications of organic materials with a low C/N ratio, such as green manure and compost, could synchronize nutrient release with plant demand and minimize the amount of inorganic fertility needed to sustain high crop yields, for short-cycle crops such as maize, rice and soybean, all of which have a high nutrient demand (Sanchez et all 1989, Lathwell 1990, Burle 1992). Fast – growing leguminous species such as Mucuna (Mucuna Utilis) and Kudzu (Pueroria Phaseoloides) can be specially useful as cover crops for erosion control, weed, suppression and for soil fertility restoration (Wilson et al 1982).

Merits Of Leguminous Green Manures And Cover Crops

Leguminous cover crops helps in the fixation of Nitrogen into the soil which is converted to Nitrite and then to Nitrate by Nitrobacta and Nitrosomonas They help in the conservation of soil from agents of soil erosion and enhances recycling of soil mineral nutrients. It requires little or no cash input.

Farmyard Manure And Houses Hold Waste

This constitutes the major source of nutrients for good crops in many parts of the tropics. The use of farmyard manure or compost as a nutrient source for good crop production depends largely on the prevailing farming system (Jones 1971, Pieni 1989).

In the semi-arid zone of West Africa, compositing is not a common practice because of the lack of water and of crop residues (Poulain (1980). Animal manure and household wastes are usually limited to areas near the farm compound where the farm animals range. Kraaling is a form or system where farmers invite nomadic herders to graze on their croplands during the dry season. It entails confining the cattle in a particular farm so as to ensure concentrated urine and feaces discharge, resulting to rich animal manure availability.

Use Of Chemical Fertilizers

Generally, manure scattered when animals are grazing is insignificant for improving soil fertility (Taylor-Power 1991). Alternatively, they could decide to make use of inorganic fertilizer to improve the soil fertility. Inorganic manures are compounded with chemical elements which are needed by plant for their enhanced growth and development. Fertilizers are named or known for the important plant nutrient they carry. Fertilizers are of different types. We have simple, single or straight fertilizer i.e the fertilizer that carries one essential plant nutrient. Examples of this type of fertilizer are Urea, Ammonium Nitrate, Rock Phosphate, Muriate of Potash and others. The inorganic fertilizer types that carry more than one essential plant nutrients are called the complex or compound inorganic fertilizer, an example of which is N.P.K fertilizer. The inorganic fertilizers that carry acidic radicals are sources of increasing soil acidic in semi-arid soils and many crops do not do well in acidic soil.

Advantages and Disadvantages of Integrated Soil Fertility Management

Waste lands are converted into productive land. Allows farmers to continuously achieve high yields on the same land for many years. Low external input agriculture is based on making better use of organic materials available on farm to build up soil organic matter. Farmers share knowledge by working in groups, improved soil moisture retention. Integrated soil fertility management is highly laborious. Since the organic materials are low in nutrients, it then means that the farmers needed quantity of organic matters to meet up with their needs. The transportation of these organic matter is high economic burden to the farmers.

CONCLUSION

The use of organic and inorganic fertilizers in an integrated programme will suffice to solve the problems of low nutrient level in semi-arid regions, so as to boast crops yield and improve continually the chemical and physical status of the referred soil type. Investing in soil fertility management using this method is necessary to help households mitigate many of the characteristics of poverty, for by improving the quantity and quality of food, income that is derived by the farmers will be enhanced.

REFERENCES

Adepetu, J.A., A.O. Obi, and E.A. Aduayi 1979. changes in soil fertility under continuous cultivation and fertilization in South-Western Nigeria. *Nigerian Jour. Agricultural Science.* 1:15-20.

Balasubramanian V. and N.K.A Blaise. 1993 short fallow management for sustainable production in Africa. In *Technologies for Sustainable Agriculture in the Tropics* J.

Ragland and R. Lal. (Eds.) ASA Special Publication No.56 Madision W.I. USA, pp 279-293.

Brams. E.A. 1971 Continuous cultivation of West African soils: Organic matter diminution and effects of applied lime and phosphorus. *Plant and Soil 35:401-414.*

Bumb, B.L. and C.A. Baanate. 1996. *The Role of Fertilizer in Sustaning Food Security and Protecting the Environment of 2010.* Food, Agriculture and the Environment Discussion Paper 17. International Food Policy Research Institute Washington D.C.

Buresh, R.J. and G. Tian 1997. Soil improvement by trees in sub-Saharan Africa *Agroforetry System. 38:51-76.*

Christainson, C.B. and P.L.G Vlek. 1991 Alleviating soil fertility constraints to food production in West Africa: Efficiency of N Fertilizer applied to food crops in: *Alleviating Soil Fertility Constraints to Increased Crop production in West Africa U. Mokwunye (Ed)* Kluwer Academic Publishers. Dordrecht. The Netherlands pp. 45-59.

Dommergues. Y.R. and F. Ganry 1986 Biological nitrogen fixation and soil fertility maintenance. In: *Management of Nitrogen and Phosphorus Fertilizers in Sub-Saharan Africa.* A.U. Mokwunye and P.L.G. Vlek (Eds) Proceedings of a symposium held in Lome, Togo, March 25-28, 1985. Martinus Nijhoff Publishers. The Netherlands, pp. 95-115.

Fernandez, E.C.M. and P.A. Sanchez. 1990. the role of organic inputs and soil organic matter for nutrient cycling in tropical soils. In: *Organic Matter Management and Tillage in Humid and Subhumid Africa, E.* Pusharajah and M. Latham (Eds). Bangkok, Thailand. International Board for Soil Research and Management, Bangkok, Thailand, IBSRAM Proceedings No. 10,pp. 169-212.

Franzluebbers. K.L.R. Hossner and A.S.R. Juo. 1998.*Integrated Nutrient management for Sustained Food Crop Production in Sub-Saharan Africa* TropSoils/TANY Tech. Bull No. 98-03. Department of Soil & Crop Sciences Texas A&M University.

Greenland D.J. 1981 *Characterization and Management of Soil in the Tropics Clarendon Press. Oxford England.*

Grove. A.T. 1978 *Africa South of the Sahara.* Oxford University Press, Oxford England, 337 pp.

Hossner, L.R. and D.W Dibb 1995 Reassessing the role of agrochemical inputs in developing country agriculture. In: *Agriculture and Environment:Bridging food Production and Environmental Production in Development Countries.* A.S.R. Juo and R.D Freed (Eds) Special Publication No. 60. American Society of Agronomy. Madision, Wisconsin, U.S.A pp. 17-33.

Ulebor, J.U (2010) *Basic Essential of Horticultural Practices*, Progress Printing Associates, Agbor, Nigeria.