

The Combined Use of Organic and Inorganic Fertilizers for Improving Maize Crop Productivity in Nigeria

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Abstract: Recent studies have revealed that the integrated use of organic and inorganic fertilizers on crop has not received adequate research attention. In this paper, maize is considered among the most important cereal crops in Nigeria and all over the world that has high requirement for organic and inorganic nutrients in order to obtain good quality and high yields. The application of inorganic fertilizer for instance has been found to increase maize performance and chemical properties of soil such as pH, total nutrient content and nutrient availability. On the other hand, its continuous use could cause nutrient imbalance, soil acidity, more so, heavy fertilization in crop production systems could exceed what maize plants are able to utilize and can be a major source of excessive nitrate leaching. Similarly, organic fertilizers are faced with the problems of scarcity, slow nutrient release and difficulty in transportation. In view of these constraints, the combined use of organic and inorganic fertilizers in improving maize crop productivity was reviewed and it was found that the total dependence on organic or inorganic fertilizers does not provide the panacea for enhanced and sustainable maize crop production in Nigeria. Therefore, the combined use of organic and inorganic fertilizers appears to be the last option and recommendation of the paper for sustaining productivity as well as enhancing the farmers' level of maize production in Nigeria.

Key Words: Organic, Inorganic, Fertilizer and Maize Crop

I. INTRODUCTION

In most parts of Africa including Nigeria, traditional method of maintaining soil fertilizer and productivity has been bush-fallow system where the arable land is allowed to revert to fallow after 3 – 4 years of continuous cultivation. However, due to the growing population and other socio-economic pressures, the fallow period had been reduced from 7 – 10 years now to almost no fallow now in order to accommodate the increasing high demand for food (Asadu and Unagwu, 2012).

The use of both organic and inorganic fertilizer by farmers has been reported to increase yield and sustain soil productivity (Chukwu *et al*, 2012). Many research works showed that the use of several organic materials especially cow dung, poultry droppings and farm yard manure as soil amendments is suitable for increasing crop production particularly among subsistent farmers in West Africa (Asadu and Unagwu, 2012). The uses of fertilizers are highly needed to replenish nutrients taken out from the soil by harvest crops and to supplement more nutrients to boost yield (Olatunji and Ayuba, 2012).

Organic fertilizer can be used to improved soil characteristics and obtain high crop yields in addition with inorganic fertilizer (Cezar, 2004). In organic fertilizer use, production of crops free from heavy metal contamination will be guaranteed (Asadu and Unagwu, 2012). The addition of organic amendments to manage the current trend of soil physical, chemical and biological degradation has been recommended by Chukwu *et al.* (2012). Organic and inorganic fertilizers have their merits and demerits. For instance, organic fertilizers are slow release nutrient sources. This implies that crops can suffer initial starvation from nutrient immobilization prior to mineralization. They are also required in large quantities which may not be readily available to small scale farmers (Agbede, and Kalu, 1995; Okigbo, 2000; Adekiya *et al.*, 2012).

On the other hand, while inorganic fertilizers ensure quick availability of nutrients to crops they have limited residual effect of the applied nutrients (Okigbo, 2000) and their reckless use can create nutrient imbalance that limits the uptake of other essential nutrients and cause soil acidity leading to low crop yields. In addition, they are expensive and may not be readily available. Maize (*Zea mays L.*) is a very high nutrient – demanding crop, requiring adequate nutrition for maximum performance (Rashid and Ryan, 2004). Among the several other factors which causes decline in maize yield is soil degradation for intensive cultivation and continuous application of the rates of NPK fertilizers which may cause nutrient imbalance and limit the uptake of other essential nutrients, thus limiting the crop performance (Rashid and Ryan, 2004; Chukwu *et al.*, 2012).

II. JUSTIFICATION

Nearly all attempts to maintain continuous crop production with inorganic fertilizers alone have failed in the country, hence there is need to adopt alternative reduced “chemical” or “ion-input” production systems involving a partial reduction in the use of chemicals. The combined use of organic and inorganic fertilizers has proven a sound soil fertility management strategy in many countries such as Tanzania, India and Central African Republic. The tendency to supply all nutrients through chemical fertilizers has to be avoided as this has deleterious effect on soil productivity (Ojeniyi, 2000).

Studies carried out in southwest Nigeria (Eneji *et al.*, 1997 and Ojeniyi and Adeniyian, 1999) have recommended combinations of farmyard manure and NPK fertilizer for sole and intercropped maize. According to these authors, Nigeria and indeed other tropical countries must not assume that the soil can be rendered productive by fertilizer alone, but plus appropriate soil management and farming techniques that build up soil organic matter. According to Ojeniyi (2000), since almost all attempts made to maintain continuous crop production with inorganic fertilizer alone in Nigeria have failed, the need to evolve production systems that will utilize the combined use of organic and inorganic fertilizers for improving maize crop productivity in Nigeria cannot be over-emphasized.

The objective of this paper is to highlight on the effects of complementary applications of organic and inorganic fertilizer on the production of maize in Nigeria.

III. FERTILIZERS AND CROP PRODUCTIVITY IN NIGERIA

The importance of fertilizer as an agricultural input cannot be over emphasized particularly in the tropics where the nutrient levels of soils in most areas are low. Maize crop requires fertilizers in sufficient amount to give the maximum economic returns. There are two main types of fertilizer for improving crop productivity in Nigeria, inorganic (or chemical or synthetic fertilizers) and organic fertilizers.

Inorganic fertilizer is an artificially prepared manure with a variable concentration of plant food and are available in the form of single fertilizer, incomplete fertilizer and complete fertilizer. Single fertilizer contain only one fertilizer element e.g. Ammonium sulphate (N), urea (N), super phosphates (P_2O_5), muriate of potash (K_2O), etc. incomplete fertilizer contain two fertilizer elements. A typical example is Ammonium sulphate (N + S) while complete fertilizers contain all three elements (NPK) which are the focus of attention in fertilizer formulation (Cooke, 1982).

Organic fertilizer are available in large quantities all over the world in Nigeria, waste from brewery fertilizers like molasses, waste from other industries can be considered as sources of organic fertilizers, other sources include materials such as cocoa pods, rice bran, bean pod, sorted town refuse, sewage and city waste, poultry droppings, animal dung, human feaces and urine. It also includes yam peelings, cassava peelings, and straws of rice, maize, millet, sorghum and sugar cane leaves. Inorganic fertilizer differ from organic fertilizers in that they usually consist of relatively simple chemical compounds of known composition and that they contain weight, much higher percentages of fertilizer elements (Lockeretz, 1995).

IV. USE OF INORGANIC FERTILIZERS FOR MAIZE CROP PRODUCTION

Ojeniyi (2002) reported that there are abundant evidences that inorganic fertilizers can improve yield of maize crop significantly. Cooke (1982) stated that fertilizers allow us to raise soil fertility so that the yield of crops need no longer be limited by the amounts of plant nutrients that the natural system can supply and factors other than nutrition then set the limit to productivity. The advent of inorganic fertilizer has thus revolutionalized maize crop production through its provision of plant nutrients for improved maize crop productivity in Nigeria.

Total dependence on inorganic fertilizers however does not provide the panacea to soil management and crop productivity problems in Nigeria. According to Ojeniyi (1995) cited in Ojeniyi (2002) there are problems that arise with continuous use of inorganic fertilizers. Most farmers apply fertilizer without soil test, thus wrong amount and type may be applied. Deficiency of secondary and micronutrients occur in soil and crop, if the common NPK type is consistently used. Ojeniyi (1981) reports that total dependence on inorganic fertilizers may be accompanied by fall in soil organic matter, increased soil acidity and degradation of soil physical properties and structure and increased erosion.

The National Research Council (1989) cited in Lockeretz (1995) stated that in the past two decades, there has been increasing concern about agricultural damage to the environment and its consumption of non-renewable resources especially through synthetic pesticides and fertilizers. Agricultural chemicals have contaminated ground and surface waters, harmed fish and wildlife and greatly increased agricultural dependence on fossil fuel resources. The fore-going underscores the need to evolve alternative “reduced chemical” or “low-input” production systems involving a partial reduction in the use of chemicals.

V. USE OF ORGANIC FERTILIZERS IN MAIZE CROP PRODUCTION

The use of organic materials is an important component for sustainable agricultural production as when such materials are applied to agricultural land they promote sustainability because of:

1. Their long term position effects on soil chemical and physical properties.
2. The possibility of recycling plant nutrients within a farm (e.g. feeding harvested fodder to livestock and then applying farmyard manure from these animal back to the land).
3. The possible substitution of readily available organic inputs for chemical fertilizer, and therefore a decreased dependence on external sources for costly fertilizer.
4. The general improvement in maize crop yield and quality obtained when adequate rates of organic soil amendment are incorporated into the soil. (Motavilli *et al*, 1994).

Plant wastes such as wood ash, spent grain, rice bran, and sawdust were effective as fertilizers (Ogbalu, 1999). Effect was enhanced by amendment with pig, goat, cattle and poultry manure. The residue increased soil organic matter, N, P, Ca, Mg and pH and reduced soil bulk density. Chemical analysis showed that the residues contained N, P, K, Ca, Mg, Fe, Mn, Cu and Zn (Folorunso, 1999) and the manures increased soil pH, nutrient contents, growth and yield of maize and okra. Odiete *et al*, (1999) found that goat manure increased soil P and K yield of okra and amaranths. In the tropical world, plant- derived ash is regarded as a suitable manure and liming material (Ogbalu, 1999, Obi and Ekperigin, 2001).

In southeast Nigeria, planting of pepper and other vegetable at household levels is sustained by the use of chicken droppings, cow dung, wood ash and plant residues (compost) as sources of improving fertility of apparently depleted soil. According to Ogbalu (1999) these traditional sources of nutrients are accessible to farmers and the use of chemical fertilizers by villagers is not common. Apart from their direct effect as fertilizers, plant residues improve soil physical properties and fauna population. Recycling of plant residues will replace 40 to 50% of N exported by a crop, 25 to 40% of the P and 70% of the K. In the Nigerian savanna, about 3.1 million tones of crop residues are produced annually in form of sorghum, millet, cotton, maize, groundnut and cowpea. About 45% N, 40% P, 86%K, 92% Ca and 72% Mg removed from soil by crop are contained in the residues (Ogbalu, 1999). Therefore, recycling of agro wastes can be a good alternative to bush fallow. Unlike in case of chemical fertilizer, soil is physically and biologically built up, acidity is controlled and erosion is controlled.

The major constraints to the use of organic materials for maize crop production are competing alternative uses, bulk, time and the quality of organic materials. In addition to incorporation and as much as mulch, plant and animal remains are also used by farmers for fuel, housing, fencing, animal feed and for industrial purposes. This alternative uses invariably reduce the quantity of waste and residues being returned into the soil. The amount of organic matter needed to achieve most optimum maize crop productivity is enormous. Apart from the problem of returning the crop residue into the soil farmers often do not produce the quantity sufficient to maintain soil fertility and conserve the soil. The farmer must allow appropriate time between incorporation and planting to enable the maize crop to benefit from nutrient released from the organic matter. Failure to synchronize the time mineralization with crops needs will lead to waste of the nutrients. There may also be injury to the crops following heat on decomposition of freshly incorporated organic matter.

For crops to derive nutritional benefits from incorporated organic matter, it must be of high quality. That is, the carbon/nitrogen ratio of the organic matter being incorporated in the soil must be below 20:1 -25:1. The foregoing shows that to derive maximum benefit of organic materials incorporation, it may be necessary to accompany it with application of inorganic chemical fertilizer. This underscores the need for combined use of chemical and organic fertilizers for sustainable soil productivity under intensive continuous cultivation of maize crop in Nigeria.

The Combined Use of Organic and Inorganic Fertilizers for Improving Maize Crop Productivity

The problems associated with the single approach application of organic or inorganic fertilizers have made a combination of organic and inorganic fertilizers a viable option in improving maize crop productivity in the Nigeria. Total dependence on inorganic fertilizers which may be accompanied by fall in soil organic matter, increase in soil acidity, degradation of soil physical properties and structure and increase erosion has to be avoided while on the other hand total dependence on organic fertilizer may be restricted in use due to competing alternative uses, bulk i.e. the amount needed to achieve optimum crop productivity, slow release of nutrients and the quality of organic matter.

However, the combined use of organic and inorganic fertilizers will ensure that the problems associated with the use of either organic or inorganic fertilizers are greatly reduced as the combination of organic and inorganic fertilizers complement each other. Ojeniyi (2002) reports that nearly all attempts to maintain continuous crop production with chemical fertilizers alone in the tropics have failed. It has been abundantly shown that combined use of organic and inorganic fertilizers is required for sustainable soil productivity under intensive continuous cultivation in Nigeria (Adepetu, 1997). The combined use of organic and chemical fertilizers has proved a sound soil fertility management strategy in many countries such as Tanzania, India and Central African. The tendency to supply all nutrients through chemical fertilizers has to be avoided as this has deleterious effect on soil productivity. Studies carried out in southwest Nigeria (Eneji *et al*, 1997; Ojeniyi and Adeniyian, 1999) have recommended combinations of farmyard manure and NPK fertilizer for sole and inter cropped maize.

According to Obi and Ebo (1995) low soil organic matter contents results in high soil bulk density, low macro porosity reduces water infiltration transmission and availability. For the Ultisols of southeast Nigeria, it has been submitted that inorganic fertilizer alone will not ensure sustainability of production under the prevailing intense rainfall with increased leaching of nutrients. The addition of organic amendment to soil is not only an economic imperative but also a management necessity if the trend of soil degradation in Nigeria is to be revised.

VI. OTHER RELATED RESEARCH WORKS

Eneje and Uzoukwu (2012) conducted an experiment at the Michael Okpara University of Agriculture, Umudike on the “*Effects of rice mill waste and poultry manure on some soil chemical properties and growth and yield of maize*”. The results showed that the addition of the organic materials have improved the soil chemical properties with the poultry manure alone giving the highest value for all the parameters analyzed, which included soil pH, available phosphorus and organic carbon. However, the use of rice mill waste in combination with poultry manure and NPK were recommended for improvement of soil fertility and pH to the optimum value required by most tropical crops, especially maize.

Chukwu *et al.* (2012) also carried out research work on the “*Effects of poultry and NPK fertilizer on soil properties and nutrient uptake of maize (Zea mays L.) Plants grown in an ultisol*”. In their research work conducted at the National Root Crops Research Institute, Umudike, Research Farm, application of one type of fertilizer alone did not significantly improve the uptake of the macro and micro nutrients by the maize crop. The results also showed that soil available P, exchangeable K, Ca and Mg as well as effective cation exchange capacity (ECEC) were significantly improved by the combined application of organic and inorganic fertilizers.

Asadu and Unagwu (2012) carried out a study on the “*Effect of Combined poultry manure and inorganic fertilizer on maize performance in an ultisol of southeastern Nigeria*”. Their results also indicated that the combined use of organic and inorganic fertilizers is required for sustainable maize crop productivity in Nigeria.

Olatunji and Ayuba (2012) studied on the “*Effects of combined applications of poultry manure and NPK 20 – 10 – 10 fertilizer on soil chemical properties and yield of maize (Zea mays L.)*” They carried out field experiments at the University of Agriculture, Makurdi, Nigeria, during the 2008 and 2009 cropping season. The results showed that the poultry manure, NPK and their combinations increased soil nutrient elements such as N, P, K, Ca, ECEC over the control. It was concluded that the combination of 4t/ha poultry with 60kg/ha NPK 20 – 10 – 10 fertilizer with the highest grain yield be used for production of maize in the study location. .

Ukem, (2012) carried out a study on the “*Yield of maize (Zea mays L.) as affected by Algifol nutrient solution and inorganic fertilizer in Northern Guinea Savanna of Nigeria*”. The result showed that the combination of nutrient solution and NPK recorded significantly higher grain yield than sole application of either nutrient solution or NPK. The greater efficiency of the combined treatments on grain yield indicates the need for optimum nutrient balance for a sustainable maize cultivation in the northern guinea savanna of Nigeria.

Osemwota *et al.*, (2012) also studied on the “*Effects of abattoir effluents and Sawdust on yield and yield components of maize (Zea mays L.)*”. The study was conducted at Ambrose Alli University Teaching and Research Farm, Ekpoma, Nigeria. Results showed that maize plant height, leaf area, stem girth and number of leaves were significantly enhanced ($P < 0.05$). Optimum grain yield of 4.04t/ha of maize was obtained from the combined application of 4.0t/ha saw dust and 6,360 litres/ha abattoir effluent.

Awanlemhem and Ojeniyi (2012) carried out an investigation on the “*Effect of oil palm bunch ash on grain yield and nutrient availability to maize*”. In their research work, field experiments were conducted at Nigerian Institute For Oil Palm Research (NIFOR) and Ekiadolor in the Rain Forest Zone of Southern Nigeria on the effects of combined applications of Oil Palm Bunch Ash (OPBA)

and NPK (15 – 15 – 15) fertilizer on soil nutrient content, nutrient uptake and maize grain yield on slightly acidic sandy soils. The effects of OPBA, NPK and their combinations on soil OM, N, P, K, Ca, Mg, CEC and leaf N, P, K, Ca and Mg were significantly observed and consequently improved the yield of maize crop.

Onwuka *et al* (2012) studied on the “*Remediation of spent engine oil polluted soil using types of organic manure and their effects on maize growth*”. In their study, poultry manure, goat dung, composted cassava peel and composted *Chromolena odorata* were found to increase maize performance and improve soil physical, chemical and biological characteristics.

Olowoake *et al* (2012) investigated on the “*Influence of differently composted organic residues on the yield of maize and its residual effects on the fertilizer of an Alfisol in Ibadan, Nigeria*”. In their research work, the potential of differently composted organic residues on the growth and yield of maize (*Zea mays L.*) as well as its residual effects on the fertility were studied in two cropping seasons. The composted organic residues combined with NPK fertilizer had potential for increased soil fertility for maize production.

Lawal *et al* (2012) also conducted a study on the “*agronomic efficiency of maize (*Zea mays L.*) as influenced by compost rates in the rain forest savanna transitional zone of South West Nigeria*”. The study was conducted during the early and late-rain season of 2010 at the Teaching and Research Farm of University of Agriculture, Abeokuta Ogun State, Growth and agronomic efficiency of maize were investigated. Study indicated a significant variation in growth and yield parameters in response to varietals difference as a result of combined applications of fertilizers.

VII. CONCLUSION

From the different studies under this review, it can be summarized that complementary application of organic and inorganic fertilizers has been shown to reduce the application rates of each fertilizer type, increase the nutrient use efficiency of a plant, reduce leaching of nutrients, thereby ensuring nutrient availability to crops when needed and maintains soil structure which enhances root growth, exchange of gases, nutrient uptake, water availability and storage capacity as well as obviates the specific limitations of the two fertilizer types.

Many authors have suggested that in order to overcome some of the deficiencies inherent in the use of only one type of fertilizer to boost crop yield, adequate and effective use of mixture of organic and inorganic fertilizer will solve the problem of food scarcity in Nigeria and keep the soil in a much better condition than when only one fertilizer type is used.

VIII. RECOMMENDATIONS

1. The combined use of organic and inorganic fertilizers appears to be the last option and recommendation of the paper for sustaining productivity as well as enhancing the farmers' level of maize production in Nigeria.
2. It may also be recommended that more field trials, using different tones of organic and inorganic fertilizers be carried out to determine their efficiencies in promoting growth and yield of maize crop in Nigeria.

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