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Review

The effects of fertilizer residues in soils and crop performance in northern Nigeria: A review

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ABSTRACT

This study seeks to review the effects of fertilizer residues in soils and on crop performance in the savanna agro-ecological zone of northern Nigeria. Studies conducted in some parts of northern Nigeria revealed that there are residual effects of fertilizers on soils and they significantly affect crop performance. The annual applications of nitrogen, phosphorus and potassium over the years significantly affected exchangeable cations and consequently crop yields. As the fertilizer rates are increased, the efficiency of fertilizer nutrient use decreases, leaving behind in the soil an increasing proportion of the added nutrients. This is more prominent in the savanna zone where rainfall is generally inadequate and the rate of weathering is high. Hence, when nutrient content of the soil is already sufficient, adding fertilizer to the soil is likely to be damaging to both the soil and the crop. Consequently, the use of organic and inorganic fertilizers in the savanna zone of northern Nigeria should be base on specific soil diagnoses to determine the need for adding nutrients.

Keywords: Fertilizer, residues, soil, crop performance.

INTRODUCTION

Just as humans and animals must have certain basic nutrients in their food for proper nutrition to promote growth and good health, so do crop have certain mineral nutrients available in the soil and air. Plants receive these essential growth elements through their roots and foliage. Mostly, the soil upon which we grow our crops does not contain enough of these nutrients to support good growth and development. In such cases, we must supplement the nutrient deficiencies by supplying substances which provide these nutrients known as fertilizers (Uriyo, 1979). In northern Nigerian, and the semi-arid tropics in general, fertilizers use are considered risky because of unreliable rainfall pattern. Also, because the buffering capacity of northern Nigeria (savanna) soils is low, the use of mineral fertilizers on a continuous basis and substantial quantities has always been of much concern (Olaitan and Lombin, 1984).

Chemical fertilizers are important in modern Agriculture, for example, the new high yielding varieties which supply so much of the country's food, only perform well when they are given good field management and a balance application of fertilizers. However, in situations where fertilizers are relatively cheap, over application becomes a problem rather than being a solution. Farmers want to ensure good crop yield by using more than the recommended rates, and apply so much such that it has a residual effect on both the soil and the crop. Apart from that, a large amount of excess fertilizer application may be wasted through leaching which may pollute rivers and underground water systems (Tankou, 2004). Fertilizers that are not taken up by plants during the growing season, plus that which is returned to the soil un-harvested portions accumulate in the soil assuming losses due to erosion and leaching are small. This is what is referred to as fertilizer residues and it is the effects of such residues on soil and crop performance that is being examined in this paper.

Conceptual and Theoretical Issues

Fertilizers Use

The term *fertilizers* refer to chemically synthesized plant nutrient compounds which are usually applied to the soil to supplement its natural fertility. Fertilizer could also be defined as any organic or inorganic materials of natural or synthetic origin which are added to a soil or foliage to supply certain elements essential for plant growth (Asiegbu, 2006). They are the most effective means of increasing crop production and of improving the quality of food and fodder. Fertilizers may contain one or more of the essential nutrients. Those that contain only one of the major elements are described as single, simple or straight fertilizers. Those that contain two or more of the major elements are classified as mixed or compound fertilizers. Nitrogen, phosphorus and Potassium are the main plant nutrients and these three provide the basis for the major groups of fertilizers.

Most fertilizers that are commonly used in agriculture contain the three basic plant nutrients: nitrogen, phosphorus, and potassium. Some fertilizers also contain certain "micronutrients," such as zinc and other metals, which are necessary for plant growth. Materials that are applied to the land primarily to enhance soil characteristics (rather than as plant food) are commonly referred to as soil amendments.

Fertilizer use is most effective on soils with high natural or improved fertility, but even on low fertility soils crop growth can be substantially improved. Crop performance is definitely improved by adequate use of fertilizers in general, and of mineral fertilizers in particular, provided they are applied in accordance with good and quality concepts and knowledge. Quality in this context is understood to include not only the presence of quality components but also the absence of unwanted surplus nutrients and of toxic substances in plant products.

In sequential cropping system, the nature of one crop and the fertilizers applied to it will probably affect the performance of the crop that follows. Crop production using adequate mineral and organic fertilizers prevents and increases resistance to many diseases. Fertilizer use has been shown to be an effective means of enhancing crop performance for more than a century. It has contributed largely to the major increase in yields which have been achieved worldwide and for the substantial improvement of human and animal health. Overuse of fertilizers could result to contamination of surface water and groundwater. The degree of pollution, which is to some extent avoidable, can be kept to an insignificant level (Singh *et al.,* 1979).

Soil Fertility Status in Northern Nigeria

One of the major constraints to crop production in the tropics is the inherent low fertility status of most of the soils, characterized by low activity clay, low level of organic matter, nitrogen, phosphorus, pottassium and exchangeable bases (Osundare, 2008). The problem of inherent low fertility status of many tropical soils has necessitated searching for many soils fertility improvement techniques such as adoption of appropriate and adequate fertilizer packages, involving the use of organic and/or inorganic fertilizers (Tankou, 2004). The use of inorganic fertilizer in improving fertility has been reported to be ineffective due to certain limitation such as declined soil organic matter contents, soil acidification as a result of the residual effects, as well as degradation of certain soil physical properties with resultant increased incidence of soil erosion (Ray, 2007).

In northern Nigeria savanna zone, just like in other developing countries of the tropics, most soils are poor because they are deeply weathered and have been leached for long, with little or no fertilizer and farm yard manure use. FAO (1978) reported that food crops give large responses to fertilizers on very poor soils and that there are similar increases in yields from the dressings of nitrogen, phosphorus and potassium sites. Also, rainfall in the savanna agro-ecology could be erratic and indiscriminate application of inorganic fertilizers to the soil could lead to its accumulation in the soil to levels that are toxic to crops or seriously reduce the level of some essential plant nutrients in the soil.

Nitrogen and its Effects on Crop

Nitrogen in the soil is the most important element for plant development. It is required in large amounts and must be added to the soil to avoid a deficiency. Nitrogen is a major part of chlorophyll and the green color of plants. It is responsible for lush, vigorous growth and development of crops. Although nitrogen is the most abundant element in our atmosphere, plants can't use it until it is naturally processed in the soil, or added as fertilizer. An excess of nitrogen, caused by fertilizer over application, can result in rapid, lush growth and a diminished root system. In extreme cases too much quick release nitrogen can cause burning of the leaf tissue, and plant death. A crop field with a nitrogen deficiency will lose its green color and begin to turn yellow.

It is generally assumed that all of the common nitrogen fertilizers used (in agriculture) are water soluble. Nitrate applied as such, or formed from both ammonium salt and urea, is liable to be lost by

Table 1. Residual effects of phosphorus and green manure applied to Potato on the uptake of P (Kg/ha) by the grains of succeeding wheat crop

	0 PKg/ha	22 P Kg/ha	44 P Kg/ha	66 P Kg/ha	88 P Kg/ha	Mean
Crotolaria	9.8	9.5	9.4	9.0	9.9	9.5
Sesbania	6.7	8.5	8.8	9.1	9.2	8.5
Pearl Millet	7.8	8.8	9.3	9.7	9.2	8.9
Maize	7.3	7.8	8.3	9.5	9.1	8.4
Mean	**7.9**	**8.6**	**9.0**	**9.3**	**9.4**	

Source: Sharma et al., 1987; SE± for crops = 0.33; SE± for Pirates= 0.23

Table 2. Residual effect of phosphorus and green manures applied to potato on the grain yield (tones/ha) of succeeding wheat crops in 1983 and 1994.

Crop	0 PKg/ha		22 P Kg/ha		44 P Kg/ha		66 P Kg/ha		88 P Kg/ha		Mean	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Crotolaria	3.2	3.1	3.8	2.6	3.4	2.6	3.6	2.6	3.8	2.7	3.6	2.7
Sesbania	3.6	2.3	3.6	2.9	3.9	2.8	4.1	2.9	3.9	2.8	3.8	2.7
Pearl Millet	3.1	2.5	3.3	2.8	3.3	2.8	3.2	2.8	3.1	2.6	3.2	2.7
Maize	3.8	2.7	3.5	2.8	3.7	2.8	3.4	2.9	3.8	3.0	3.7	2.9
Mean	**3.4**	**2.7**	**3.5**	**2.8**	**3.6**	**2.8**	**3.6**	**2.8**	**3.7**	**2.8**		

Source: Sharma *et al*. (1988). SE± for crops= 0.08, SE for P rates= 0.10

denitrification or leaching and only about 30 to 50% is recovered by plants. The left over nitrogen undoubtedly varies with soil and climatic condition. In some cases large quantities are lost from the profile and in others a gradual build up takes place resulting in considerable amounts of nitrogen fertilizer being found in the soil.

Kitur *et al*. (1984) stated that 28% to 42% of nitrogen fertilizer applied to maize remained in the soil depending on nitrogen rate and tillage. Kuer (2003) found that 28 and 31%, respectively, of urea and oxanide nitrogen applied to sorghum were in the upper 25cm soil depth at the end of the cropping season. Sanchez and Black (1988) found that 19 to 23% of anhydrous ammonia applied to continuous maize cropping was still in the soil. Timmons and Cruse (1990) Reported that 16 to 27% soluble nitrogen applied to continuous corn was still in the soil. Most of the residual nitrogen fertilizers remaining in the soils were found in the organic nitrogen pool.

Reddi *et al*. (1973) reported that soya beans yields increased from 1.3-1.9 t/ha when the nitrogen applications in the proceeding rice crop (residual effect) increased from 0 to 180kgN/ha. This means that the residual effect of nitrogen fertilization is affected by so many variables and is therefore site specific. The fertilizer rate applied, leaching, immobilization, denitrification and rainfall patterns are likely to affect the magnitude of the residual effect.

Phosphorus and its Effects

Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. Phosphorus is, therefore, important in cell division and development of new tissue. Phosphorus is also associated with complex energy transformations in the plant. Adding phosphorus to soil low in available phosphorus promotes root growth and winter hardiness, stimulates tillering, and often hastens maturity.

It has been reported that an annual crop rarely takes up more than about 25% of the phosphate applied to it as fertilizer so that utilization of the residues by later crops are important. This is especially so for rock phosphate which may be poorly available to the crop to which it was applied. Phosphorus applied to potato showed a residual effect on phosphorus uptake by wheat (Table1). The overall results showed that phosphorus applied to potato at the economic rate left sufficient residual phosphorus to meet the need of succeeding wheat crops (Singh *et al*., 1997). According to the authors there was a significant interaction between the treatments applied to potato and the grain yield of the succeeding wheat crop (Table 2). In 1983, 22kg P/ha applied to potato resulted in positive residual effect on grain yield in crotolaria treatment. Wheat grown in plots green manure with sesbania showed residual effects in both years. The yield of wheat following pearl millet was lower than in any other treatment in 1983 compared to 1984. There was no significant residual effect in any of the maize treatments.

The effects of the application of three phosphate fertilizers namely: Ground rock phosphate (GRP),

Table 3. Mean effect of levels of P from different sources on exchangeable Ca (Meq/100kg) and % loss*(in parenthesis) at the end of three years of cropping at Samaru

Total P_2O_5 (Kg/ha)	GRP	GRP+S	SSP.
0	2.2(31)	2.3(28)	2.4(25)
100	2.7(16)	2.3(28)	2.2(31)
200	2.4(25)	2.2(31)	2.4(25)
300	2.4(25)	2.3(28)	2.9(09)
400	2.7(16)	2.5(22)	2.8(12)
SE±	0.15	0.18	0.16
Mean	2.5 (22.6)	2.3(27.4)	2.5(20.4)

Source: Mokwunye (1981); * Percentage of calcium prior to cropping (3.2 meq/100g)

Table 4. Mean effect of levels of P from different sources on exchangeable magnesium (meq/100g) and % Mg loss*(in parenthesis) at the end of 3 years of cropping at Samaru.

Total P_2O_5 (Kg/ha)	GRP	GRP+S	SSP.
0	0.63(35)	0.60(37)	0.65(32)
100	0.73 (23)	0.61(36)	0.59(38)
200	0.63(34)	0.59(38)	0.56(41)
300	0.65(32)	0.56(41)	0.62(35)
400	0.69(27)	0.63(34)	0.63(34)
SE±	0.07	0.09	0.08
Mean	0.66(30.2)	0.60(37.2)	0.61(36.0)

Source: Mokwunye (1981); * Percentage of Mg content prior to cropping (=0.95 meq/100g).

Table 5. Mean effect of levels of P from different sources on exchangeable potassium at the end of three years.

Total P_2O_5 (Kg/ha)	GRP	GRP+S	SSP
0	0.16 (27)	0.14 (36)	0.16 (27)
100	0.15(32)	0.12 (45)	0.13 (41)
200	0.14 (36)	0.13 (41)	0.12 (45)
300	0.14 (36)	0.13 (41)	0.13 (41)
400	0.13(41)	0.13 (41)	0.13(41)
SE ±	0.02	0.02	0.02
Mean	0.14(34)	0.13(41)	0.13(39)

Source: Mokwunye (1981); *Percentage of K content prior to cropping (= 0.22 meq/100g)

Ground Rock Phosphate Sulphur (GRP+S) and single superphosphate (SSP) on the amounts and ratios of exchangeable cations in Nigerian savanna soils were examined by Mokwunye (1981) at Samaru. The results indicated that after three years of continuous cropping the value of exchangeable calcium, Magnesium and potassium had fallen as shown in Tables 3, 4 and 5.

The mean loss of calcium was 22.6, 27.4 and 20.4 for GRP, GRP+S and SSP, respectively (Table 3). Highest mean Ca loss was recorded with GRP+S indicating that continuous use of this source could accelerate soil acidification with subsequent reduction in the response and yield of crops. Table 4 indicated that the loss of magnesium was more severe than the loss of calcium; while Table 5 showed the effect of P source on exchangeable soil K and it is clear that out of the three cations losses measured, the loss in K was highest. From the result presented it is evident that fertilizer residues in the soil could lead to loss of substantial amounts of exchangeable bases from the soil with subsequent reduction in the *pH* of the soil which is important for the growth, development and yield of crops.

The use of single super phosphate increased exchangeable calcium while addition of muriate of potash had little effect and the annual applications of 11-22kg/N/ha as ammonium sulphate seriously reduced the exchangeable calcium and Magnesium contents of savanna soils (Sharma *et al*., 1987). Reddi *et al*. (1973) reported that annual applications of calcium, potassium and Nitrogen (as urea) over three years significantly affected exchangeable cation ratios and subsequent crop yields in Samaru.

SUMMARY AND CONCLUSION

As fertilizer rates are increased, the efficiency of fertilizer nutrient use decreases leaving behind in the soil an increasing proportion of the added nutrient. This is more prominent in the northern part of Nigeria (savanna zone) where rainfall is generally inadequate and rate of weathering is high. Therefore, where the nutrient supplying power of the soil is already sufficient, adding fertilizer to the soil is likely to be damaging both to the soil and to environment. We recommend that the use of organic and inorganic fertilizers in the savanna agro ecological zone of Nigeria should be base on specific soil diagnoses to determine the need for adding nutrients.

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