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Estimations of NPK in Zero-Tillage Soils Post Soybean (*Glycine max* (L) Merr.) Croppings in Two Locations in Southwestern Nigeria

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Abstract: Field studies were carried out in 2 different soils (Alfisol and Ultisol) occupying Ajibode in Ibadan between latitude 07°0[1] and longitude 03°53[1]E and Ikorodu in Lagos between latitude 6° and 7[1]N and longitude 3 and 4°E, respectively in Southwestern Nigeria. To estimate NPK in zero-tillage soils after harvesting 2 croppings of soybean (*Glycine max* (L) Merr). With the aims of investigating this leguminous crop its potential to either increase or decrease these nutrients in different soils when cropped without inorganic fertilizer applications. The zero-tillage concept was introduced because it is assumed to encourage soil conservation in these soils suspected to be erosion prone. The NPK were used as test nutrients because of their significant to crop yields and to validate the zero-tillage practice, which was expected to reduce the depletion of NPK that are easily leached in these soils. The initial routine soil analysis before soybean croppings showed that both soils had low NPK content, when compared to critical levels for Southwestern Nigeria. The estimated NPK of both soils after harvesting the first and second soybean croppings, respectively showed increases of these nutrients when compared to initial values before the croppings. However, the Alfisol had higher values than the Ultisol. This might be related to a probable susceptibility of these nutrients to be leached in the Ultisol more than in the Alfisol due to variabilities of their ecological zones. The location (Ikorodu in Lagos) having Ultisol experiences more rainfall (annual rainfall of about 1029 mm, with a range of 1016-1270 mm) than the Ajibode in Ibadan with 1100, with a range of 980-1200 mm. Increased NPK in both soils might also have been encouraged by remains of soybean roots parts (debris) within the soil after harvest. These act as compost of plant origin, which upon decomposition by soil microbes probably increased organic matter and through mineralization helped to increase these nutrients. Similarly, it is expected that the soybean in association with the bacteria rhizobium japonicum fixes nitrogen. This study therefore, inferred that in these soils under zero-tillage after harvesting soybean croppings there were increased NPK in both soils with a reduction in erosion. Without which the soil NPK would had been reduced due to leaching.

Key words: NPK, soils, zero-tillage, soybean, Nigeria

INTRODUCTION

The assumed processes and soil properties characteristics of the soil orders (Alfisols and Ultisols) according to definitions of processes given by Buol *et al*. (1980), indicate that dominant processes are eluviation, illuviation, calcification of Alfisols whereas Ultisols are leaching, eluviation, illuviation. With both soils having properties of a coarse textured surface horizon overlying a horizon with a clay augmentation.

The most important crop nutrients in agricultural systems are Nitrogen (N), Phosphorus (P) and Potassium (K) (Chude *et al*., 2004). However, nitrogen might be lost in soils by leaching and volatilization, while phosphorus and K might be fixed or leached. Therefore, a farming method that encourages a maintenance or build up of these nutrients in the soil would be of great importance to farmers especially when poor resource farmers cannot afford the finances of soaring NPK inorganic fertilizer prices.

The zero-tillage concept has multiple benefits to farmers, such as soil conservation and maintenance of soil fertility. The system encourages less leaching of nutrients because the soil structure and texture are minimally disturbed, therefore there is soil aggregate stability (Hulugalle *et al*., 1991). Zero-tillage is a system of soil management that eliminates all preplanting seed bed preparation, except for the opening of a narrow (20-30 mm wide) strip or hole in the ground for seed placement to ensure seed-soil contact. The entire soil surface is covered by crop residue mulch or killed sod (Lal, 1983). Long-term studies for >10 years on sub humid and humid tropical Alfisols and Ultisols have shown that, compared with ploughing, zero-tillage improves soils and water conservation, reduces supra optimal soil temperatures, improves soil fertility, reduces soil compaction, increases the activity of beneficial soil funna and microfcora, reduces labour requirements and increases crop yields (Lal, 1983, 1987). However, there is still some paucity of results in these soils when crops are grown in zero tillage environments.

Soybean cropped in soils (Alfisols and Ultisols) with low nitrogen levels might perform well due to their ability to manufacture nitrogen in symbiosis with the bacteria Rhizobium japonium. Although, soybean might do well with applied P and K fertilizer. The objective of this study, therefore was to estimate the NPK in 2 different soils (Alfisols and Ultisols) at zero-tillage post soybean harvest in 2 locations in Southwestern Nigeria. That is to find out whether soil NPK were either increased or decreased in respect to a zero tillage system that is expected to discourage leaching by conserving the soil.

MATERIALS AND METHODS

The study was carried out, at 2 locations, Ajibode in Ibadan and Ikorodu in Lagos, both in Southwestern Nigeria. The soils studied represents 2 parent materials namely basement complex rocks (Granite) and sedimentary rocks (Coastal plain sands) formations (Soil Survey Staff, 1999). The classification of the soils in the 2 locations fall under Alfisols and Ultisols (Murdock *et al.*, 1976).

A random sampling scheme was used to collect representative composite core soil samples from pre-classified sites at the depth of 0-15 cm at the 2 locations. The soil samples collected were air-dired, crushed and sieved to poss through a 2 mm mesh after, which the following analyses were carried on them.

The soil pH by the procedures out lined by Mylavarapus and Kennelley (2002). Organic carbon by the Walkey and Black method (Nelson and Sommers, 1982). Nitrate-nitrogen was colorimetrically determined using phenol-2-4-disulphonic acid method (Jackson, 1970). The macro-kjeldhal method (Bremner and Mulvaney, 1982) was used for soil total -N. Available -P by the Bray P_1 method (Olsen and Sommers, 1982) and colour developed in soil extract using the ascorbic acid method (Murphy and Riley, 1962). Exchangeable (Na, K, Ca, Mg) were extracted with 1 N NH_4OAc buffered at pH 7.0 (Thomas, 1982). Exchangeable Na and K were read on an EEL flame photometer, Ca and Mg were read on an atomic absorption spectrophotometer. Exchangeable acidity was extracted with 1 N KCl (Thomas, 1982) and determined by titration with 0.05 N NaOH using phenolphthalein indicator. Summation of the exchangeable bases (Na, K, Ca, Mg) and exchangeable acidity gave the effective cation exchange capacity (Chapman, 1965). Extractable micronutrient (Mn, Cu Zn, Fe) were extracted with 0.1 N Hcl (Viets and Boawn, 1965) and determined using atomic absorption spectrophotometer.

First cropping: The experiment occupied an area of (30×30 m^2). This was cleared manually using matchets to expose the soil surface. A zero tillage was maintained. Soybean were planted using the drilling method 50 cm between rows. Variety TGx 536-02D was planted. This was done in July for both location, respectively. When the plants germinated and established they were observed to be crowded, a partial thinning was done to reduce the crowdiness. The soybean were rainfed with water and allowed to grow and mature. Weeding was done 3rd and 6th weeks of planting using traditional native hoes. Harvesting was done manually by cutting the above ground portions of the plants and threshing to get out the seeds. No yield measurements were taken since this was not the aim of this study. Rather the study concerned was the soil properties. After harvest a random soil sample was done. The soil was air dried, crushed, sieved with a 2 mm mesh and analysed.

Second cropping: The same sites were used for the second cropping at the next planting season. With similar operations carried out as in the first cropping. At the end random soil sampling was done and the soil prepared was analysed. The results of the soils were subjected to stastical analyses (Little and Hill, 1978) for the investigated nutrients.

RESULTS

The physicochemical properties of the soils initially before cropping and those after the 1st and 2nd croppings are shown in Table 1. Before cropping the initial level of the nutrients investigated (NPK) were relatively low N = 0.90 and 0.65 g kg^{-1}; p = 6.10 and 5.30 mg kg^{-1}; K = 0.24 and 0.19 cmol kg^{-1} for the Alfisol and Ultisol, respectively when compared to their critical levels, N = 1.50-2.00 g kg^{-1} (sobule and Osiname) (1981): p = 10.00-16.00 mg kg^{-1} (Agboola and Corey, 1973; Adeoye and Agboola, 1985); K = 0.16-0.20 cmol kg^{-1} (Hunters, 1975). For Southwestern Nigerian soil. There were however differences in these nutrient after the first and second croppings. A comparative view of the nutrients (NPK) is shown in Table 2. The nutrients results showed differences.

Table 1: Some chemical properties of the initial soils analyses before cropping and those after the first and second croppings

	Values							
Parameters	IBCA	AFCA	ASCA	IBCU	AFCU	ASCU	$\bar{X}$	LSD (5%)
pH (H_2O)	6.70	6.10	6.00	5.70	6.00	5.50	6.00	0.57
pH ($CaCl_2$)	5.60	6.00	5.85	5.15	5.00	5.10	5.45	0.59
Organic -C (g kg^{-1})	6.00	6.17	6.70	5.70	5.95	6.14	6.11	0.47
Organic -M (g kg^{-1})	5.90	6.14	6.35	4.65	4.20	5.80	5.50	1.23
Total -N (g kg^{-1})	0.90	1.24	1.73	0.65	1.06	1.55	1.18	0.57
Nitrite -N (mg kg^{-1})	5.30	5.75	5.90	5.00	5.09	5.29	5.38	0.50
C:N ratio	1:7	1:5	1:4	1:9	1:6	1:4	-	-
Available -P (mg kg^{-1})	6.10	5.35	6.90	5.30	5.87	6.00	6.08	0.74
Exchangeable bases cmol (+)/kg soil								
K^+	0.24	0.20	0.31	0.19	0.15	0.28	0.22	0.08
Na^+	0.09	0.07	0.07	0.06	0.06	0.05	0.06	0.02
Ca^{++}	0.27	0.29	0.32	0.19	0.22	0.29	0.26	0.06
Mg^{++}	0.24	0.21	0.19	0.15	0.15	0.11	0.17	0.06
Total Exch. Bases (TEB)	0.48	0.77	0.89	0.59	0.58	0.73	0.73	0.18
Exch. Acidity (mg kg^{-1})	0.47	0.39	0.29	0.55	0.49	0.35	0.42	0.13
E.C.E.C (mg kg^{-1})	1.31	1.16	1.18	1.14	1.07	1.08	1.15	0.12
Extractable Mn (cmol kg^{-1})	1.94	1.70	1.50	1.14	1.05	0.92	1.37	0.56
Extractable Cu (mg kg^{-1})	0.21	0.19	0.25	0.18	0.19	0.14	0.19	0.05
Extractable Zn (mg kg^{-1})	0.45	0.31	0.40	0.39	0.42	0.38	0.39	0.06
Extractable Fe (mg kg^{-1})	1.13	1.20	1.30	1.24	1.32	1.29	1.24	0.10

IBCA = Initial Before Cropping in Alfisol; AFCA = After First Cropping in Alfisol; ASCA = After Second Cropping in Alfisol; IBCU = Initial Before Cropping in Ultisol; AFCU = After First Cropping in Ultisol; ASCU = After Second Cropping in Ultisol

Table 2: NPK content of soils before and after first and second soybean croppings

	ABC^0	UBC^0	AFC^1	UFC^1	AFC^2	UFC^2	$\bar{X}$	LSD (5%)
Nitrogen	0.90	0.65	1.24	1.06	1.73	1.55	1.18	0.57
Phosphorous	6.10	5.30	6.35	5.87	6.90	6.00	6.08	0.74
Potassium	0.24	0.19	0.20	0.15	0.31	0.28	0.22	0.08

N = g kg^{-1}; P = Mg kg^{-1}; K = cmol kg^{-1}. ABC^0 = Alfisol Before Croppings; UBC^0 = Ultisol Before Croppings; AFC^1 = After First Croppings; UFC^1 = Ultisol after First Croppings; AFC^2 = Alfisol After second Croppings; UFC^2 = Ultisol After second Croppings

DISCUSSION

The initial routine analysis of both (Alfisol and Ultisol) soils before soybean cropping showed that the nutrients NPK investigation were relatively low, after the first and second cropping the nutrients level of N was relatively increased in both soils. Significant (p = 0.05) differences between the initial soils N levels and that after the croppings were observed with values after the second cropping to be higher than those after the first cropping. This suggest that a second cropping of soybean in both soils might be necessary to increase the soil N content that would be within the levels for southwestern Nigerian soils. The available P in the soils after both cropping was not significantly (p = 0.05) increased. Even before cropping the soils had low P content when compared to the critical level in southwestern Nigerian soils. After cropping there were changes in the K level in the 2 soils. In both soils, there was an initial decrease in the K content after the first cropping, then after the second cropping there was an increase. This might had been released from the fixed K in the soils. In soils of the humid tropics the occurrence of a gradual release of K is sometime observed.

From this study it might therefore be inferred that when zero-tillage is practiced with soybean cultivation after 2 continues croppings, soybean would encourage a gradual N build up within the soils, especially when the initial N level is low. However, P and K might be applied depending on their status in these soils. The zero-tillage process encourage the maintenance of the soil N that might had been depleted.

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