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EFFECTS OF DIFFERENT ORGANIC MATERIALS AND NPK FERTILIZER ON THE PERFORMANCE OF MAIZE

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SUMMARY

The interest in organic materials as soil fertility restorer is increasing due to the high cost and unavailability at the right time of inorganic fertilizer and the problem associated with residue disposal by burning which can further aggravate global warming. The effects of different organic materials and NPK fertilizer on the performance of maize were examined in field experiments carried out at the Teaching and Research Farm of the Ambrose Alli University, Ekpoma in a forest savanna transition zone of Edo State, Nigeria. The investigations were carried out during the 2008 and 2009 cropping seasons and involved the use of organic materials (wood shavings, rice hulls, kola husks and their combinations) and NPK fertilizer. The layout of the experiment was a randomized complete block design with three replicates. The results indicated that most of the organic materials, especially kola husk and mixtures with kola husk and NPK increased yield and its components. The treatments significantly increased the concentrations of N, P, K and Na in ear leaves and grains.

Key-words: maize yield, wood shavings, rice hull and kola husk

INTRODUCTION

Maize (*Zea mays* L.*)* is an important cereal crop in the rain forest and savanna zones (Gazel and Khan, 2005). It is well adapted to the humid condition and the traditional methods of cultivation in the topics. As a result of increase in population pressure, soil nutrients are gradually depleted by farmers who are unable to sufficiently compensate losses by returning nutrients to the soil via crop residues, manures, fallowing and mineral fertilizers (Feng and Liv, 2009). The low yield of maize varieties in Nigeria has been partly attributed to depletion of organic matter and soil nutrients (Lal and Greenland, 1979). The research attention in tropical countries has shifted to the utilization of agro-industrial and organic wastes which can pose environmental hazards if not converted to agricultural and economic use (Ayeni, 2010); these materials include city wastes, animal wastes and crop residues.

Several studies have been carried out on the fertilizer requirement of maize (Remison and Omueti, 1982; Remison and Lucas, 1982; Iremiren, 1989; Remison and Fajemison, 1989; Remison, 1990). The general fertilizer recommendation for the crop in Nigeria is 300 kg/ha of NPK though this depends on the fertility status of the soil. However, most farmers are not economically endowed to invest on fertilizers. The alternative means of boosting the fertility status of the soil is to apply organic materials such as crop residues, manures and compost. They have great potentials for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Malaiya et al., 2004). Incorporation of rice husk into the soil was found to affect many crops (Sharma et al., 1988). The use of rice husk as an organic fertilizer can play a vital role in improving soil physical conditions and provide soil nutrients (Ebaid and El- Refaeee, 2007). However, not much work has been done on the use of various types of organic materials that abound in most farming communities in Nigeria. In oil palm Estates, shredded oil palm (*Elaeis guineensis*) bunch refuse is used routinely as soil amendment, especially in the nursery. Similar use could be made of heaps of other organic materials like kola (*Cola spp.*) husk, rice (*Oryza sativa*) hull, wood shavings etc. lying around in many communities for raising arable crops.

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The need for sustainable agriculture has indeed led to a renewed interest in recycling of crop residues as sources of soil organic matter and plant nutrients in restoring soil fertility and sustaining crop productivity. This investigation was therefore designed to study the effects of some organic materials (wood shavings, refuse, rice hull and kola husk) on the performance of maize.

MATERIAL AND METHODS

The experiments were conducted at the Teaching and Research farm of Ambrose Alli University, Ekpoma on Latitude 6^0 45^1 N and Longitude 6^0 08^1 E in a forest - savanna transition zone of Edo State, Nigeria. The area is characterized by a bimodal rainfall pattern, which starts in late March and ends in late July while the short rainy season extends from September to late October after a dry spell in August. The soil order is an Acrisol and the site is classified locally as kulfo series (Moss, 1957). The experiments were carried out during the wet seasons of 2008 and 2009 respectively. A composite soil sample was collected from 0-30 cm depth prior to planting to determine the pH and the nutrient status of the soil. Soil pH was analyzed in 1:2 water, total N content was determined by Kjeldahl method (Bremner, 1965); available phosphorus was analyzed using the Olsen method (Olsen and Sommers, 1982) and exchangeable cations was determined by standard procedures (AOAC, 1980). Details of the chemical composition of the soils are shown in Table 1.

Table 1. Chemical properties of the soil at the experimental site

Tablica 1. Kemijska svojstva tla na pokusnoj parceli

Year	Soil pH	Percent			Ppm	cmol/kg soil			
		Org. C	Org. matter	Total N	P	K	Ca	Mg	Na
2008	6.90	1.05	1.10	0.09	6.99	0.32	5.04	0.96	0.79
2009	6.97	0.87	0.99	0.13	8.01	0.31	4.95	0.84	0.61

In the first experiment subsequently referred to as Expt. 1, the site was cleared of existing vegetation and packing of the debris was carried out before it was marked into plots. The site was cropped to cassava (*Manihot esculenta*) in the previous season. Tilling of the soil was carried out by using hoes and planting was done on the 8 April, 2008 using Swan 2-SRY maize variety at a spacing of 75cm between rows and 25 cm within rows, in plots of 3 x 4.5 meters. Sowing was done on the flat at the rate of two seeds per hill, and thinned two weeks later to one seedling per stand to give 53,000 plants per hectare. Organic materials used were wood shavings, rice hull, kola husks and their combinations. The organic materials were applied at the rate of 10t/ha to the plots two weeks before planting. NPK 15:15:15 fertilizer was also applied at the recommended rate of 300 kg/ha by side placement at two weeks after planting. The control treatment had no fertilizer or organic materials added. The experimental design was a randomized complete block with three replicates. Data were collected on vegetative traits (plant height, ear height, stem diameter, number of leaves, and ear leaf), lodging, yield and yield components. Plant height was assessed by measuring the height of the plant from the base to the crown by using a measuring tape; ear height was determined by measuring height of the plant from the base to the point of the first ear. The stem diameter was measured by using a digital vernier caliper. The number of leaves per plant was assessed by taking a visual count of the green leaves. The lodging at silking and at harvest were determined by taking a visual count of the lodged plants at silking and at harvest and the leaf area was estimated as leaf length multiplied by the widest width, multiplied by a constant 0.75 (Watts, 1973; Moll and Kamprath, 1977).

The second experiment, subsequently referred to as Expt 2, was similar to the first; it was sown on the 8 April, 2009 at a site previously cropped to cassava *(Manihot esculenta*). Weeds were manually controlled in both experiments at 3 and 7 weeks after planting. Data were also collected on vegetative traits, dry matter yield, grain yield and yield components. Chemical analyses for N, P, K, Mg, Ca and Na were carried out on the ear leaves and grains after oven drying at 80ºC for twenty four hours and milling.

RESULTS AND DISCUSSION

In Expt 1, plant height, number of leaves and ear leaf area were not affected by the application of some organic residues (wood shavings, rice hull and kola husk) applied but ear height of plants increased significantly ($P<0.05$) in plots treated with NPK and a combination of wood shavings and rice hull (Table 2). Similarly the diameter of plants treated with NPK, kola husk and combinations of rice hull and kola husk increased relative to control treatments.

The percentage of lodged plants were generally very few and significantly ($P<0.05$) less in plots treated with NPK, rice hull and kola husk at harvest (Table 2). NPK, rice hull plus kola husk and wood shavings plus rice hull significantly ($P<0.05$) increased the number of ear relative to the control. All the treatments significantly ($P<0.05$) increased grain yield, especially the combination of wood shavings and kola husk which out yielded the control by over 100% (Table 2). The treatment had no effect on the shelling percentage.

Table 2. Effects of different organic materials and NPK fertilizers on maize status (Expt. 1)

Tablica 2. Utjecaj različitih organskih tvari i NPK gnojiva na status kukuruza (Pokus 1.)

Treatment	Morphological properties of maize at silking						Lodging (%)		CN 100 p	GY (kg/ha)	Shelling (%)
	Plant height (cm)			Stem diameter (cm)	Leaves number	ELA (cm^2)	LS	LH			
	Total	To cob	Above cob								
A	154	62	92	2.0	10	501.3	2.5	10.0	71	2244.5	63.0
B	162	71	91	2.44	12	576.8	2.5	5.0	94	4240.0	75.0
C	142	61	84	2.31	11	483.2	3.3	7.5	76	3604.1	74.0
D	151	55	96	2.28	11	463.8	1.7	5.8	79	3851.3	71.0
E	165	68	97	2.45	11	554.3	1.7	4.2	76	4063.3	65.0
F	171	75	96	2.17	12	539.7	2.5	9.2	88	3886.7	77.0
G	165	68	97	2.35	11	527.7	3.3	7.5	82	4558.0	79.0
H	149	61	88	2.42	12	558.0	1.7	8.3	91	3745.3	70.0
Mean	157.4	65.1	96.6	2.30	11.3	525.6	2.4	7.2	82.1	3774.2	71.8
SE±	9.5	6.5	4.8	1.19	0.6	56.3	0.68	1.49	7.8	664.27	8.12

A = control; B = NPK; C = wood shavings; D = rice hull; E = kola husk; F = C+D; G = C+E; H = D+E; ELA = the ear-leaf area; LS = lodging at silking; LH = lodging at harvest; CN 100 p = cobs number in 100 plants; GY = grain yield

In Expt 2, there were generally no increase in plant height after 50% tassel; the treatment with wood shaving plus kola husk had the tallest plants (Table 3). The treatments had no effect on the number of leaves. Leaf senescence after 50% tassel was however clearly apparent especially after 28 days of 50% tassel. At 42 days after tasselling, the decrease in the number of green leaves was generally over 40% in the treated plots (Table 3).

Table 3. Effects of different organic materials and NPK fertilizers on height of maize plant (Expt. 2)

Tablica 3. Utjecaj različitih organskih tvari i NPK gnojiva na visinu biljke kukuruza (Pokus 2.)

Treatment		Maize properties in stages: 50%t (50% of tassel appearance) and number of days (14, 28 and 42) after tasseling (LNP =leaf number per plant)								
		Plant height (cm)				Leaf senescence (LNP)				
		50% t	14	28	42	50% t	14	28	42	-% at 42
A	Control	157.8	158.0	147.0	147.3	10.0	11.3	10.0	6.3	37
B	NPK	163.0	166.1	166.4	166.0	11.5	10.8	9.5	6.3	45
C	Wood shavings	162.5	164.0	164.0	163.5	11.3	11.3	10.0	4.5	60
D	Rice hull	161.3	166.5	168.3	166.5	11.5	11.5	10.8	5.3	54
E	Kola husk	174.5	178.8	181.0	178.8	11.3	10.8	8.8	3.8	66
F	C + D	178.0	180.0	181.0	180.0	11.8	11.5	10.0	6.0	49
G	C + E	181.3	181.0	182.3	182.3	11.8	12.5	10.3	6.8	42
H	D + E	168.8	160.3	171.3	160.3	11.8	11.3	10.3	4.8	59
Mean		168.4	169.3	170.2	168.1	11.4	11.4	10.0	5.5	51.5
SE±		10.79	8.58	6.86	5.66	0.58	0.65	0.77	1.33	

As observed in Expt 1, plants treated with NPK, kola husk or kola husk plus wood shavings had thicker stemmed plants than the control (Table 4). Only NPK application have significantly ($P<0.05$) affected ear leaf area. The partition of dry matter to the leaves increased with the application of NPK, rice hull and kola husk and to the stem by all the treatments.

Total dry matter (TDM, without the ear) was also similarly increased by the treatments, especially kola husk, which increased TDM by 64% (Table 4).

The number of ears was significantly ($P<0.05$) more in plots treated with NPK and wood shavings plus kola husk (Table 4). Grain yield also increased with the treatments especially wood shavings plus kola husk, which increased yield by 82, 79, 68 and 57% respectively. The treatments had no effect on shelling percentage.

Table 4. Effects of different organic materials and NPK fertilizers on morphological traits, dry matter yield and grain yield of maize (Expt 1)

Tablica 4. Utjecaj različitih organskih tvari i NPK gnojiva na morfološka svojstva, prinos suhe tvari i prinos zrna kukuruza (Pokus 1.)

Treatment		Plant diameter (PD), the ear-leaf area (ELA), number of ears of 100 plants (E100), grain yield (GY) and shelling							
		PD (cm)	ELA (cm^2)	Dry matter (g/plant)			E100	GY (kg/ha)	Shelling (%)
				Leaves	Stem	Total			
A	Control	2.01	574.8	60.9	75.1	136.0	74	2650.1	71.6
B	NPK	2.59	677.8	110.6	109.5	220.1	98	4740.9	79.2
C	Wood shavings	2.06	504.9	63.6	110.3	173.9	86	4452.3	77.1
D	Rice hull	2.11	519.8	120.3	100.7	221.0	77	3773.6	76.3
E	Kola husk	2.44	628.4	109.9	112.6	222.5	89	4155.6	78.1
F	C + D	2.13	576.3	90.8	110.2	201.0	95	3243.6	77.9
G	C + E	2.45	515.9	90.3	94.3	184.6	110	4812.4	79.8
H	D + E	2.30	530.5	75.8	94.9	170.7	93	3773.6	77.3
Mean		2.26	566.05	81.98	100.9	191.2	90.2	3950.3	77.2
SE±		0.188	36.26	6.78	8.74	16.08	8.7	688.31	7.94

The concentration of N in ear leaf significantly ($P<0.05$) increased with the application of NPK and wood shavings relative to the control (Table 5). Treatment with wood shavings, wood shavings plus rice hull and NPK significantly ($P<0.05$) increased P content. The concentration of K increased with the application of NPK and kola husk while Ca increased with NPK, wood shavings plus kola husk and rice hull plus kola husk. The treatment had no effect on Mg content. All treatments in which wood shavings were present increased Na content. The level of N in the grain was similar to that in the ear leaf and treatments with NPK, kola husk and wood shavings plus rice hull had the highest levels (Table 5). The concentration of P was significantly ($P<0.05$) increased with NPK, wood shavings plus kola husk while K increased with all the treatments. The concentration of Ca and Mg were not affected by the treatments but Na increased with rice hull, kola husk and a combination of both.

There was leaf senescence after 50% tassel and senescence at 42 days after tasselling was most pronounced in plots receiving kola husk amendment. Plants in these plots showed higher productivity than other treatments and the only possible explanation of the high senescence in this period may be the rapid translocation of metabolites from the leaves to the grain sites. Allison (1969) reported that a greater transfer of metabolites to the grain can result in deficiency of carbohydrates in the leaves which may hasten senescence.

In this study, stem diameter, dry matter yield and yield components increased with organic waste amendments, especially kola husk or combinations in which kola husk was present. The increase in the performance of maize with some of these amendments shows that substantial quantities of nutrient elements were released into the soil for uptake by the maize plants.

Table 5. Effects of different organic materials and NPK fertilizer on nutrient concentration (%) in ear leaf and grain of maize (Expt. 2)

Tablica 5. Utjecaj različitih organskih tvari i NPK gnojiva na koncentraciju nutrijenata (%) u komušini i zrnu kukuruza (Pokus 1.)

Treatment	Impacts of fertilization (A – H) on leaf and grain composition											
	The ear-leaf (% in dry matter)						Grain (% in dry matter)					
	N	P	K	Ca	Mg	Na	N	P	K	Ca	Mg	Na
A	1.12	0.07	0.46	0.31	0.54	0.04	1.10	0.72	0.40	0.58	0.16	0.06
B	1.63	0.35	1.17	0.60	0.47	0.03	1.60	0.95	0.57	0.51	0.11	0.04
C	1.40	1.17	0.02	0.44	0.45	0.10	1.27	0.84	0.48	0.51	0.10	0.05
D	1.15	0.16	0.65	0.38	0.43	0.06	1.33	0.77	0.56	0.48	0.14	0.43
E	1.25	0.11	0.80	0.38	0.43	0.09	1.57	0.72	0.48	0.61	0.10	0.23
F	1.17	1.18	0.72	0.44	0.51	0.10	1.47	0.74	0.48	0.61	0.19	0.05
G	1.26	0.07	0.05	0.76	0.49	0.10	1.44	0.87	0.54	0.58	0.18	0.06
H	1.26	0.11	0.37	0.76	0.35	0.05	1.44	0.67	0.43	0.51	0.10	0.21
Mean	1.28	0.40	0.53	0.51	0.46	0.07	1.40	0.81	0.45	0.55	0.14	0.14
SE±	0.074	0.021	0.155	0.077	0.051	0.007	0.051	0.022	0.039	0.016	0.014	0.039

A = control; B = NPK; C = wood shavings; D = rice hull; E = kola husk; F = C+D; G = C+E; H = D+E

Titiloye et al. (1986) showed that organic materials enhanced maize yield due to release of nitrate N and ammonium N. They noted this release increased gradually up to the 4th and 6th weeks for NH_4-N and NO3-N respectively.

The purpose of applying wood shavings, rice hull and kola husk as organic materials will help to conserve and improve the biological and physical-chemical properties of the soil, to obtain increase availability and utilization of plant nutrients. Bahrani et al. (2007) reported that the incorporation of plant residues and manures not only improved the physical-chemical properties but also increased the yield of maize. Organic matter is a reservoir of chemical elements essential to the growth of plants and during its decay in the soil, plant nutrients are gradually released and changed into forms available to the plants. This is essentially true of carbon and nitrogen, and to a lesser degree of phosphorus, iron, sulfur and other elements (Anon, 1982). Apart from nutrient relationships, organic matter influences soil productivity indirectly, well decomposed organic matter increases the cohesion of sandy soils and together with coarse raw organic matter, decreases that of clay soils. It also improves soil structure, aeration, the water holding capacity and permeability, as well as erosion resistance.

The presence of higher concentration of some of the elements, especially N, P and K and Na in ear leaf and grain (Table 5) confirm that substantial quantities were indeed released into the soil for uptake by maize. Plots receiving NPK application also had concentrations of most of the elements. The concentration of Ca in the leaves dry matter was in consonance with the findings of Jones (2003). It has frequently been demonstrated that increasing the concentration of a given element in the medium in which a plant is growing, generally increased the quantity of that element in the plant. In previous experiments, we had shown that the concentration of N in ear leaf and stover of maize increased with increase in N application though P and K were significantly affected (Remison and Fajemisin, 1982; Remison, 1990). Corrcia et al. (2005) confirmed that manure provided maize with nitrogen requirement for optimum vegetative and reproductive growth. Iremiren (1989) also found out higher N contents in the ear leaf of maize in plots in which N fertilizer was applied, reflecting effective uptake of the nutrient. The result is also in consonance with the findings of Rasool et al. (2008) that grain yield and uptake of N, P and K by maize were higher when organic manures were applied.

From the results of this study, it is clear that there are enormous potentials in the use of crop residues and other organic materials for restoring soil fertility and sustaining crop productivity. They could be used alone or in combination with conventional fertilizers in areas where the soils are very impoverished.

CONCLUSION

The results of the experiments clearly indicated that the use of organic materials can be gainfully employed in soil fertility restoration by small scale farmers, especially kola husk and mixtures with kola husk and NPK as their combinations increased yield and its components. The treatments also significantly increased the concentrations of N, P, K and Na in ear leaves and grains.

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UTJECAJ RAZLIČITIH ORGANSKIH TVARI I NPK GNOJIVA NA PERFORMANCE KUKURUZA

SAŽETAK

Interes za organskim tvarima koje poboljšavaju plodnost tla povećava se zbog visoke cijene i pravovremene nedostupnosti anorganskoga gnojiva, a taj je problem povezan sa zbrinjavanjem ostataka koji se spaljuju, što može dodatno pogoršati globalno zagrijavanje. Utjecaj raznih organskih tvari i NPK gnojiva na performanse kukuruza ispitan je u poljskim pokusima provedenim na farmi za istraživanje Sveučilišta Ambroze Alli, Ekpoma u području prelaska šume u savanu u državi Edo, Nigerija. Istraživanja su se provodila tijekom vegetacije 2008. i 2009. godine, a obuhvatila su uporabu organskih tvari (drvene strugotine, rižine i koline ljuskice, kao i njihove kombinacije) i NPK gnojiva. Pokus se provodio prema slučajnome potpunome blok rasporedu u tri ponavljanja. Rezultati su ukazali na to da su većina organskih tvari, naročito ljuskice kole i njihove mješavine, kao i NPK gnojivo, povećali prinos njegove komponente. Ti su postupci značajno povećali koncentracije N, P, K i Na u komušini i zrnu.

Ključne riječi: prinos kukuruza, drvene strugotine, rižine i koline ljuskice

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