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Farming systems and nutrient integration effect on soil nutrient dynamics and yield of maize

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Abstract

Experiments were conducted to examine soil nutrient dynamics under different farming systems and nutrient sources on maize yield. It was a split plot fitted into RCBD with three replicates. Main plots included two cropping systems (CS) (maize and groundnut fallow): sub-plots; groundnut residue (GNR), maize residue (MZR), Cow dung (CD), pig manure (PGM); four composts; (PGM+MZR, PGM+GNR, CD+GNR and CD+MZR) each at 5 t/ha; NPK at 120 kg/ha, and (Co) control. Nutrient content of the soil were measured under groundnut fallow (GF) and continuous maize cropping system (CMCS), nutrient sources and yield at harvest. Data collected were subjected to analysis of variance and means separated by Duncan Multiple Range Test at 5% probability level. The CS impacted nutrient dynamics, with increased of 31.25% N, 8.25% P and 35.45% K from GF with reduction of 33.33% N and 19.35% K but increase of 3.98% P in CMCS. Composted waste (GFCW) gave an efficient and better performance relative to CMCS. The use of PGM+GR improved grain yield (5.6 t/ha) than others and better than Cos (GC0 and MC0) by 149.6% and 171.9% in 20. The residual implies GPGM +GR had the highest N% (0.84%) in soil which was 381.8% and 466.7% higher than the Cos. GF improved soil chemical properties than CMCS and enhanced yield response of maize to organic amendments. The residual implied GPGM+GR had the highest N% (0.84%) in soil with 381.8% and 466.7% higher than the Cos. Hence, GPGM+GR is recommended for maize production.

Key words: Soil nutrient dynamics, Farming system, lntegrated nutrient management, Maize yield

Introduction

Continuous crop production without external nutrients input rapidly depletes the soil and thus, the soil suffers multi-nutrient deficiencies (Adekunle et al., 2013). Generally, tropical soils have low resilience therefore corrective measures following continuous use of fertilizers may be expensive. As a result, farmers use both the available organic sources and the affordable amount of chemical fertilizers to cut down the high cost of chemical fertilizers for higher crop yields. Optimizing the use of these alternative nutrient resources should be a target for work that seeks to support future food production, in order to reduce reliance on externally-derived inorganic fertilizer resources and to better close the loop on farm nutrient cycles (Petersen et al., 2007).

The resulting depletion of nutrients from soils has caused crop production to stagnate or decline in many African countries. In some cases, the rate of depletion is so high that even drastic measures, such as doubling the application of fertilizer or manure or halving erosion losses, would not be enough to offset nutrient deficits. Unless concerted effort is made towards confronting the problems of nutrient depletion, deteriorating agricultural productivity will seriously undermine the foundations of sustainable economic growth in Africa. Thus, to achieve intended goals, fertilizer use must be combined with a broad spectrum of complimentary practices, such as soil conservation, recycling of crop residues, livestock management, and use of organic fertilizers. The ultimate goal is to tailor the fertilizing regime to the soil, climate and crops in a way that offers both good yield and a healthy product with a high nutrient value.

However, for farming system to be sustainable, it must address issues of environmental, economic and social sustainability in its approach apart from input consideration. Hence, the need to adopt production systems that are environmentally friendly especially in food production marks the beginning of organic farming (Bello & Adekunle, 2013). One of the major problems of tropical soils is the low organic matter content. Thus, a major objective of scientists in the region is to develop cropping systems that would maintain or even increase soil organic matter. Increasing soil organic matter by organic farming has the added benefit of improving soil quality and thereby enhancing the long-term sustainability of agriculture (Laird et al., 2001).

Cropping system and nutrient integration has attracted considerable interest as a sustainable technology for improving soil fertility in the tropics; information on their potential to amend infertile sandy loam soils under maize cropping system in the derived savannah zone of the tropics is rather limited. Furthermore, many traditional sources of organic amendment like crop wastes, animal manure and cropping systems available in Nigeria, which by and large remain under exploited for integrated nutrient management. Thus, the use of these residues, wastes and cropping system for soil restoration as well as crop productivity might be ecologically promising. The present study therefore, aimed to address the potential of integrated nutrient management under different farming system on soil nutrient dynamics and maize yield in south western part of Nigeria.

Material and Methods

The experiment was conducted at the Teaching and Research Farm, Oyo State College of Agriculture and Technology, Igbo-Ora, Nigeria between November 2014 and June, 2015 and June and October 2016. The fields used had been under continuous cropping for more than ten years and were cleared, ploughed and harrowed. Top soil (0-15 cm depth) samples were taken randomly on the field before planting, after groundnut and maize cultivation before treatments application and after planting. The soils were bulked to form a composite. The soil was air-dried and sieved to pass through 2 mm mesh-size sieve and taken to the laboratory for routine soil analysis. Selected physico-chemical properties of the experimental plots are presented in table 1.

The production of cow-dung and swine manure based compost with groundnut and compost preparation commenced by collecting cow dung from the cattle pen, while swine dung also collected from the piggery pen. The collection was done on the 21st of December 2013, and taken to the farm where it stayed for three weeks. The maize materials collected after harvesting at 13 weeks and the maize stovers were cut into pieces using cutlass and heaped together on the 2nd of November, 2013, and stored till compost preparation began. Similarly, the groundnut plants were also harvested with hoes and cutlass. The groundnut pods were detached and dried separately with the maize stovers. The pods were opened and the pods with other parts (shoot, root and leaves) were properly dried and stored for compost preparation for the next planting season.

The trials were laid out in a split plot fitted into randomized complete block design (RCBD) replicated three times. Each plot measured 3x3 m with 1 m gap between plots and 3 m space between farming system. The experiment consisted of sixteen treatments; No fertilizer (control 1 & 2, MCO no fertilizer on maize fallowed plot & GCO No fertilizer on groundnut fallowed plot), composts (PGM+MR), (Pig+maize), CD+MR cow-dung maize, PGM+GR (Pig+groundnut) and CD+GR cow-dung groundnut base composts), pig manure (PGM) and cow-dung (CD) manures, groundnut residues (GRR), maize residues(MRR) all at t/ha. Full dose of NPK 20:10:10 was applied at 120 kg/N/ha. Poultry manure (PM) was collected from manures that had been left to decompose for five months on the farm while both cow-dung (CD) and pig manures (PGM) were evacuated from the College farm during daily cleaning and deposited outside the ranch. The manures and compost were applied two weeks before planting. The proximate analysis of the manures were carried out before addition to reveal their nutrients. The plots were weeded manually with the use of hoes whenever necessary throughout the experimental period. Maize was planted at a distance of 1x0.25 m with 3 seeds/hole and at thinned to one 3 weeks after planting (WAP). Hoe weeding was carried out three times before harvest.

Maize was harvested at 14WAP and was sun-dried to 14% moisture content. The yield characters evaluated were weight of grain, number of seeds per cob, cob weight and cob diameter. Ear leaf samples were collected per treatment each site, bulk, oven-dried at 70^0 C for 24 hrs, milled and ashed for 6 hrs at 500^0 C. Nutrients were extracted using nutricperchloric acid mixture (Tel & Hargerty, 1984) and N was determined by Kjeldahl method. The P in the extract was determined using molybdenum blue colorimetry and read on spectrometer. The EDTA titration method was used to evaluate Ca and Mg while K and Na was analyzed using flame photometer.

The analysis of variance (ANOVA) procedure was used to evaluate the treatment effects. Mean values were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability. The analysis of variance (ANOVA) procedure was done to evaluate the treatment.

Result

Table 1 shows the results of soil analysis before the study, at maize and groundnut harvest plots respectively. The pre-soil analysis before planting at the experimental site is slightly acidic, low in organic matter, nitrogen, P, K, deficient in Ca, Mg and Na. However, the result of the soil analysis after maize cultivation indicates an increase in the soil pH value while the organic matter, N, K, Ca, Mg and Na content of the soil were lowered with the exception of P nutrient that was slightly raised and the acidity was increased.

There was a reduction in the soil acidity value at the groundnut cultivated plots while the Organic matter, N, P, Ca, and Mg content were raised. Also, the Na and acidity values were reduced with the exception of Mn amount that was maintained compared with the initial values before cultivation.

The proximate analysis of the waste and their compost are presented in table 2. Piggery groundnut compost had the highest nitrogen (N) content of 0.005 g/kg followed by maize compost (0.004 g/kg). Phosphorus (P) was highest in piggery groundnut compost followed by piggery maize compost and piggery manure. Piggery groundnut compost had the highest K content and maize residue recorded the least. Compost were however higher than the

Table 1. Physical and chemical analysis of the site before and after maize and groundnut production in the sub plots

Elements	Pre-planting Analysis	After-Maize cultivation	After-Groundnut cultivation
$pH_{(H20)}$ 1:2	6.67	5.74	6.85
Organic C%	1.56	1.32	1.66
N%	0.16	0.12	0.21
C/N ratio	9.75	11	7.9
P ($mgkg^{-1}$)	17.6	18.3	19.1
Exchangeable Bases			
Ca ($cmolkg^{-1}$)	3.3	2.7	3.6
Mg ($cmolkg^{-1}$)	0.40	0.30	0.45
K ($cmolkg^{-1}$)	0.31	0.25	0.42
Na ($cmolkg^{-1}$)	0.37	0.19	0.27
Exchangeable Acidity (Al^{3+}+H^{+})	0.42	0.51	0.35
Mn ($cmolkg^{-1}$)	0.2	0.16	0.21
CEC($cmolkg^{-1}$)	4.58	3.60	4.95
Particle Size - Analysis (g/kg)			
Sand	744	744	744
Silt	136	136	136
Clay			
Texture Sandy loam	120	120	120

other organic materials, which means composts are richer than un-composted waste in terms of nutrient amount and availability. Although the chemical analysis of crop residues indicated that groundnut residue had higher values of total nitrogen content (0.001 g/kg), Av. P (0.006 g/kg) and K (0.053 g/kg) compared with maize stover residues which had N of 0.001 g/kg, Av. P (0.004 g/kg) and K (0.044 g/kg).

The N g/kg indicated that groundnut quality is better than maize waste and considering the magnitude of the essential nutrients in these residues. The result of the farm yard manures showed that piggery manure had higher N, P and K content compared with that of cow-dung manure respectively. Therefore, piggery manure was higher in the major nutrients required for growth of crops. The application of piggery manure and its compost are expected to improve fertility of the experimental soils and yield of maize.

There was no significant difference between CD-comp and GR for grain weight result on both fallow plots and similar response was shown with CD and MR with respect to weight and same between GR, CD and CD+MR, and MRR, GCO in the case of grain number per sample. With the grain weight/cob, there was no significant difference between NPK and PGM+GR, CD+GR; PGM, CD and MRR respectively.

In terms of total grain yield and cob yield (t/ha), the highest value was obtained from plant treated with both NPK (6.20 t/ha) and (5.51 t/ha) on groundnut and maize plot followed by PGM (5.76 t/ha and 5.04 t/ha) on similar plots.

Table 2. Proximate analysis of the crop residues, manures and their compost

Organic materials Total	N available P	P (g/kg)	K
Piggery manure	0.003	0.015	0.057
Cow-dung manure	0.003	0.006	0.053
Maize residue	0.001	0.004	0.044
Groundnut residue	0.001	0.006	0.053
Cow-dung maize compost	0.004	0.009	0.054
Cow-dung groundnut compost	0.004	0.010	0.056
Piggery maize compost	0.004	0.015	0.059
Piggery groundnut compost	0.005	0.016	0.063

Table 3. Response of yield to crop residue management, NPK, animal manures and their integration on maize performance

	Grain Wt./cob (kg)		Grain No/cob		Grain wt (t/ha)	
Treatment	Gf	Mf	Gf	Mf	Gf	Mf
Control	0.27fg	0.19g	361.00e	290.00f	3.85fg	3.35g
CD –comp	0.31c-f.	0.31cdef	469.33abc	429.00bcd	6.15a	5.51ab
CD	0.31c-f	0.29ef	380.00de	376.33de	4.43de	4.07ef
G-residues	0.33b-f	0.33bcdef	396.67de	429.00bcd	4.68cd	4.52cd
M-residues	0.30def	0.28ef	377.67de	348.67ef	5.15bc	4.43de
NPK	0.42a	0.39abc	508.00a	507.67a	6.20a	5.51ab
PGM	0.34abcdef	0.35a-f	469.33abc	439.33bcd	4.93bcd	5.40bc
PGM-comp	0.40ab	0.35a-f	447.00ab	439.33bcd	5.76ab	5.04bcd

Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT

Where: Gf=groundnut fallow plot, Mf=maize fallow plot, CD-comp=cow dung manure compost, PGM-comp=pig manure compost, G=groundnut and M=maize

The lowest value (3.85 t/ha and 3.35 t/ha) were obtained from both GCO and MCO treatments respectively. Groundnut fallow increases subsequent crop yields. A synthesis of result from the managed trials from table 3 shows that groundnut fallow maize soil increased grain yield by approximately 3.85 t/ha for the groundnut fallow control (GCO) compared with continuous maize control plot.

The response derived from table 3 show that maize grain yield increase from groundnut fallow is greater if animal manure and crop waste compost especially groundnut-composts (GPGM+GR and GCD+GR) are incorporated into the soil (5.15 and 5.04 t/ha) than either the compost application on the continuous maize fallow plot or separate application of the manures or crop residues alone. After the addition of external inputs from both fallow plots, the amount of organic matter, soil total nitrogen percentage, extractable K in the soil were higher on the groundnut plot compared with maize fallow plot. Also, the NPK addition on groundnut fallow plot gave the highest OM (4.76%), N (0.55%) and K (4.89 cmol/kg) while the GCO (control) gave the least nutrient content.

The effects of fallow on succeeding maize crop yields (table 3) are highly variable but generally positive, depending on the fallow type, farmyard manures, crop residues compared with the control from both plots.

The farming systems and manure applications significantly enhanced the available P and exchangeable K content of the soil. Similarly, available P and exchangeable K content were significantly higher in the groundnut fallow soils compared with those from the maize continuous plot (table 4). Highest available P and exchangeable K were produced by NPK from both soils followed by the Pig manure compost while the control gave the least.

Table 4 showed that there were significant differences among the treatments over the level of organic matter in the soils. The organic matter accumulation was significantly higher in the groundnut fallow soil compared with the continuous farming plot.

The groundnut fallow soil had significantly higher organic matter content ($P < 0.05$) than the maize fallow plot. The PGM-comp on groundnut fallow soil gave the highest SOC (3.38%) and this was 9.03% better than PGM-compost with the highest SOC from the maize fallow soil. The controls (GCO and MCO) gave the least amount with 2.36 and 2.01% respectively and the GCO treatment is 17.41% better than that of MCO from the maize fallow soil. Similar trend was observed from the N% content of the soil one year after the treatment application. The groundnut fallow soil contained significantly higher N ($p < 0.05$) than the maize fallow soil.

However, composting of crop waste with farmyard manures raised the soil N content more than separate application of either manure or NPK on residual trials. From the groundnut plot the PGM-comp gave the highest N content (0.84 %) while the control gave the least (0.22%). The PGM-comp was 62% better than the GCO and same trend was noticed from the maize fallow plot of PGM-comp (0.69%) and MCO (0.18%) respectively and thus the PGM-comp was 51% better than the control and this is 11% lower than the margin observed from groundnut fallow.

The observed trend of N% content is PGM-comp > CD-comp > PGM > NPK > CD > GR > MR > GCO on the groundnut fallow soil while same trend was seen on the maize fallow soil with the exception of CD that was better than the NPK in the sequence. P2O5 was found to be significantly higher ($p < 0.05$) in groundnut fallow plot compared with that maize fallow soil, whereas PGM-comp gave the highest (11.94 mg/kg) level of available phosphorus among the treatment on the same plot with (GCO) control as the least (7.32 mg/kg).

The observed trend was also noticed on the maize fallow soil. The groundnut fallow soil contained significantly higher level of K ($p< 0.05$) than the maize fallow plot whereas groundnut fallow system raised the levels of K across the plot unlike the continuous maize cropping that depressed K across the plot.

The compost treatment gave the higher K levels while the control (GCO) the least and the same trend was observed the maize fallow plot respectively. The groundnut fallow soil contained significantly higher Ca ($p < 0.05$) than the maize fallow plot. The exchangeable Mg content of the two fallows essentially followed the same pattern like that of Ca. However, groundnut fallow soil had significantly lower Fe ($p < 0.05$) compared to the maize fallow plot that was higher. Continuous maize cropping plot raised the Fe value across the plot while the Fe was reduced.

The maize plants grown on fallow soil were significantly ($P < 0.05$) better than the ones grown on maize fallow soil. Generally, the yield from the PGM-comp and CD-comp produced significantly ($P < 0.05$) better yield compared with either the use of residue or farmyard manure alone on either fallow plot. From table 5, significant ($P > 0.05$) treatments effect were obtained on cob diameter, cob yield, biomass weight, seed per cob, grain yield and husk weight after the repeated cultivation of maize without fertilizer application. The

Table 4. Influence of crop residue management, NPK, animal manures and their combination on soil chemical properties

	OM, %		N, %		P, %		K, (cmolkg^{-1})	
Treatment	Gf	Mf	Gf	Mf	Gf	Mf	Gf	Mf
Control	2.36d	1.63e	0.17cde	0.07f	6.54d	3.83f	0.18cd	0.09f
CD-comp	4.10b	3.02c	0.42abc	0.27cde	11.82bc	10.24c	4.45ab	2.78c
CD	3.99bc	2.94cd	0.35abcd	0.23bcde	11.40bc	9.69c	3.23bc	1.26d
Gresidue	3.62bc	2.53cd	0.27bcde	0.19bcde	11.00bc	6.55d	1.36d	1.09de
M- residue	2.66cd	2.25de	0.21bcde	0.11de	7.64d	4.47ef	1.63cd	0.86e
NPK	4.76a	4.26ab	0.55a	0.45ab	15.51a	13.92ab	4.89a	4.61ab
PGM	4.05b	3.38c	0.36abcd	0.266cde	11.46bc	9.84c	3.42bc	1.34de
PGM-comp	4.18ab	3.75bc	0.42abc	0.32abcde	12.57ab	10.49bc	4.48ab	3.14bc

Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT

Where: Gf =groundnut fallow plot, Mf=maize fallow plot, CD-comp=cow dung manure compost, PGM-comp=pig manure compost, G=groundnut and M=maize

Table 5. Residual effect of crop residue management, NPK, farmyard manures and their integration on yield of maize

	Maize cob length filled (cm)		Dehusk wt (kg)		Grain wt t/ha	
Treatment	Gf	Mf	Gf	Mf	Gf	Mf
Control	.00hi	6.33i	0.10gh	0.07h	2.55de	2.16e
CD-comp	21.83a	18.00bc	0.29ab	0.23bcd	6.27a	5.29abcd
CD	15.83cd	12.00efg	0.20bcde	0.16efgh	5.48abc	4.31abcde
G-residues	14.37cde	10.50fgh	0.18defg	0.13efgh	4.70abcde	3.53bcde
M- residues	9.92fghi	8.58ghi	0.12efgh	0.11fgh	3.14cde	2.74de
NPK	14.92cde	11.50efgh	0.19cdefg	0.14efgh	5.09abcd	3.92abcde
PGM	16.87bc	12.83def	0.21bcde	0.17defg	5.88ab	4.51abcde
PGM-comp	22.00a	19.67ab	0.32a	0.25abc	6.07a	5.49abc

Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT

Where: Gf=groundnut fallow plot, Mf=maize fallow plot, CD-comp=cow dung manure compost, PGM-comp=pig manure compost, G=groundnut and M=maize

result followed similar trend when compared with observation from both groundnut fallow and maize fallow soil respectively. For all the yield characters evaluated, the highest value of residual effect was obtained from groundnut fallow plot treated with PGM-comp at 5 t/ha of application. The treatment PGM-comp gave the best response for maize Cob length filled (22 cm), dehusk cob weight (0.32 kg), biomass weight, and sample grain weight (0.31 kg), length of cob (22.17 cm), cob diameter (24.17 cm) and seed number/cob (794) on groundnut fallow soil. The lowest values were obtained from the control (GCO) but better than those from MCO.

The result also showed the soil chemical properties as affected by integrated nutrient management techniques after 2013 cropping season. Maize fallow soil had significantly lower pH ($p < 0.05$) compared to those treatments from the groundnut fallow plot. Continuous cropping of maize depressed pH across the maize fallow plot, whereas groundnut fallow raised the pH on the plot. PGM-compost on groundnut fallow soil had the highest pH (6.75) compared to PGM-compost on the maize fallow soil with (6.62) pH while the controls (GCO and MCO) from both plots gave the lowest pH values of 5.67 and 5.36 respectively.

The groundnut fallow soil had significantly higher organic matter content ($P < 0.05$) than the maize fallow plot. The PGM-comp on groundnut fallow soil gave the highest SOC (3.38%) and this was 9.03% better than PGM-compost with the highest SOC from the maize fallow soil. The controls (GCO and MCO) gave the least amount with 2.36 and 2.01% respectively and the GCO treatment is 17.41% better than that of MCO from the maize fallow soil. Similar trend was observed from the N% content of the soil one year after the treatment application. The groundnut fallow soil contained significantly higher N ($p < 0.05$) than the maize fallow soil.

However, composting of crop waste with farmyard manures raised the soil N content more than separate application of either manure or NPK on residual trials. From the groundnut plot the PGM-comp gave the highest N content (0.84%) while the control gave the least (0.22%). The PGM-comp was 62% better than the GCO and same trend was noticed from the maize fallow plot of PGM-comp (0.69%) and MCO (0.18%) respectively and thus the PGM-comp was 51% better than the control and this is 11% lower than the margin observed from groundnut fallow.

From table 6, the observed trend of N% content is PGM-comp > CD-comp > PGM > NPK > CD > GR > MR > GCO on the groundnut fallow soil while same trend was seen on the maize fallow soil with the exception of CD that was better than the NPK in the sequence. P_2O_5 was found to be significantly higher ($p < 0.05$) in groundnut fallow plot compared with that maize fallow soil, whereas PGM-comp gave the highest (11.94 mg kg^{-1}) level of available phosphorus among the treatment on the same plot with (GCO) control as the least (7.32 $mgkg^{-1}$) .

The observed trend was also noticed on the maize fallow soil. The groundnut fallow soil contained significantly higher level of K ($p < 0.05$) than the maize fallow plot whereas groundnut fallow system raised the levels of K across the plot unlike the continuous maize cropping that depressed K across the plot.

The compost treatment gave the higher K levels while the control (GCO) the least and the same trend was observed the maize fallow plot respectively. The groundnut fallow soil contained significantly higher Ca ($p < 0.05$) than the maize fallow plot. The exchangeable Mg content of the two fallows essentially followed the same pattern like that of Ca. However, groundnut fallow soil had significantly lower Fe ($p < 0.05$) compared to the maize fallow plot that was higher. Continuous maize cropping plot raised the Fe value across the plot while the Fe was reduced.

The response of the fallow and treatments was in inverse direction with the control given the highest while the composts gave the least from both sides.

Discussion

The most obvious and widely studied benefit of using a leguminous fallow is the addition of biologically fixed N and its effect on cereal yield (Ragland & Lal, 1993; Peoples et al., 1995). Similarly, Carsky et al., (2001) further concluded that leguminous fallow may contribute other possible effects on systems performance which may include numerous other nutritional and non-nutritional factors. In-line with the above assertion Steiner, 1994; and Adetunji, 1996 then confirmed that groundcover during the off-season and the application of organic matter (crop and animal waste) have been shown to improve soil physical, chemical, and biological parameters.

The lower soil organic matter content under continuous cultivation may be due to rapid rate

Table 6. Effect of crop residue management, NPK, farmyard manures and their integration on soil chemical properties after the first cropping

Treatment	pH		OM, %		N, %		P (mg/kg)	
	Gf	Mf	Gf	Mf	Gf	Mf	Gf	Mf
Control	5.67ghi	5.36i	2.36a-d	2.01d	0.22kl	0.18l	7.32ef	6.48f
CD-comp	6.70ab	6.54abcd	3.24ab	3.02abcd	0.77ab	0.65cd	11.59ab	11.11ab
CD	6.32abcdef	6.01efgh	3.17abc	2.73abcd	0.54def	0.39ghi	10.48bc	9.5bcd
G-residues	6.22cdef	5.88fgh	3.00abcd	2.53abcd	0.45fgh	0.32ijk	10.12bcd	8.7cde
M-residues	5.94fgh	5.62hi	2.36abcd	2.27bcd	0.27jkl	0.24jkl	8.05cdef	7.72def
NPK	6.56bcdef	5.95efgh	3.05abcd	2.62abcd	0.49efg	0.39ghi	10.34abc	9.02cde
PGM	6.39abcde	6.09defg	3.28ab	2.81abcd	0.59de	0.42ghi	10.75abc	9.8bcd
PGM-comp	6.75a	6.62abc	3.38a	3.10abc	0.84a	0.69bc	11.94a	11.26ab

Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT

Where: Gf=groundnut fallow plot, Mf = maize fallow plot, CD-com =cow dung manure compost, PGM-comp=pig manure compost, G=groundnut and M=maize

of oxidation (Giller et al., 1997). Similarly, the higher amount of organic matter from the groundnut fallow plot may be due to production of ground cover that increases shading, which enhances the build-up of the amount of humus in the soil. The view is also similar with the assertion of Vine, (1953) in his work on tropical soil restoration using legume fallow cover. The respond of organic matter accumulation in both soils follow similar pattern as expressed in the N content soil earlier.

Trials using groundnut fallow control may be more appropriate scientifically, because continuous cereal could suffer from specific pest and diseases especially soil dwelling types.

However, a continuous cereal system reflects farmers act when faced with land scarcity.

The performance of the mineral fertilizer may be due to complete mineralization of the NPK in the soil. The result implies that the organics were partially incompletely mineralized. Similar trend was also shown from the maize fallow plot with the NPK followed by the compost and control the least (MCO).

The result clearly indicated that leguminous fallow system performed remarkably better than continuous maize farming system while the PGM compost had the best residual effects. The trend noticed from groundnut fallow plot was also repeated on the maize fallow soil.

Improvement in the soil pH of organic wastes amended plots might be due to the possible enrichment of the soil with calcium from the organic wastes. Improved availability of Cations might lead to higher soil pH of organic wastes amended soil to the supply of basic elements such as N, P, and K.

There was a general increase in the yield parameters throughout the growing period and there was significant difference among treatments. The above observation agreed with reports of Mbah & Mbagwu, (2003), who observed that organic wastes differ in their ability to provide nutrients and enhance soil qualities due to difference in their rates of decomposition and nutrient release patterns. NPK 20:10:10 at the rate of 120 kg/ha gave the best performances in almost all the maize yield parameters followed by compost mixture of piggery and groundnut residue manures (PGM+GR) at 5 t/ha. The performance of maize, treated with NPK, could be attributed to the fact that it is readily available and easily absorbed by maize. The above observation is similar with the findings of Mulongoy & Sanginga, (1990), who found that NPK fertilizer amended plots compared with organic wastes treated plots at the end of the first cropping, might be attributed to the quick release of the nutrients from the fertilizer, since nutrients are slowly release from organic waste sources.

The combined application of piggery manure and groundnut residue (PGM+GR) performances significantly equal to NPK 20:10:10 (mineral fertilizer) considering some of the parameters of measurements compared with others. This is because the organic fertilizer materials was able to supply balanced nutrients required by the maize as a complete fertilizer containing all the essential elements in moderate proportion. The performance of the PGM+GR compost were better than that of other composts (CD+MR, PGM+MR and CD+GR) inferred the higher nutrient content. Variation in nutritional contents of compost material had earlier been reported by other authors, Adebayo et al., (2011) working with organic amendment and its effect on early growth of Moringa oleifera, observed higher nutrient concentrations in compost made from elephant grass and poultry manure.

The experiment also revealed that the combined effect of animal manures and crop residues composts (CD+MR, PGM+MR, PGM+GR, and CD+GR) gives better performance in almost all the characters evaluated than when not combined (PGM, CD, GRR, MRR and GCO).This is due to the fact that animal manure added to crop residues as compost make N, P, K content higher than that of separate application. This is in line with the findings of Kaur & Benipal, (2006), that the recycling of nutrients through crop residues and animal manures can make up nutrient uptake of the harvest products for maximum productivity.

It also shows that farmyard manures fertilizer application (PGM and CD) performed better than crop residues (MRR, GRR, GCO and MCO (control). This showed that farmyard manures fertilizer has beneficial effect on growth and yield of maize. Therefore, the possibility of obtaining economic response is higher when animal manure is compared with crop residues. Superior response of farmyard manure compared with crop residues have been reported by other authors. The earliness in tasselling following animal manure application could be attributed to the relatively higher nutrients in the manures which promoted vigorous foliage growth, increased meristematic and more intense physiological activities in plants which favored the synthesis of more photo-assimilates and early flowering. These results are consistent with those of Uwah et al., (2011) who observed a reduction in number of days to 50% tasseling in maize with increases in farmyard manure compared with crop residues rates.

The experiment also shows that piggery manure (PGM) fertilizer gives a better response in maize growth and yield parameter than the use of cow-dung manure. This is due to the higher availability of essential nutrients (NPK) in adequate quantity and form enhanced protoplasmic development and cell proliferation. The above observation agreed with the reports of Akanbi et al., (2000) who observed that nutrient content of fertilizer material determines the uptake of such nutrient by plants. The findings further shows that groundnut crop residue treated plots (PGM +GR, CD+GR, GRR & GCO) gives a better result in maize growth, yield and soil nutrient restoration than that of maize residues (PGM+MR, CD+MR, MRR & MCO). These studies found waste derived from groundnut improved yield of maize. The result is similar with the work of Ojeniyi & Ighomrore (2004) with respect to cassava, who found that mulching with Chromolaena a leguminous weed increased soil and plant nutrients and tuber yield of cassava significantly due to release of nutrient from its residue.

Also, the response on physical and chemical analysis of the site before and after maize and groundnut production in the sub plots shows that (GCO) groundnut fallow plot greater than MCO (control) maize continuous cropping system. Groundnut fallow system before maize production replenishes soil nutrients with essential nutrients (mostly N) and enhancing crop yield, but has a greater beneficial residual effect on soil with better yield while maize continuous cropping system decline yield due to acidification, soil compaction and loss of organic matter Thus, Confirmed the findings of Dabney et al., (2001) that large increases in maize yields following groundnut cultivation several times on research stations in Zimbabwe. John et al., (2004) affirmed that even with the nutrient depleted conditions commonly found on small holder fields and farmers current practices and inputs, a groundnut plus maize rotation can make a significant contribution to the productivity and sustainability of maize cropping on farm in Sub-humid parts of Zimbabwe. Nottidge et al., (2010) further concluded that the incorporation of residues of leguminous food crops such as groundnut and cowpea are good alternatives in improvement of soil physical conditions and productivity of maize than the planting on short or bare fallow lands or continuous cropping with maize.

Trials using groundnut fallow control is probably more appropriate scientifically, because a continuous cereal control could suffer from cereal specific pest and diseases especially soil dwelling types. Although, a continuous cereal system reflects farmers act when faced with land scarcity.

The performance of all the treatments was in line with Ayeni, (2010) findings who observed that the main benefit of using combined application of organic and inorganic fertilizers, is that it reduces the amount of mineral fertilizer and timely mineralization of nutrients from organic manures. The result of the residual effects of farmyard manure and crop residue management on yield support the work of Ghosh et al., (2004) who found that the application of farmyard manure had the most beneficial effect on grain yield of maize. Sharma & Mittra (1991) also affirmed that nutrient contained in farmyard manures are released more slowly and are stored for a longer period of time in the soil thereby ensuring a long residual effect, thus supporting better root development leading to higher crop yield as viewed by Abou El-Majd et al., (2006).

The groundnut fallow soil naturally had higher organic carbon than the maize fallow plot, accruing from the microbial activity from the root nodules. The result clearly indicated that leguminous fallow system performed remarkably better than continuous maize farming system while the PGM compost had the best residual effects. The trend noticed from groundnut fallow plot was also repeated on the maize fallow soil.

The significant variation in the pH of both fallow plots and the treatment applied was as a result of the nature and composition of the materials. Apparently the higher organic matter content of the leguminous fallow soil raised the soil pH values of soil. The fixation of nitrogen by groundnut plant raises the pH while the organic manures also raised the soil pH. The organic residues have a store of nutrients hence they raised the soil cations and stabilized the CEC of the soils on the leguminous fallow plot. The superior performance of the groundnut fallow soil compared with maize fallow plot was ascribed to the fact that the leguminous plot contains many microorganisms that enhance nutrient fixation.

The response of the treatments to soil fertility restoration supports the work of Nottidge et al., (2010) who viewed that the return of crop residues to soil as the main component of fallowing, resulting into accumulation of nutrients, increases in organic matter and improvement of soil structure. This assertion was also supported with the findings of Aribe, 2003 and Udeata, 2008 that plant residues and other biomass constitute an important resource; as they have a potential of maintaining soil fertility after decomposition.

Conclusion and Recommendations

A decline in SOM due to continuous cultivation was observed with continuous maize cropping system while fallowing with groundnut enhanced the content. Additions of NPK fertilizer were more effective than the use of either manures (crop wastes and/ or Animal manures) as a means of offsetting SOM decline in the first cropping after application. However, the best protection against SOM loss was achieved by combinations of inputs (PGM-cmp and CD-comp). Crop residues (maize and groundnut waste) and farm yard manures (PGM and CD) are counterbalanced organic resources because both are major sources of organic matter generation. Hence, addition of manures appears to be more advantageous to farmers especially their integration rather than separate application in terms of both crop performance and the formation and quality of soil organic matter.

Also, it can be concluded that Crop residues and farm-yard manures compost performed better than the separated use of either crop residues (groundnut and maize) or farmyard manures (Pig and cow dung) alone. The pig manure performed better than cow-dung manure while ground nut residue gave a higher result than maize residue respectively.

The use of PGM+GR (5 t/ha) improved grain yield (5.6t/ha) than others with exception of NPK that had same value and better than controls (GCO and MCO) by 149.6% and 171.9%.The residual implies GPGM +GR had the highest N% (0.84%) which was 381.8% and 466.7% higher than the controls (GCO and MCO). GCO>MCO (control) infer that groundnut fallow system had an added advantage in nutrient restoration and release compared with continuous cropping that depleted the soil rapidly.

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