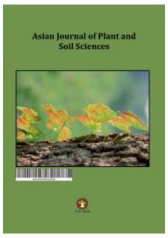

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Analysis of Impacts of Tillage Practices for Integrated Nutrients Management Systems on Maize performance

Nenge, A. S. [a*], Ibrahim, N. [a] and Adaikwu, A. O. [b]

[a] *National Biotechnology Development Agency, Abuja, Nigeria.*
[b] *Department of Soil Science, College of Agronomy, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were carried out during the 2018 and 2019 cropping seasons to assess the impact of tillage practices and integrated nutrients management systems on soil physical properties and grain yield of maize in Makurdi, Benue State, Nigeria. Treatments were made of factorial combination of three (3) tillage practices (No Tillage (NT),Minimum tillage (MT) and 30cm Raised seed bed (RSB) and ten (10) levels of integrated nutrients management systems (No application,100 Kg NPK/ha,200 Kg NPK/ha**,** 300 Kg NPK/ha,100 Kg NKP + 5 t/ha PM**,** 100 Kg NPK + 5 t/ha CD**,** 200 Kg NPK + 5 t/ha CD,200 Kg + 5 t/ha PM**,** 10 t/ha PM and)10 t/ha CD) resulting in total of thirty (30) treatment combinations. The treatment combinations were laid out in a randomized complete block design (RCBD) and replicated three times. The tillage practices constituted the main plots while the nutrients levels were assign to the sub-plots. Three (3) composite auger soil samples were collected at 0 - 15 cm depth before planting for physico -

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**Corresponding author: E-mail: mumiesusie@gmail.com;*

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chemical properties analysis. Ninety (90) undisturbed soil samples were also taken at 0-15 cm each in 2018 and 2019 across the experimental plots using core sampler to assess soil physical properties such as bulk density, surface soil porosity, hydraulic conductivity and soil moisture content. The maize variety Oba 2 Hybrid was planted at a spacing of 0.25 m x 0.75 m. Grain yield (t/ha) was taken at harvest to assess the effect of tillage practices and integrated nutrients management systems on maize performance. The data collected on soil physical properties and grain yield of maize were analyzed using ANOVA test based on randomized complete block design (RCBD). Results show that the soil pH of the study area was slightly acidic, low nutrients status, high bulk density (1.72 Mg/m^3), low surface soil porosity (35 %,) low hydraulic conductivity in the surface horizon with sandy loam in texture. Raised seed bed tillage practice significantly ($p<0.05$) improved soil physical properties, and grain yields of maize in the two cropping seasons. Integrated nutrients management systems show significant ($p<0.05$) improvement on soil physical properties and maize performance in the two cropping seasons. Improved values of soil physical properties grain yields of maize were obtained at 200 kg/ha NPK + 5 t/ha poultry manure amendments plots follow by other plots amended with combined organic and inorganic manures relative to the control and other plots containing either single application of organic or inorganic manure. Combined use of raised seed bed + 200 kg/ha NPK + 5 t/ha poultry manure significantly ($p<0.05$) improved the physical properties of soil and grain yield of maize relative to other treatment combinations both in 2018 and 2019 cropping seasons. Use of raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure is recommended for sustainable maize production in the study area. Integrated use of organic and inorganic fertilizers is hereby, recommended for sustainable maize production in makurdi, Southern guinea Savanna Zone of Nigeria.

Keywords: Conservation practice; soil productivity; maize; integrated nutrients management; fertilizers; physical properties.

1. INTRODUCTION

In recognition of the current global food crises, Nigeria currently pursues policy of expanding the land area under cultivation as well as intensifying crop production by continuous cropping system, of which maize is included (Nwite et al., 2012). Therefore, adoption of more sustainable strategies for the maintenance of soil fertility under such conditions becomes imperative to sustain crop yield. Inorganic fertilizers which in the past years, have proved to be effective in restoring soil fertility have their own problems (Sullivan, 2010; Nelson & Sommers, 1982; Udo & Ogunwale, 2009). Apart from the after effect of continuous use of inorganic fertilizer, they are expensive for the resources-poor, small scale crop farmer in the sub-Saharan African region to purchase (Wambi, 2009). According to Abou El-Magd et al. (2005), organic manure can be used and an alternative nutrient input.

Although, the nutrient content of organic materials is relatively lower than inorganic fertilizers, they have the additional property of improving the physical properties of the soil (Adeniyan & Ojeniyi, 2005; Nwite & Nnoke, 2005; Ifejimalu, 2018; Singh et al., 2013). However, because of huge quantity of the organic wastes required for field crop production and its handling problems limits its used to distant farmers, it has become necessary to combine different types (Albuquerque et al., 2001; Chaudhary et al., 1992). It is also necessary to integrate chemical fertilizers into the organic sources to reduce the quantity required and enhance nutrient release. Studies (Uyovbisere & Elemo, 2000) have shown the superior effect of integrated nutrient supply over sole use of inorganic or organic source in terms of balances nutrient supply, improved soil physical fertility and crop yield.

Tillage is one of the fundamental agro technical operations in agriculture because of its influence on soil properties and crop growth (Follet & Stewart, 1985; Karlen et al., 1999; Khurshid et al., 2006). Since intensive soil tillage strongly influence the soil properties, it is important to apply appropriate tillage practices that avoid the degradation of soil structure, maintain crop yield as well as ecosystem stability (Adeniyan & Ojeniyi, 2005; Kamprath, 1970; Van Lierop, 1990; Sims & Johnson, 1996)

Good soil management is a key to sustainable farming practices (Morgan, 1995; Motavalli et al., 2003). Karlen (2004) opined that what a farmer can achieve is highly dependent on good soil management and climate of the area. Since then, research has gradually shifted towards an approach based on Integrated Soil Fertility Management (ISFM), which combines various existing soil fertility management techniques with external inputs**.** This research is therefore; design to assess the impacts of tillage practices and integrated nutrients management systems on soil productivity and performance of maize in Makurdi, Benue State, Nigeria

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out during the 2018 and 2019 cropping seasons at the Teaching and Research Farm of the University of Agriculture Makurdi within the southern Guinea Savanna agro-ecological zone of Nigeria, located on latitude $7^{0}46^{'}$ – $7^{0}50^{'}$N and Longitude $8^{0}36^{'}$ – $8^{0}40$'E at an average elevation of 97 – 100m above mean sea level. The experimental site is characterized by worm tropical climate with distinct wet and dry seasons. The wet season starts from April to October with and annual rainfall of about 1250mm. the rainfall amount and duration vary annually.

2.2 Experimental Treatments and Design

Treatments were made of factorial combination of three (3) tillage practices (No Tillage, Minimum tillage and 30cm Raised seed bed) and ten (10) levels of integrated nutrients management systems (No application,100 Kg NPK, 200 Kg NPK, 300 Kg NPK, 100 Kg NKP + 5 t/ha PM, 100 Kg NPK + 5 t/ha CD, 200 Kg NPK + 5 t/ha CD, 200 Kg + 5 t/ha PM, 10 t/ha PM and 10 t/ha CD). Giving total treatment combinations of 30. The treatment combinations were laid in randomizes complete block design and replicated 3 times

The experimental field was divided into three blocks with 2m demarcation. Each block was further divided into thirty (30) experimental plots of 3m x 3m ($9m^2$) m with 3m alley between them. Maize (low Nitrogen tolerant yellow) developed by IITA was used as test crop.

The plots were manually cleared using hoe and cutlass to remove grasses, plants and left over plant debris. The soil amendments, cow dung (CD) and poultry manure (PM) at 5t/ha, 10t/ha each was evenly spread on appropriate plots and was worked into the soil during tillage. The amendments were allowed to decompose for 14 days before planting maize. Maize seeds were treated with apron plus before planting. Planting was done manually at two seeds per hoe using a spacing of 25cm (within rows) and 75cm (between rows). The seedling was thinned down to one seed per hole one week after emergence to give a population of 3,240 stands. Fertilizer (NPK 15:15:15) was applied at the rate of 300kg/ha, 200kg/ha and 100kg/ha at the designated plots two weeks after planting. The experimental plots were kept weed free from crop emergence to crop harvest.

2.3 Soil Sampling/Analysis

Composites surface soil samples (0-15cm) were collected at the beginning of the experiment and after harvest in each of the treatment plot both in 2018 and 2019 cropping seasons for physico – chemical soil analysis.

Particle size distribution was determined by Bouyoucos hydrometer method of mechanical analysis (Trout et al., 1987). Soil pH was measured electrometrically using glass electrode pH meter in a solid-liquid ratio of 1:2.5. Total nitrogen was determined by micro-Kjeldahl digestion technique method. Exchangeable bases were determined by the neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982). Exchangeable acidity was got by a method described by McLean (1982). Total carbon was analyzed by wet digestion and the organic carbon content was multiplied by a factor (1.724) to get the percentage organic matter (Bray & Kurtz, 1945). Available phosphorous was determined by Bray Il method according to the procedure of (Bray & Kurtz, 1945). Cation Exchange Capacity was determined using neutral ammonium acetate leachate method (Summer, 1982). Base saturation was computed as Total exchangeable bases divided by Cation Exchange Capacity.

Crop data: plant height, leave area index, number of leaves, and stem growth were taken at 4 and 8 WAP while seed yield of maize (t/ha) was collected at harvest

Productivity index according to Riquier et al. (1970) given as: Pa = H x D x P x T x Fa was used in calculating the actual and potential productivity of the soil.

Where:

Pa = Soil Productivity, H = Soil moisture based on number of wet/dry months.
D = Drainage, T = Soil texture/structure and Fa = Actual fertility index consisting Organic matter, pH, Base saturation, Exchangeable capacity of clay (Cmol kg^{-1}) and Total soluble salts (s)). Table 1 was used in the determination of the productivity classes

Table 1. Scale of Productivity (P), Rating, RI – Range and Potentiality (Pi)

10	Rating	RI – Range	Pi
1	Excellent	65–100	I
2	Good	35–64	Ii
3	Average	20–34	Iii
4	Poor	8–19	Iv
5	Extremely poor to Nil	0–7	V

Source: Riquier et al. 1970

2.4 Data Analysis

The soil tillage practices, integrated nutrients management systems and crop data collected were subjected to analysis of variance (ANOVA) using Genstat 5 Releases 3.1 (Lawes Agricultural Trust, Roth Amsted Experimental Station, 1993). Treatments that show significant difference were separated using Duncan Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Effect of Tillage Practices and Integrated Nutrients Management systems on Maize Performance

The effect of tillage practices on maize leaf area index (LAI), number of leaves (NOL), plant height, stem growth and grain yield for 2018 and 2019 copping seasons are presented in Table 2. The results showed significant ($p<0.05$) difference among the tillage practices both in 2018 and 2019. Raised seed bed till plot gave significant higher grain yield of 2.3 t/ha and 2.0 t/ha in 2018 and 2019 cropping seasons respectively. Generally, maize planted on raised seed bed significantly ($p<0.05$) had higher growth parameters and grain yield followed by minimum till and no till practices. In the minimum and zero tillage practices, nutrients might have washed away by the rains, soil compaction, low infiltration and slow decomposition of organic matter resulting to possible non availability of soil amendments to the roots for plant uptake contributed to low maize yield parameters. Similar results were observed by Diaz-Zorita (2000), who reported that plant height was significantly higher in the ridge and surface tillage than those under no-tillage. These results are also in agreement with those of Bonari et al. (1994).

The main effect of integrated nutrients management practices on maize performance for 2018 and 2019 cropping seasons are presented in Table 3. The results show that plant height was significant at 8 WAP both in 2018 and 2019 cropping seasons. Stem growth and LAI exhibited significant at 4 and 8 WAP both in 2018 and 2019 cropping seasons. The number of leaves show significant difference at 4 WAP only in 2019. The effect on grain yield of maize however, were significant ($p<0.05$) both in 2018 and 2019 cropping seasons.

Plots treated with 200 kg/ha NPK + 5 t/ha poultry manure significantly ($p<0.05$) had higher grain yields (2.5 t/ha and 2.8 t/ha in 2018 and 2019 respectively) and growth parameters while the least grain yield values of 1.4 t/ha and 1.6 t/ha in 2018 and 2019 cropping seasons respectively and other growth parameters were observed on the control plot. Application of the integrated components increased availability of N, P and K in the soil, in addition to improve concentration of Ca, Mg and pH. Thus, the poultry manure has liming effect on soil through release of Ca. These findings are in agreement with that of Ojeniyi et al. (2014). These results are also in concord with previous studies that combinations of poultry manures with fertilizers can significantly improve soil fertility.

The**i**nteraction effect indicated significant ($p<0.05$) differences among the treatment The results showed that the plots treated with raised seed bed tillage practice + different levels of soil nutrient applications significantly ($p<0.05$) increased growth and grain yield of maize followed by minimum tillage and no tillage practices

3.2 Soil Productivity Assessment Using Riquier Productivity Index (RI) Model

Calculated Riquier Productivity Index (RI), Coefficients of Improvement (CI), and their respective grain yields of maize for 2018 and 2019 cropping seasons are presented in Table 4. In 2018 cropping season, the calculated potential productivity (PI) ranged from 0.23 – 0.25. The highest RI value of 0.25 was recorded for raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure treatment combination while no tillage practice + no application recorded least RI value

Table 2. Effect of Tillage Practices on Maize Performance

2018 Cropping Season

S/No.	Tillage Practice	Leaf Area Index 4 WAP	Leaf Area Index 8 WAP	No. of Leaves Per plant 4 WAP	No. of Leaves per plant 8 WAP	Plant height (cm) 4 WAP	Plant height (cm) 8 WAP	Stem growth (cm) 4 WAP	Stem growth (cm) 8 WAP	Grain yield (t/ha)
1	No tillage	0.28	0.3727 c	10.30	13.03 a	79.57	147.2 c	6.723 c	9.8	1.734 c
2	Minimum tillage	0.30	0.4500 b	10.53	13.63 a	79.86	157.3 b	7.143 b	10.4	1.962 b
3	Raised seed bed	0.31	0.4690 a	10.63	18.07 a	80.07	164.7 a	7.457 a	13.4	2.269 a
LSD (P<0.05)		NS	0.121	NS	NS	NS	2.313	0.386	1.621	0.231

2019 Cropping Season

S/No.	Tillage Practice	Leaf Area Index 4 WAP	Leaf Area Index 8 WAP	No. of Leaves Per plant 4 WAP	No. of Leaves per plant 8 WAP	Plant height (cm) 4 WAP	Plant height (cm) 8 WAP	Stem growth (cm) 4 WAP	Stem growth (cm) 8 WAP	Grain yield (t/ha)
1	No tillage	0.2460 c	0.3980 c	9.500	12.50	70.62	219.2 c	6.24	7.88	1.62 c
2	Minimum tillage	0.3170 b	0.4580 b	10.000	12.53	82.32	226.2 b	7.36	8.20	1.86 b
3	Raised seed bed	0.3530 a	0.4817 a	10.467	12.80	83.17	230.4 a	7.54	8.30	1.99 a
LSD (P<0.05)		0.028	0.040	NS	NS	4.414	9.49	0.510	0.215	0.356

Table 3. Effect of integrated nutrients management system on maize performance

(2018 Cropping Season)

S/No	Integrated Nutrients Management System	LAI 4WAP	LAI 8 WAP	NL 4WAP	NL 8 WAP	PLHT (cm)4WAP	PLHT (cm) 8 WAP	SG (cm) 4 WAP	SG (cm) 8 WAP	GY (t/ha)
1	Control	0.20	0.2667 j	9.88	13.00 b	72.86 cd	136.4 j	6.253 e	9.7	1.417 j
2	Cow dung (10 t/ha)	0.29	0.4500 e	10.22	13.33 b	70.37 d	152.4 g	6.907 d	9.8	1.613 i
3	Poultry manure (10 t/ha)	0.32	0.4900 a	10.77	14.00 b	81.50 abc	159.8 c	7.617 a	10.4	1.917 f
4	NPK (100 kg/ha)	0.25	0.3967 i	10.55	13.00 b	75.88 bcd	150.4 i	7.084 c	9.8	1.660 h
5	NPK (200 kg/ha)	0.29	0.4856 c	10.66	13.33 b	85.12 ab	168.6 b	7.109 c	10.0	2.410 b
6	NPK (300 kg/ha)	0.29	0.4700 d	10.22	13.00 b	77.91 abcd	158.6 e	7.126 c	9.9	2.253 d
7	NPK (100 kg/ha) + Cow dung (5 t/ha)	0.31	0.4100 h	10.22	13.33 b	81.89 abc	157.6 f	6.960 d	10.2	1.843 g
8	NPK (200 kg/ha) + Cow dung (5 t/ha)	0.31	0.4333 f	11.00	14.33 b	83.17 ab	159.1 d	7.487 b	10.8	2.297 c
9	NPK (100 kg/ha) + Poultry manure (5 t/ha)	0.31	0.4167 g	10.44	13.33 b	77.52 abcd	152.0 h	7.107 c	10.0	1.951 e
10	NPK (200 kg/ha) + Poultry manure (5 t/ha)	0.35	0.4867 b	10.89	28.44 a	87.68 a	169.5 a	7.427 b	11.5	2.523 a
LSD (P<0.05)		NS	0.21	NS	NS	NS	6.931	0.704	0.167	0.712

2019 Cropping Season

S/No	Integrated Nutrients Management System	LAI 4 WAP	LAI 8 WAP	NL 4 WAP	NL 8WAP	PLHT (cm) 4 WAP	PLHT (cm) 8 WAP	SG (cm) 4 WAP	SG (cm) 8 WAP	GY (t/ha)
1	Control	0.2633 h	0.3289 j	10.00 oc	11.32	69.39	207.4 h	6.20	9.10	1.59 j
2	Cow dung (10 t/ha)	0.2900 g	0.4600 e	9.667 d	12.66	76.44	206.8 i	6.97	9.90	1.87 i
3	Poultry manure (10 t/ha)	0.3067 e	0.4967 b	10.000 c	12.88	80.38	223.7 f	7.49	10.90	2.56 f
4	NPK (100 kg/ha)	0.2900 g	0.4033 i	10.000 c	12.22	79.18	226.9 e	7.11	10.38	1.81 h
5	NPK (200 kg/ha)	0.3300 b	0.4933 c	10.333 b	12.56	81.41	232.9 c	7.82	11.63	2.61 b
6	NPK (300 kg/ha)	0.2967 f	0.4733 d	9.667 d	12.44	79.73	230.6 d	6.93	10.01	2.33 d
7	NPK (100 kg/ha) + Cow dung (5 t/ha)	0.2900 g	0.4167 h	10.000 c	12.11	76.23	230.6 d	7.30	11.40	2.19 g
8	NPK (200 kg/ha) + Cow dung (5 t/ha)	0.3233 c	0.4400 g	10.000 c	12.66	78.23	238.0 b	7.81	11.03	2.69 c
9	NPK (100 kg/ha) + Poultry manure (5 t/ha)	0.3167 d	0.4433 f	9.667 d	12.33	82.60	217.3	7.69	11.32	1.83 e
10	NPK (200 kg/ha) + Poultry manure (5 t/ha)	0.3467	0.5033	10.556 b	13.44	83.44	238.7 a	7.98	13.13	2.80 a
LSD (P<0.05)		0.051	0.074	NS	0.699	NS	17.33	0.913	1.035	0.817

Key: LAI = Leaf Area Index, NL = Number of Leaves, PLHT = Plant Height, SG = Stem Growth, GY = Grain Yield (t/ ha)

Table 4. Riquier Productivity Index (RI), Coefficient of Improvement (CI) and Grain Yield for 2018 and 2019 Cropping Seasons

S/No	Treatment Combination	2018			2019		
		RI	CI	GY(t/ha)	RI	CI	GY(t/ha)
1	Zero tillage x Control	0.23	1.00	1.26	0.21	0.91	1.24
2	Zero tillage x Cow dung (10 t/ha)	0.25	1.09	1.31	0.24	1.04	1.38
3	Zero tillage x Poultry manure (10 t/ha)	0.23	1.00	1.36	0.24	1.04	1.68
4	Zero tillage x NPK (100 kg/ha)	0.23	1.00	1.47	0.25	1.09	1.48
5	Zero tillage x NPK (200 kg/ha)	0.23	1.00	2.20	0.24	1.04	2.25
6	Zero tillage x NPK (300 kg/ha)	0.25	1.09	2.17	0.25	1.09	2.20
7	Zero tillage x NPK (100 kg/ha) + CD (5 t/ha)	0.25	1.09	1.67	0.25	1.09	1.87
8	Zero tillage x NPK (200 kg/ha) + CD (5 t/ha)	0.25	1.09	2.09	0.25	1.09	2.29
9	Zero tillage x NPK (100 kg/ha) + PM (5 t/ha)	0.25	1.09	1.39	0.26	1.13	1.63
10	Zero tillage x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	2.42	0.26	1.13	2.68
11	Min. tillage x Control	0.25	1.09	1.38	0.24	1.04	1.43
12	Min. tillage x Cow dung (10 t/ha)	0.25	1.09	1.72	0.26	1.13	2.02
13	Min. tillage x Poultry manure (10 t/ha)	0.25	1.09	1.97	0.27	1.17	2.13
14	Min. tillage x NPK (100 kg/ha)	0.25	1.09	1.63	0.26	1.13	1.98
15	Min. tillage x NPK (200 kg/ha)	0.25	1.09	2.38	0.28	1.22	2.55
16	Min. tillage x NPK (300 kg/ha)	0.25	1.09	2.20	0.27	1.17	2.47
17	Min. tillage x NPK (100 kg/ha) + CD (5 t/ha)	0.23	1.00	1.70	0.26	1.13	1.80
18	Min. tillage x NPK (200 kg/ha) + CD (5 t/ha)	0.23	1.00	2.19	0.29	1.26	2.31
19	Min. tillage x NPK (100 kg/ha) + PM (5 t/ha)	0.23	1.00	1.96	0.26	1.13	2.18
20	Min. tillage x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	2.49	0.26	1.13	2.73
21	Raised bed x Control	0.25	1.09	1.61	0.25	1.09	1.74
22	Raised bed x Cow dung (10 t/ha)	0.25	1.09	1.81	0.26	1.13	2.25
23	Raised bed x Poultry manure (10 t/ha)	0.23	1.00	2.42	0.26	1.13	2.52
24	Raised bed x NPK (100 kg/ha)	0.25	1.09	1.88	0.27	1.17	2.09
25	Raised bed x NPK (200 kg/ha)	0.23	1.00	2.65	0.32	1.39	2.78
26	Raised bed x NPK (300 kg/ha)	0.23	1.00	2.39	0.33	1.43	2.49
27	Raised bed x NPK (100 kg/ha) + CD (5 t/ha)	0.23	1.00	2.16	0.29	1.26	2.26
28	Raised bed x NPK (200 kg/ha) + CD (5 t/ha)	0.23	1.00	2.61	0.33	1.43	2.79
29	Raised bed x NPK (100 kg/ha) + PM (5 t/ha)	0.23	1.00	2.50	0.27	1.17	2.60
30	Raised bed x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	2.66	0.35	1.52	2.97

Key: RI = Riquire Index, CI = Coefficient of Improvement, GY = Grain Yield (t/ha)

Table 5. Riquier Productivity Index (RI), Coefficient of Improvement (CI) and Potentiality Classes for 2018 and 2019 Cropping Seasons

S/No	Treatment Combination	2018			2019			AP/Class
		RI	CI	PIC	RI	CI	PIC	
1	Zero tillage x Control	0.23	1.00	Average	0.21	0.91	Average	0.23/AV
2	Zero tillage x Cow dung (10 t/ha)	0.25	1.09	Average	0.24	1.04	Average	0.23/AV
3	Zero tillage x Poultry manure (10 t/ha)	0.23	1.00	Average	0.24	1.04	Average	0.23/AV
4	Zero tillage x NPK (100 kg/ha)	0.23	1.00	Average	0.25	1.09	Average	0.23/AV
5	Zero tillage x NPK (200 kg/ha)	0.23	1.00	Average	0.24	1.04	Average	0.23/AV
6	Zero tillage x NPK (300 kg/ha)	0.25	1.09	Average	0.25	1.09	Average	0.23/AV
7	Zero tillage x NPK (100 kg/ha) + CD (5 t/ha)	0.25	1.09	Average	0.25	1.09	Average	0.23/AV
8	Zero tillage x NPK (200 kg/ha) + CD (5 t/ha)	0.25	1.09	Average	0.25	1.09	Average	0.23/AV
9	Zero tillage x NPK (100 kg/ha) + PM (5 t/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
10	Zero tillage x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
11	Min. tillage x Control	0.25	1.09	Average	0.24	1.04	Average	0.23/AV
12	Min. tillage x Cow dung (10 t/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
13	Min. tillage x Poultry manure (10 t/ha)	0.25	1.09	Average	0.27	1.17	Average	0.23/AV
14	Min. tillage x NPK (100 kg/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
15	Min. tillage x NPK (200 kg/ha)	0.25	1.09	Average	0.28	1.22	Average	0.23/AV
16	Min. tillage x NPK (300 kg/ha)	0.25	1.09	Average	0.27	1.17	Average	0.23/AV
17	Min. tillage x NPK (100 kg/ha) + CD (5 t/ha)	0.23	1.00	Average	0.26	1.13	Average	0.23/AV
18	Min. tillage x NPK (200 kg/ha) + CD (5 t/ha)	0.23	1.00	Average	0.29	1.26	Average	0.23/AV
19	Min. tillage x NPK (100 kg/ha) + PM (5 t/ha)	0.23	1.00	Average	0.26	1.13	Average	0.23/AV
20	Min. tillage x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
21	Raised bed x Control	0.25	1.09	Average	0.25	1.09	Average	0.23/AV
22	Raised bed x Cow dung (10 t/ha)	0.25	1.09	Average	0.26	1.13	Average	0.23/AV
23	Raised bed x Poultry manure (10 t/ha)	0.23	1.00	Average	0.26	1.13	Average	0.23/AV
24	Raised bed x NPK (100 kg/ha)	0.25	1.09	Average	0.27	1.17	Average	0.23/AV
25	Raised bed x NPK (200 kg/ha)	0.23	1.00	Average	0.32	1.39	Average	0.23/AV
26	Raised bed x NPK (300 kg/ha)	0.23	1.00	Average	0.33	1.43	Average	0.23/AV
27	Raised bed x NPK (100 kg/ha) + CD (5 t/ha)	0.23	1.00	Average	0.29	1.26	Average	0.23/AV
28	Raised bed x NPK (200 kg/ha) + CD (5 t/ha)	0.23	1.00	Average	0.35	1.43	Good	0.23/AV
29	Raised bed x NPK (100 kg/ha) + PM (5 t/ha)	0.23	1.00	Average	0.27	1.17	Average	0.23/AV
30	Raised bed x NPK (200 kg/ha) + PM (5 t/ha)	0.25	1.09	Average	0.35	1.52	Good	0.23/AV

Key: RI = Riquire Index, CI = Coefficient of Improvement, PIC = Potentiality Index Class,AP = Actual Productivity, AV = Average of 0.23. In 2019, potential Productivity ranged from 0.21 – 0.35. The highest value of 0.35 was recorded for raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure treatment combination. The least value of 0.21 was recorded for zero tillage x control plot.

The highest (1.09) and least (1.00) coefficient of improvement (CI) for 2018 cropping season were observed under Raised seed bed x 200 kg/ha

NPK + 5 t/ha poultry manure and Zero tillage x control, respectively. In 2019, raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure treatment recorded highest (1.52) coefficient of improvement (CI) while and the least (0.91) coefficient of improvement (CI) was observed for Zero tillage x control plot. Generally, the results indicate that the values of the maize grain yields increased with increase in RI and CI values across all the treatment combinations both in 2018 and 2019 cropping seasons.

Higher RI values obtained under application of raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure indicate that the treatment provided improved micro environment of the plant than other treatment combinations. The higher RI values of the soil properties observed under poultry manure and cow dung treatment combinations might be attributed to their soil condition improvement abilities. There was a reduction in coefficient of improvement to 0.09 under Zero tillage x control plot in 2019. This implies that productivity of the plots treated with those management practices will be reduced by 24 % upon applications of the said treatments. Delay in decomposition of soil amendments could also contributed to the low improvement in soil productivity. This result agree with that of Agber (2012),

The calculated potentiality index resulting from the application of the treatments showed improvement in the class, ranging from average to good (Table 5). This may probably be due to the inadequacies of the added nutrients

Higher Coefficient of improvement obtained under Raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure (1.52) in 2019 implies that productivity of the plots treated with those management practices will be multiply by one and half ($1^{1/2}$) upon applications of the said treatments while treatments no tillage + no application gave least CI of 0.91. This also implies that productivity of the plots treated with those management practices will be reducing by 09 % upon applications of the said treatment. The generally lower CI values observed could be due to plant uptake of nutrients from the soil, leaching of appreciable nutrients and erosion that contributed to the decline in the soil productivity. Delay in decomposition of soil amendments could also contributed to the low improvement in soil productivity (Lal, 1995).

4. CONCLUSION

Integrated nutrients management systems show significant ($p<0.05$) improvement on soil productivity and maize performance in the two cropping seasons. improved values of soil productivity values, growth p and grain yields of maize were obtained at 200 kg/ha NPK + 5 t/ha poultry manure amendments plots follow by other plots amended with combined organic and inorganic manures relative to the control and other plots containing either single application of organic or inorganic manure, Combined use of raised seed bed + 200 kg/ha NPK + 5 t/ha poultry manure significantly ($p<0.05$) improved the productivity of the soill and maize performance relative to other treatment combinations both in 2018 and 2019 cropping seasons. Use of raised seed bed x 200 kg/ha NPK + 5 t/ha poultry manure is recommended for sustainable maize production in the study area. Also integrated use of organic and inorganic fertilizers is hereby, recommended for sustainable maize production in makurdi, Southern guinea Savanna Zone of Nigeria

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Nwite, J. C., Essien, B. A., Anaele, M. U., Obalum, S. E., Keke, C. I., & Igwe, C. A. (2012). Supplementary use of poultry dropping and rice-husk waste as organic amendments in southeastern Nigeria. 1:

Soil chemical properties and maize yield. *Libyan Agriculture Research Center Journal International, 3*(2), 90-97.

Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. In *Methods of soil analysis, part 2: Chemical and microbiological properties* (2nd ed., Agronomy Monograph, 9, pp. 539-579). American Society of Agronomy.

Udo, E. J., & Ogunwale, J. A. (2009). *Laboratory manual for soil and plant analysis.* University of Agriculture.

Wambi, M. (2009). Agriculture – Africa: Calls for sustainable given revolution. *IPS News*. www.ipsnews.net

Abou El-Magd, M., Hoda, M., Mohammed, A., & Fawzy, Z. F. (2005). Relationship, growth, and yield of broccoli with increasing N, P or K ration in mixtures of NPK fertilizers. *Annuals Agriculture Science Moshtohor, 43*, 791-805.

Adeniyan, O. N., & Ojeniyi, S. O. (2005). Effect of poultry manure, NPK 15-15-15 fertilizer and combinations of their reduced levels on maize growth and their chemical properties. *Soil Society of Nigeria Journal, 15*, 34–41.

Nwite, J. N., & Nnoke, F. N. (2005). Productivity assessment of floodplain in Abakaliki, South and maize yield under reduced tillage practices. *Soil and Tillage Research, 26*, 89-92.

Ifejimalu, A. C. (2018). Effects of rice mill wastes on soil properties in a rice-producing state of South-eastern Nigeria. *Nigerian Journal of Soil Science, 28*(2), 115-122.

Singh, B. T., Nandini, D. K., Bijen, K. Y., Bishworjit, N., Nongdren, K. S. L., & Herojit, S. A. (2013). Characterization, and evaluation for crop suitability in lateritic soils. *African Journal of Agricultural Research, 8*(37), 4628-4636.

Albuquerque, J. A., Sangoi, L., & Ender, M. (2001). Modification in the soil physical properties and maize parameters including by cropping and grazing under two tillage systems. *Revista Brasileira de Ciência do Solo, 25*, 717–723.

Chaudhary, A. D., Juved, M., Rana, M. A., Sarwar, A., & Zaman, Q. (1992). Comparative performance of direct drilling and conventional tillage practices under rice-wheat rotation system. *Pakistan Journal of Agriculture Science, 29*, 5–8.

Uyovbisere, E. O., & Elemo, K. A. (2000). Effect of inorganic fertilizer and foliage *Azadirachta* and *Parkia* species on the productivity of early maize. *Nigeria Journal of Soil Research, 1*, 17–22.

Follet, R. F., & Stewart, B. A. (1985). Soil erosion and crop production. *American Society of Agronomy*, Madison, Wisconsin, USA, 261–274.

Karlen, D. L., Kamar, A., Kanwar, R. S., Cambardella, C. A., & Colvin, T. S. (1999). Tillage systems effects on 15 years carbon-based and simulated N budgets in a tile-drained Iowa field. *Soil and Tillage Research, 48*(3), 155-165.

Khurshid, K., Iqbal, M., Arif, M. S., & Nawaz, A. (2006). Effect of tillage on soil physical properties and growth of maize. *International Journal of Agriculture and Biology, 8*(5), 593-596.

Lal, R. (1995). Tillage and mulching effects on maize yield for seventeen consecutive seasons on a tropical alfisol. *Journal of Sustainable Agriculture, 5*, 79–93.

Kamprath, E. J. (1970). Lime requirement of soils with high aluminum saturation. *Soil Science Society of America Journal, 34*(3), 457-460.

Van Lierop, W. (1990). Liming to improve crop production on acid soils in the tropics: A review of research results from the International Institute of Tropical Agriculture (IITA). *Tropical Agriculture, 67*(1), 1-10.

Sims, J. T., & Johnson, G. V. (1996). The role of soil pH in nutrient availability and crop production in acid soils: A review of research results from the University of Delaware. *Delaware Agricultural Experiment Station Report*.

Morgan, R. P. C. (1995). *Soil erosion and conservation* (2nd ed.). United Kingdom: Longman Group Limited, 112–119.

Motavalli, P. P., Stevens, W. E., & Hartwig, G. (2003). Remediation of subsoil compaction effects on corn N availability by deep tillage and application of poultry manure in a sandy textured soil. *Soil and Tillage Research, 71*, 121–131.

Karlen, D. L. (2004). Soil quality as an indicator of sustainable tillage practice. *Soil Tillage Research, 78*, 129-130.

Trout, T. J., Garcia-Castillas, I. G., & Hart, W. E. (1987). *Soil engineering field and laboratory manual*. Perks, Indiana, 43-44.

McLean, E. O. (1982). Soil pH and lime requirement. In *Methods of soil analysis, part 2: Chemical and microbiological properties* (2nd ed., Agronomy Monograph, 9, pp. 199-224). American Society of Agronomy.

Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science, 59*(1), 39-45.

Riquier, J., Boulanger, A., & Dufour, J. (1970). A method for calculating the productivity index of soils. In *Soil Fertility and Fertilizers* (pp. 123-130).

Diaz-Zorita, M. (2000). Tillage practices and soil quality: Effects on crop production. *Soil and Tillage Research, 53*(3), 175-186.

Bonari, E., Mazzoncini, M., Silvestri, N., Pagliai, M., Barbafieri, M., Borin, M., & Sattin, M. (1994). Effects of different soil tillage systems on soil physical characteristics and maize yield. *Proceedings of the Third Congress of the European Society for Agronomy*, Padova University, Abano-Padova, Italy, 454–455.

Ojeniyi, S. O., Balogun, F. A., & Awodun, M. A. (2014). Effect of combined application of NPK fertilizer and poultry manure on okra production. *The Proceedings of the 38th Annual Conference of the Soil Science Society of Nigeria*, 524–529.

Agber, P. I., & Abagyeh, S. O. I. (2012). Influence of combined application of organic manures and NPK fertilizer on soil physical properties, growth and yield of maize in an alfisol in the Southern Guinea Savannah, Nigeria. *Nigeria Journal of Soil and Environmental Resources, 10*, 30–34.

Sullivan, P. (2010, November 15). *Sustainable soil management: Soil system guide.* ATTRA National Sustainable Agriculture Information Service, National Center for Appropriate Technology (NCAT).

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