ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2682-7786 (Online)
CODEN: BDAIDR

Big Data in Agriculture (BDA)

DOI: http://doi.org/10.26480/bda.01.2025.39.47

CrossMark

REVIEW ARTICLE

CAN NPK MINERAL FERTILIZER AND ORGANIC RESIDUES IMPROVE MAIZE PERFORMANCE AND SELECTED SOIL PROPERTIES IN TWO SIMULATED ERODED SOIL SERIES IN SOUTH WESTERN NIGERIA?

Kolawole G. O.* and Oyeyiola Y. B.

Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo State, Nigeria.
****Corresponding Author Email: ogkolawole@lautech.edu.ng***

ARTICLE DETAILS

Article History:

Received 19 March 2025
Revised 25 April 2025
Accepted 22 May 2025
Available online 18 June 2025

ABSTRACT

Top soil removal from farmlands may cause decline in soil and crop productivity. The extent to which NPK mineral fertilizer and organic residues may alleviate this negative effect on maize performance and soil chemical properties was determined at the Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria between March and August, 2020 for two dominant soil series in south western Nigeria (Itagunmodi (Rhodic Paleustult) and Majeroku (Abruptic Tropaqualf). NPK fertilizer, poultry manure (PM) and tithonia compost (TC) and no amendment (for comparison) were applied to soils collected from (0 – 5, 6 – 10, and 11 – 15 cm soil depths). Pre planting and post-harvest soil chemical analyses were conducted. Height, weights of dry grain of maize plants were recorded. Itagunmodi soil was inherently more acidic than Majeroku soil at all the soil depths. Soil organic carbon and nitrogen were low and declined with depth in both soils. In Itagunmodi soil, removal of 5 and 10 cm top soil respectively without soil amendment caused 63.9% and 87.5% reduction in maize grain weight. Similarly, the corresponding grain weight reductions in Majeroku soil were 27.8% and 100%. In Itagunmodi soil, NPK fertilizer reduced the negative effect of top soil removal to 26.4% and 48.6% respectively compared to TC which improved maize grain weight by 289% and 119%. In Majeroku soil, NPK reduced grain weight by 43.1% and 1.4% compared with TC which improved it by 402% and 213.9% respectively. Top soil removal reduced post-harvest soil organic carbon content. The organic residues were superior in improving soil pH and organic carbon than NPK and the control. Top soil removal had no significant effect on post-harvest soil available P. Tithonia compost improved available P (11.32 mg/kg) and (16.92 mg/kg) in Itagunmodi and Majeroku soils than 1.51 mg/kg and 2.82 mg/kg observed for NPK in both soils. In conclusion, the soil series differed in their effects on maize performance. Surface soil removal had adverse effect on maize performance and soil chemical characteristics. The organic residues (PM and TC) were superior to NPK fertilizer in mitigating the effects of top soil removal on the maize performance and soil properties.

KEYWORDS

Maize, Mineral fertilizer, Organic residues, Soil properties, Top soil removal

1. INTRODUCTION

Many farmlands in southwestern Nigeria have identifiable areas of low productivity due to poor soil fertility occasioned by soil erosion. Soil erosion is a natural process of soil material (including plant nutrients) removal and transportation through the action of erosive agents such as water, wind, gravity and human disturbance (Hacisalihoglu et al., 2010). Soil erosion is a globally significant environmental process which degrades the soil upon which we rely on for food, fuel, clean water, carbon storage and substrates for building and infrastructure (Quinton, 2014). Soil erosion has been a problem in crop production since time immemorial. The most prominent effect of erosion on the soil is a loss of soil productivity due to reduced capacities in biological, chemical and physical properties. Crop yields has generally been reduced by soil erosion (Chengere and Lal, 1995; Lin et al., 2019). The major pathways of soil fertility decline on farmlands include the loss of nutrients through erosion, leaching, volatilization, crop uptake and harvest without the corresponding replenishment. Soil nutrients replenishment is therefore a prerequisite for halting soil fertility decline. This may be accomplished through the application of mineral and organic fertilizers. Several options have been employed by farmers for correcting or compensating for soil erosion and restoring the productivity of these soils. Some of these options include crop rotation, planting of cover crops, organic residue mulches, planting of trees and shrubs, application of organic residues of plant and animal origin and mineral fertilizer application to improve crop performance and limit the potential of further erosion. Among these options, the most common approach in Africa is to apply more mineral fertilizer to eroded areas. Application of livestock manure is another option where manure is readily available. Typical significant yield responses to application of mineral fertilizers on eroded soils has been reported but, these responses only partly compensate for the yield losses due to erosion (Mbagwu et al., 1984; Mahli et al., 1994; Zhang et al., 2021). Furthermore, application of manure to eroded land has been observed to increase crop yield (Larney and Hanzen, 1996; Sui et al., 2009; Maysoon et al., 2017). Research has shown that combinations of organic and mineral fertilizers result in greater crop yields compared with sole organic or sole mineral fertilizers (Chiyenge et al., 2009; Singh et al., 2016; Sparling et al., 2018; Mitiku et al., 2023). This increase in grain yield has been attributed to improved N synchrony with combined inputs through direct interactions of the organic and N fertilizers.

Maize (Zea mays L.) is the most important cereal worldwide (Ashraf et al., 2016). Its cultivation, however, can be difficult in locations with degraded soils, such as those affected by erosion. Crop yields are frequently low under these conditions, and soil fertility is diminished, making it difficult to continue maize production. The utilization of mineral fertilizers and organic manure to promote soil fertility and enhance maize yields is one possible solution to this problem (Li et al., 2015; Wang et al., 2017; Khan et al., 2018). According to the study, applying N fertilizers to maize in eroded soils can enhance leaf area, biomass, and yield by improving the crop's vegetative development and photosynthetic ability (Lal, 2004).

Quick Response Code	Access this article online	
	Website: www.bigdatainagriculture.com.my	**DOI:** 10.26480/bda.01.2025.39.47

Cite The Article: Kolawole G. O. and Oyeyiola Y. B. (2025). Can Npk Mineral Fertilizer and Organic Residues Improve Maize Performance and Selected Soil Properties in Two Simulated Eroded Soil Series in South Western Nigeria?. *Big Data in Agriculture, 7(1): 39-47.*

However, high N fertilizer rates can cause nutritional imbalances, waterlogging, and nutrient leaching, all of which can impair crop growth and production and environmental quality (Sparling et al., 2018). They reported that using mineral fertilizers in eroded soils can reduce crop yields by causing nutritional imbalances in the soil (Yao et al., 2018). This is because fertilizers can give an abundance of some of these nutrients, such as N and P, but deficient in others, like K. This can result in lower crop growth and production.

Organic fertilizers are obtained from animal or plant waste and are used to increase soil fertility and crop growth (Kibet and Mucheru-Muna., 2015). They are more environmentally friendly than mineral fertilizers because they are produced from natural sources and can increase soil structure and water-holding capacity (Singh et al., 2016). They observed that using organic fertilizers in degraded soils can boost crop yields by providing vital nutrients to the soil (Zhang et al., 2017). This is due to the fact that manure can supply a balance of nutrients such as N, P, and K, which can contribute to increased crop growth and yield. Another investigation reported that use of organic fertilizers in degraded soils can increase soil fertility by improving soil structure and water - holding capacity (Wang et al., 2022). This is due to the fact that manure can contribute organic material to the soil, which can increase soil structure and strengthen the soil's ability to store water.

Mineral fertilizers and organic manure have been extensively examined for their impact on maize on degraded soils. Several studies have demonstrated that using mineral fertilizers and organic manure can enhance soil fertility, boost maize yields, and decrease erosion (Singh et al., 2016; Sparling et al., 2018). According to a study conducted in India, co-application of mineral and organic fertilizers enhanced maize yields by 25-30% when compared to using mineral fertilizer alone (Singh et al., 2016). Similarly, another study in Ethiopia noted that combining mineral and organic fertilizers enhanced maize yields by 40% when compared with sole mineral fertilizer application (Sparling et al., 2018). Furthermore, mineral fertilizers and organic manure could help increase maize yields and improve soil fertility in degraded soils. The present study was therefore conducted to determine the potentials of mineral fertilizer and organic residues applied solely or combined in improving maize performance and selected soil chemical properties in simulated eroded soils.

2. Materials and Methods

2.1 Soil collection, preparation and analysis

Two dominant soil series in the southern Guinea savanna, Nigeria: Itagunmodi (Rhodic Paleustult) and Majeroku (Abruptic Tropaqualf) were collected from two study sites in Osun and Oyo States, Nigeria respectively. Itagunmodi soil series was obtained from Idominasi (Ilesa – Osogbo road), Osun State while Majeroku soil series was collected from the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Randomly selected areas were demarcated at the field sampling sites. Soil samples were excavated sequentially to simulate erosion levels, at three different soil depths; 0 - 5 cm, 6 -10 and 11 – 15 cm denoted as non-eroded, moderately eroded and severely eroded soils respectively. Soils from the respective depths from each of the sampling sites were mixed thoroughly to form composites. The soils were air dried and sieved to pass through 2- and 0.5-mm mesh sizes. The sub samples were taken to the laboratory for physical and chemical analysis. The samples were analyzed for pH (1:2 soil: water ratio), particle size distribution (Gee and Bauder, 1986), total N using the macro Kjeldahl method Bremner and Mulvaney, 1982) and exchangeable cations (Ca, Mg, K and Na). After soil extraction with 1N NH_4OAc (buffered at pH 7), K in the filtrate was measured with a flame photometer and calcium and magnesium were determined using atomic absorption spectrophotometer. Available P was determined by colorimetry procedure after extraction with Bray 1 solution (Bray and kurtz, 1945).

2.2 Site description for the pot experiment

The pot experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso (Longitude 4° 10´ E, Latitude 8° 10´ N and alt. 213m asl), Oyo State, in the Southern Guinea Savanna Agro-ecological zone of Nigeria between March and August, 2020.

2.3 Treatments and experimental design

The soil types (Itagunmodi and Majeroku) formed the main factor treatments, the soil amendments formed the sub factor treatments while the soil depths (0 – 5, 6 – 10, and 11 – 15 cm) were the sub-sub factor treatments. The treatments were arranged as 2 x 8 x 3 factorial in completely randomized design replicated three times.

2.4 Agronomic activities

Cured poultry manure and tithonia compost used were obtained from the Department of Crop Production and Soil Science, LAUTECH. They were applied at 5 t ha^{-1}. Sub samples of the poultry manure and tithonia compost were ground and taken to the laboratory and analysed for N, P, and K contents (Table 1). The N, P and K contents of the organic residues were used to calculate the N, P and K rates supplied in each treatment (Table 2).

Table 1: Nitrogen, P and K contents of tithonia compost and poultry manure used

	N	P	K
	-------------------------	(%)------------------------	
Tithonia compost	2.26	0.95	2.13
Poultry manure	2.98	1.31	2.34

Table 2: Treatment application schedule

	Inorganic source			Organic source			Total		
	--------(kg/ha)---------			-----------(kg/ha)-----------			-----------(kg/ha)---------		
Treatments	N	P	K	N	P	K	N	P	K
Control	0	0	0	0	0	0	0	0	0
NPK	120	60	30	0	0	0	120	60	30
Tithonia compost (TC)	0	0	0	113.0	47.5	106.5	113.0	47.5	106.5
Poultry manure (PM)	0	0	0	149.0	65.5	117.0	149.0	65.5	117.0
½(NPK+TC)	60	30	15	56.5	23.75	53.25	116.5	53.75	71.5
½(NPK+PM)	60	30	15	74.5	32.75	58.5	134.5	62.75	73.5
½(TC+PM)	0	0	0	131.0	56.5	111.75	131.0	56.5	111.75
$^{1}/_{3}$(NPK+TC+PM)	40	20	10	87.3	37.6	74.5	127.3	57.6	84.5

A total of 144 polythene pots were each filled with 20 kg soil. The pots were perforated at the base. Poultry manure and tithonia compost were applied appropriately and mixed thoroughly with the soil in designated pots one week before planting. The soils in all the pots were watered to field capacity and left to equilibrate before planting. Three seeds each of maize var. Yellow tropical *Zea mays*, extra early, striga resistance cycle 5 population Tzee-Yposp SIR 15 were planted per pot. The seedlings were later thinned to one/pot at two weeks after sowing. NPK mineral fertilizer was applied at 120-60-30 kg/ha to designated pots in ring form about 3 cm away from the plant. Hand pulling of weeds was done as required. Uprooted weeds were left in each pot to decompose. Watering was done uniformly as the need arose.

2.5 Data collection

Height of maize plant in each pot was measured at 10 WAP. The maize plants were thereafter harvested and separated into shoot and cob. They were put in well labelled envelopes and oven dried at 80°C for 72 hours. Dry grains were shelled from the cobs. Weights of dry maize shoot and grain were measured on sensitive balance. Post planting soil was sampled with the aid of an iron pipe (diameter 24 mm) and analyzed for pH, organic carbon, available P and extractable potassium.

2.6 Statistical analysis

Data recorded were subjected to Analysis of Variance (ANOVA) using SAS statistical software (SAS, 1999). Significant differences were assessed at 5% level of probability and the treatment means were separated using the Duncan's Multiple Range Test procedure.

3. Results

3.1 Pre-sowing characteristics of the soils used for the experiment

Itagunmodi soil was more acidic irrespective of the soil depths (pH 5.01, 5.07 and 5.10 at the 0-5, 6-10 and 11-15 cm depths respectively) than Majeroku soil (pH 5.73, 5.72 and 5.65 respectively). Soil pH was fairly similar across the soil depths for both soil types (Table 3). Soil organic carbon and N were low in both soils and declined with soil depth. This was however more pronounced for Majeroku soil. Available phosphorus was quite low in both soils across the depths, except for Majeroku soil at 6-10 cm depth where available P concentration l was fairly moderate (10.82 mg/kg).

Potassium, Ca, Mg and Na were fairly similar across the soil depths for both soil types. However, Mg was higher in Itagunmodi soil than in Majeroku soil. Itagunmodi soil was sandy loam while Majeroku was sandy (Table 3).

Table 3: Pre-sowing chemical and physical characteristics of two soil series used for the experiment

	Itagunmodi			Majeroku		
	Soil depth (cm)			Soil depth (cm)		
Parameters	0 – 5	6 - 10	11 - 16	0 - 5	6 - 10	11 - 16
pH (H_2O)	5.01	5.07	5.10	5.73	5.72	5.65
Org. C (%)	1.01	0.86	0.74	0.84	0.59	0.39
Tot. N (%)	0.07	0.05	0.04	0.10	0.09	0.09
P (mg/kg)	3.90	3.03	3.61	12.19	10.82	3.38
Exch. cations (Cmol/kg)						
K	0.13	0.11	0.09	0.10	0.10	0.10
Ca	7.79	4.47	2.57	5.61	2.73	3.66
Mg	2.18	1.84	1.50	0.98	0.91	0.95
Na	0.31	0.27	0.23	0.37	0.41	0.35
Al	0.16	0.24	0.24	0.00	0.00	0.00
ECEC	10.57	6.93	4.63	7.06	4.15	5.06
Sand (%)	73.2	69.2	75.2	87.2	89.2	87.2
Silt (%)	17.4	19.4	15.4	5.4	3.4	5.4
Clay (%)	9.4	11.4	9.4	7.4	7.4	7.4
Textural class	Sandy Loam			Sandy soil		

3.2 Effect of soil amendments on maize plant height in two simulated eroded soil series

Plant height was not significantly affected by soil depths in Itagunmodi soil series (Table 4). However, soil amendment with NPK+TC produced significantly tallest maize plants (134.6 cm) while amendment with NPK+PM produced significantly shortest plants (98.8 cm) with values not significantly different from the control (104.9 cm). Similarly, for Majeroku soil series, soil depths did not significantly influence maize plant height. On the average, soil amended with PM+TC had significantly tallest plants (146.8 cm) while the control had significantly shortest plants (86.7 cm). All the soil amendments had significantly taller plants than the control.

Generally, from the grand mean values, Majeroku soil supported significantly taller plants (125.8 cm) than Itagunmodi soil (120.2 cm). Height of maize planted in the soil from the 6-10 cm depth was significantly taller than that planted in the soil from the 0-5 cm depth. The heights of plants in the soil from the 0-5 and 11-15 cm depths were not significantly different from each other. All the plants that received soil amendments were significantly taller than the plants that did not receive any amendment (Control). Amendment with PM+TC (135.9 cm) and NPK+TC (135.8 cm) produced tallest plants. Although, these were not significantly different from the height of plants that received TC (133.0 cm) and NPK (130.1 cm) (Table 4).

Table 4: Effect of organic and inorganic amendments on maize plant height in two simulated eroded soil types at ten weeks after planting

	Itagunmodi				Majeroku			
	Soil Depth (cm)				Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean	0 – 5	6 – 10	11 – 15	mean
	Plant height (cm)							
Control	97.0	107.9	109.7	104.9cd	105.7	88.9	65.7	86.7d
NPK	126.5	133.4	105.3	121.8ab	121.6	157.3	136.4	138.4ab
Tithonia compost (TC)	121.5	133.7	135.0	130.0ab	127.7	142.0	138.4	136.0ab
Poultry manure (PM)	128.6	118.6	131.0	116.0bc	100.2	116.2	106.3	107.6c
½(NPK+TC)	138.9	135.9	129.1	134.6a	143.8	140.1	127.2	137.0ab
½(NPK+PM)	100.0	121.8	100.9	98.8d	134.5	115.8	130.1	126.8b
½(TC+PM)	107.9	133.3	134.0	125.1ab	142.7	155.1	142.5	146.8a
⅓(NPK+TC+PM)	131.5	115.7	118.1	121.8ab	123.3	122.7	134.2	126.7b
Soil depth mean	115.2	125.0	120.4 ns		124.9	129.7	122.6 ns	

Table 4 (cont): Effect of organic and inorganic amendments on maize plant height in two simulated eroded soil types at ten weeks after planting

GRAND MEANS

Soil types Itagunmodi = 120.2b Majeroku = 125.8a

Soil depth 0 – 5 cm = 120.1b 6 – 10 cm = 127.4a 11 – 15 cm = 121.5ab

Treatments

Control = 95.8e

NPK = 130.1ab

Tithonia compost (TC) = 133.0ab

Poultry manure (PM) = 111.8d

½(NPK+TC) = 135.8a

½(NPK+PM) = 117.2cd

½(TC+PM) = 135.9a

¹/₃(NPK+TC+PM) = 124.2bc

3.3 Effect of soil amendments on maize dry grain weight grown in two simulated eroded soil series

Dry grain weight values recorded for the soil depths were statistically similar in Itagunmodi soil (Table 5). Although, the trend was 6-10 cm > 11-15 cm > 0-5 cm. On the average, application of PM+TC promoted significantly highest grain weight (23.3 g/plant), while the control had the lowest grain weight (3.6 g/plant) but, not significantly different from the values recorded for NPK+PM, NPK, NPK+PM+TC, NPK+TC and PM. Response to the soil amendments was more pronounced in soil from the 6-10 cm depth except for PM which was more effective at the 11-15 cm depth. Without any soil amendments, removal of 5 cm surface soil (6-10 cm depth) reduced maize grain weight by 63.9% and by 87.5% with 10 cm surface soil removal (11 – 15 cm depth) compared with the 0 – 5 cm depth. Whereas, application of NPK mineral fertilizer reduced this adverse effect to 26.4% with the removal of 5 cm surface soil (6-10 cm depth) and to 48.6% with 10 cm surface soil removal (11 – 15 cm depth). However, application of TC improved maize grain weight by 289% and 119% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). PM improved maize grain weight by 27.8% and 226.4% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). Combination of NPK+TC improved maize grain weight by 86.1% and 43.1% respectively with removal of 5 cm surface soil (6-10 cm depth) and 10 cm surface soil removal (11 – 15 cm depth). On the other hand, NPK+PM improved maize grain weight by 76.4% with removal of 5 cm surface soil (6-10 cm depth), while it reduced maize grain weight by 77.8% with 10 cm surface soil removal (11 – 15 cm depth) compared with the 0 – 5 cm depth without any soil amendments. Combination of PM+TC improved maize grain weight by 347.2% and 240.3% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). However, NPK+PM+TC improved maize grain weight by 173.6% with removal of 5 cm surface soil (6-10 cm depth), while it reduced maize grain weight by 36.1% with 10 cm surface soil removal (11 – 15 cm depth).

In contrast to the observation for Itagunmodi soil type, dry maize grain weight was significantly higher in the soil from the 6-10 cm depth (16.8 g/plant) and 0-5 cm depth (14.9 g/plant) than the 11-15 cm depth (8.2 g/plant) in Majeroku soil type.

Application of TC promoted significantly highest grain weight (27.1 g/plant) while the control had the lowest grain weight (4.3 g/plant). Application of NPK, PM and NPK+TC were most effective in influencing grain weight at the 0-5 cm depth, while TC, NPK+PM, PM+TC and NPK+PM+TC were more effective at the 6-10 cm depth.

In Majeroku soil series without any soil amendments, removal of 5 cm surface soil (6-10 cm depth) reduced maize grain weight by 27.8% and by 100.0% with 10 cm surface soil removal (11 – 15 cm depth) compared with the 0 – 5 cm depth. Application of NPK mineral fertilizer even reduced maize grain weight by 43.1% and 1.4% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). Application of TC improve maize grain weight by 402% and 213.9% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). In contrast, PM reduced maize grain weight by 37.5% and 100% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). Similarly, NPK+TC reduced maize grain weight by 20.8% and 1.4% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth). On the other hand, NPK+PM, TC+PM and NPK+PM+TC increased maize grain weights by 165.3 and 5.6%, 297.2 and 88.9% and 329.2 and 4.2% respectively with removal of 5 cm surface soil (6-10 cm depth) and10 cm surface soil removal (11 – 15 cm depth)) compared with the 0 – 5 cm depth without any soil amendments.

From the grand mean values, the soil series did not influence maize grain weight significantly. However, soil depths had significant effect on grain weight. Soil from the 6-10 cm depth had significantly higher grain weight (16.10 g/plant) than 11-15 cm depth (9.40 g/plant). Maize plants from unamended soil (Control) produced significantly the lowest grain weight (3.92 g/plant). This however, was not significantly different from what was recorded for NPK (7.59 g/plant), NPK+PM (8.27 g/plant) and NPK+TC (10.98 g/plant). Plants that received TC produced significantly highest grain weight (23.80 g/plant) which was not significantly different from the value recorded for PM+TC (20.52 g/plant).

Table 5: Effect of organic and inorganic amendments on maize dry grain weight in two simulated eroded soil types

	Itagunmodi				Majeroku			
	Soil Depth (cm)				Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean	0 – 5	6 – 10	11 – 15	mean
	Maize dry grain weight (g/pot)							
Control	7.20	2.6	0.9	3.6c	7.2	5.2	0.0	4.3c
NPK	11.9	5.3	3.7	6.9c	13.5	4.1	7.1	8.2bc
Tithonia compost (TC)	17.6	28.0	15.8	20.5ab	22.7	36.2	22.6	27.1a
Poultry manure (PM)	4.5	9.2	23.5	12.4bc	25.6	4.5	0.0	10.1bc
½(NPK+TC)	11.7	13.4	10.3	11.8bc	17.7	5.7	7.1	10.2bc
½(NPK+PM)	1.0	12.7	1.6	5.1c	7.7	19.1	7.6	11.5bc
½(TC+PM)	13.3	32.2	24.5	23.3a	10.9	28.6	13.6	17.7ab

Table 5(cont): Effect of organic and inorganic amendments on maize dry grain weight in two simulated roded soil types

1/3(NPK+TC+PM)	10.6	19.7	4.6	11.6bc	13.1	30.9	7.5	17.2ab
Soil depth mean	9.7	15.4	10.6ns		14.9a	16.8a	8.2b	

GRAND MEANS

Soil types Itagunmodi = 11.90ns Majeroku = 13.29ns

Soil depth 0 – 5 cm = 12.30ab 6 – 10 cm = 16.10a 11 – 15 cm = 9.40b

Treatments

Control = 3.92d

NPK = 7.59cd

Tithonia compost (TC) = 23.80a

Poultry manure (PM) = 11.25c

½(NPK+TC) = 10.98cd

½(NPK+PM) = 8.27cd

½(TC+PM) = 20.52ab

1/3(NPK+TC+PM) = 14.40bc

3.4 Effects of soil amendments on post-harvest properties of two simulated eroded soil series

3.4.1 Soil pH

The pH of Itagunmodi soil series was significantly higher at the 11 – 15 cm depth (6.51) than at the 0 – 5 cm (6.14) and 6 – 10 cm (6.30) depths (Table 6). Application of TC, PM+TC and NPK+PM+TC improved soil pH significantly compared with NPK, the control, PM and NPK+PM. Similarly, soil pH was significantly higher at the11 – 15 cm depth (7.09) than at the 0 – 5 cm depth (6.72) and 6 – 10 cm depth (6.51) for Majeroku soil. Almost all the soil amendments had significantly higher soil pH than the control which was not however significantly different from NPK, NPK+PM and PM+TC.

From the grand mean values, Majeroku soil was significantly less acidic (pH 6.77) than Itagunmodi soil (pH 6.31). Soil acidity decreased with soil depths. The control (pH 6.27) and NPK fertilizer treatment (pH 6.31) were significantly more acidic than the other soil amendment treatments. Application of TC (pH 6.83), PM+TC (6.71) and NPK+PM+TC (pH 6.71) significantly reduced soil acidity compared with the other treatments.

Table 6: Effect of organic and inorganic amendments on post-harvest soil pH in two simulated eroded soil types

	Itagunmodi				Majeroku			
	Soil Depth (cm)				Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean	0 – 5	6 – 10	11 – 15	mean
	pH							
Baseline	5.01	5.07	5.10		5.73	5.72	5.65	
Control	6.13	6.30	6.20	6.13cd	6.51	6.51	6.40	6.42b
NPK	5.93	5.63	6.10	5.86d	6.33	6.19	7.80	6.76ab
Tithonia compost (TC)	6.23	7.19	7.00	6.80a	6.90	6.87	6.90	6.86a
Poultry manure (PM)	6.14	5.91	6.60	6.21c	6.68	6.93	7.00	6.84a
½(NPK+TC)	6.08	6.55	6.30	6.30bc	6.99	6.69	7.00	6.88a
½(NPK+PM)	6.15	5.82	6.20	6.06cd	6.80	6.86	6.70	6.79ab
½(TC+PM)	6.12	6.89	7.00	6.65a	6.77	5.82	7.70	6.77ab
1/3(NPK+TC+PM)	6.32	6.39	7.00	6.54ab	6.80	6.36	7.50	6.89a
Soil depth mean	6.14b	6.30b	6.51a		6.72b	6.51b	7.09a	

GRAND MEANS

Soil types Itagunmodi = 6.312b Majeroku = 6.77a

Soil depth 0 – 5 cm = 6.43b 6 – 10 cm = 6.40b 11 – 15 cm = 6.80a

Treatments

Control = 6.27f

NPK = 6.31ef

Tithonia compost (TC) = 6.83a

Poultry manure (PM) = 6.52cd

½(NPK+TC) = 6.59bc

½(NPK+PM) = 6.43de

½(TC+PM) = 6.71ab

1/3(NPK+TC+PM) = 6.71ab

3.4.2 Soil organic carbon

Soil organic carbon (SOC) decreased with increase in soil depths for both soil series (Table 7). Averaged across soil depths, application of TC had significantly highest SOC (1.04%) while the control had significantly lowest SOC (0.70%) for Itagunmodi soil series. For Majeroku soil series, averaged across soil depths, application of PM enhanced highest SOC (0.69%), though not significantly different from the control (0.68%), TC (0.61%) and NPK+TC (0.59%) while application of PM+TC (0.29%) and NPK+PM+TC (0.38%) had significantly lowest SOC.

From the grand mean values, SOC was significantly higher in Itagunmodi soil (0.90%) than in Majeroku soil (0.51%). SOC decreased significantly with soil depth. Application of TC (0.83%) significantly improved SOC than the other treatments except PM (0.77%). The lowest SOC was recorded for PM+TC (0.63%). For Itagunmodi soil series, without any soil amendment, removal of 5 cm and 10 cm surface soil reduced SOC by 7.2% and 39.8% respectively. Application NPK fertilizer reduced it by 12.5% with 5 cm surface soil removal and improved it by 3.6% with 10 cm surface soil removal. Application of TC reduced SOC by 2.4% and improved it by 3.6% with removal of 5 and 10 cm surface soil respectively. PM reduced SOC by 14.5% and 9.6% with removal of 5 and 10 cm surface soil respectively. Similarly, NPK+TC, NPK+PM and NPK+PM reduced SOC by 4.8% and 9.6%, 4.8% and 31.3%, and 0% and 32.5% respectively with removal of 5 and 10 cm surface soil respectively. Combined application of TC and PM improved SOC 26.5% and reduced it by 37.3% respectively with removal of 5 and 10 cm surface soil. NPK+PM+TC improved SOC by 12% and 0% respectively with removal of 5 and 10 cm surface soil.

For Majeroku soil series, surface soil removal did not affect SOC significantly. Generally, the soil amendments had negative effect on SOC irrespective of soil depths except PM which improved SOC by 12.3% with 10 cm surface soil removal.

Table 7: Effect of organic and inorganic amendments on post-harvest soil organic carbon in two simulated eroded soil types

	Itagunmodi				Majeroku			
	---				--			
	Soil Depth (cm)				Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean	0 – 5	6 – 10	11 – 15	mean
	Soil organic carbon (%)							
Baseline	1.01	0.86	0.74		0.84	0.59	0.39	
Control	0.83	0.77	0.50	0.70d	0.65	0.69	0.67	0.68a
NPK	1.26	0.71	0.86	0.95abc	0.87	0.38	0.07	0.44bc
Tithonia compost (TC)	1.44	0.81	0.87	1.04a	0.90	0.48	0.46	0.61ab
Poultry manure (PM)	1.10	0.71	0.75	0.85bc	0.87	0.43	0.73	0.69a
½(NPK+TC)	1.04	0.79	0.57	0.81cd	0.83	0.51	0.41	0.59ab
½(NPK+PM)	1.22	0.83	0.56	0.88bc	0.55	0.37	0.40	0.44bc
½(TC+PM)	1.35	1.05	0.52	0.98ab	0.54	0.21	0.11	0.29c
¹/₃(NPK+TC+PM)	1.22	0.93	0.83	0.99ab	0.61	0.32	0.21	0.38c
Soil depth mean	1.19a	0.82b	0.69c		0.73a	0.42b	0.38b	

GRAND MEANS

Soil types Itagunmodi = 0.90a Majeroku = 0.51b

Soil depth 0 – 5 cm = 0.96a 6 – 10 cm = 0.62b 11 – 15 cm = 0.53c

Treatments

Control = 0.69bc

NPK = 0.69bc

Tithonia compost (TC) = 0.83a

Poultry manure (PM) = 0.77ab

½(NPK+TC) = 0.70bc

½(NPK+PM) = 0.66c

½(TC+PM) = 0.63c

¹/₃(NPK+TC+PM) = 0.69bc

3.4.3 Available phosphorus

For both soil types, available P content was not significantly affected by soil depths (Table 8). Application of TC (11.32 mg/kg) and PM+TC (11.21 mg/kg) had significantly highest available P averaged across soil depths for Itagunmodi soil while NPK (1.51 mg/kg) and NPK+PM (2.06 mg/kg) had the least available P values. For Majeroku soil, application of TC (16.92 mg/kg) had significantly highest available P, followed by NPK+TC (9.05 mg/kg) while available P concentrations were not significantly different in the other treatments.

In Itagunmodi soil series, removal of 5 cm surface soil depressed available P by 54.3%, whereas with 10 cm surface soil removal available P improved by 20.2% without soil amendments. Compared to the control, NPK reduced available P by 57.8% and 44.3% with 5 and 10 cm surface soil removal respectively. Similarly, PM and NPK+PM reduced available P with 5 and 10 cm surface soil removal. On the other hand, TC improved available P by 54.5% and 386.8%; NPK+TC increased it by 14.$% and 76.0%; TC+PM improved it by 457.2% and 93.5%; NPK+TC+PM improved available P by 76.0% and 140.5% respectively with removal of 5 and 10 cm surface soil. In Majeroku soil series, surface soil removal of 5 and 10 cm respectively without soil amendments depressed available P by 49.0% and 60.0%. Application of NPK, PM, NPK+PM, TC+PM and NPK+TC+PM reduced available P to different degrees irrespective of soil depth. However, TC and NPK+TC improved available P by 76.3% and 329.6%, and 75.3% and 18.3% respectively with surface soil removal of 5 and 10 cm.

From the general mean values, available P concentrations were not significantly different between the soil types. However, available P was significantly higher at the 11 – 15 cm depth (6.43 mg/kg). Phosphorus availability was significantly improved by the application of TC (14.12 mg/kg) while NPK (2.16 mg/kg), NPK+PM (2.62 mg/kg), control (3.32 mg/kg) and PM (3.35 mg/kg) supported least P availability.

Table 8: Effect of organic and inorganic amendments on post-harvest available phosphorus in two simulated eroded soil types

	Itagunmodi				Majeroku			
	Soil Depth (cm)				Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean	0 – 5	6 – 10	11 – 15	mean
	Available Phosphorus (mg/kg)							
Baseline	3.09	3.03	3.61		4.19	10.82	3.38	
Control	3.41	1.56	4.10	3.00bc	5.75	2.93	2.30	3.59c
NPK	1.22	1.44	1.90	1.51c	3.44	1.80	3.20	2.82c
Tithonia compost (TC)	12.06	5.27	16.60	11.32a	15.95	10.14	24.70	16.92a
Poultry manure (PM)	5.97	0.83	3.00	3.20bc	2.47	5.40	2.60	3.50c
½(NPK+TC)	3.50	3.90	6.00	4.47bc	10.23	10.08	6.80	9.05b
½(NPK+PM)	1.25	2.02	2.90	2.06c	3.38	2.44	3.70	3.18c
½(TC+PM)	7.92	19.00	6.60	11.21a	2.63	5.52	5.40	4.52c
$^{1}/_{3}$(NPK+TC+PM)	3.29	6.00	8.20	5.84b	6.36	4.88	4.90	5.38c
Soil depth mean	4.81ns	5.01ns	6.17ns		6.27ns	5.40ns	6.69ns	

GRAND MEANS

Soil types Itagunmodi = 5.33ns Majeroku = 6.12ns

Soil depth 0 – 5 cm = 5.54ab 6 – 10 cm = 5.21b 11 – 15 cm = 6.43a

Treatments

Control = 3.32d

NPK = 2.16d

Tithonia compost (TC) = 14.12a

Poultry manure (PM) = 3.35d

½(NPK+TC) = 6.76bc

½(NPK+PM) = 2.62d

½(TC+PM) = 7.86b

$^{1}/_{3}$(NPK+TC+PM) = 5.61c

3.4.4 Exchangeable potassium content

Exchangeable K content was significantly higher at the 0 – 5 cm depth (0.16 cmol/kg) than at the two other depths in Itagunmodi soil series (Table 9). Application of TC influenced significantly highest exchangeable K while the control and NPK treatments had the least values. On the other hand, exchangeable K content did not differ significantly among the soil depths, neither did the soil amendments for Majeroku soil.

From the grand mean values, exchangeable K was significantly higher in Itagunmodi soil (0.14 cmol/kg) than in Majeroku soil (0.09 cmol/kg). Soil from the 0 – 5 cm depth had significantly higher K (0.13 cmol/kg) than those from the 6 – 10 and 11 – 15 cm depths (0.11 cmol/kg). TC (0.14 cmol/kg), NPK+PM+TC (0.13 cmol/kg) and NPK+TC (0.12 cmol/kg) supported significantly higher K contents while the control had the least K value (0.097 cmol/kg).

Table 9: Effect of organic and inorganic amendments on post-harvest exchangeable potassium in two simulated eroded soil types

	Itagunmodi					Majeroku			
	Soil Depth (cm)					Soil Depth (cm)			
Treatments	0 – 5	6 – 10	11 – 15	mean		0 – 5	6 – 10	11 – 15	mean
	Potassium (cmol/kg)								
Baseline	0.13	0.11	0.09			0.10	0.10	0.10	
Control	0.07	0.13	0.09	0.10d		0.07	0.11	0.10	0.09ns
NPK	0.12	0.10	0.13	0.11d		0.08	0.13	0.07	0.09
Tithonia compost (TC)	0.15	0.18	0.18	0.172a		0.10	0.10	0.09	0.10
Poultry manure (PM)	0.16	0.10	0.11	0.12cd		0.13	0.09	0.08	0.10
½(NPK+TC)	0.18	0.15	0.11	0.134abcd		0.10	0.11	0.09	0.10
½(NPK+PM)	0.14	0.10	0.13	0.127bcd		0.08	0.08	0.06	0.08
½(TC+PM)	0.21	0.11	0.12	0.149abc		0.09	0.08	0.07	0.08
$^{1}/_{3}$(NPK+TC+PM)	0.26	0.11	0.13	0.167ab		0.05	0.07	0.17	0.10
Soil depth mean	0.16a	0.12b	0.13b			0.09	0.096	0.09ns	

Table 9 (cont): Effect of organic and inorganic amendments on post-harvest exchangeable potassium in two simulated eroded soil types

GRAND MEANS

Soil types Itagunmodi = 0.14a Majeroku = 0.09b

Soil depth 0 – 5 cm = 0.13a 6 – 10 cm = 0.11b 11 – 15 cm = 0.11b

Treatments

Control = 0.097d

NPK = 0.11cd

Tithonia compost (TC) = 0.14a

Poultry manure (PM) = 0.11cd

½(NPK+TC) = 0.12abc

½(NPK+PM) = 0.10cd

½(TC+PM) = 0.115bcd

$^1/_3$(NPK+TC+PM) = 0.13ab

ns = not significant

3.5 Discussion

The soil series used in this study exhibited inherent differences in chemical and physical characteristics. Itagunmodi soil was more acidic than Majeroku soil irrespective of soil depth. Soil organic carbon and nitrogen were low in both soils and declined with depth. Available P was quite low in Itagunmodi soil. This observation is supported by the work, who compared the physical and chemical parameters of Majeroku and Itagunmodi soils in Nigeria s (Kolawole et al., 2010; Kolawole et al. 2018; Oyeyiola et al., 2015).

In this study, soil types had varied effects on maize growth. Majeroku soil supported taller maize plants compared to Itagunmodi soil. This may be due to the less acidic nature and higher contents of nitrogen and available phosphorus in Majeroku soil than Itagunmodi soil. Furthermore, Itagunmodi soil is more clayey than Majeroku soil. Adiaha (2016) evaluated the influence of soil types on maize height and reported that loamy soil produced maize crops with highest height compared to other soil types. The fact that the soil types were not similar in their effects on maize performance agrees with the reports of (Kolawole et al., 2010; 2018). This is in consonance with the study conducted by (Ziadi et al., 2013). They observed that loamy soil type produced higher maize yield compared to sandy soil type. This conclusion was linked to the fact that loamy soil had higher water-holding capacity, which allowed for increased nutrient uptake by maize plants.

Soil depths did not affect maize height in both soil types. There is no plausible reason that can be adduced for this observation since the major nutrients declined with soil depth in this study. However, previous workers opined that the lack of effects of soil depths on maize plant height may be because similar levels of available nutrients are stored in both eroded and non -eroded topsoil (0 to 10 cm depth) (Issah, 2023).

Generally, the soil amendments increased maize plant height compared to the control. Combined application of NPK mineral fertilizer with PM or TC or combination of the organic residues were superior to sole application of these amendments. This can be attributed to improved N synchrony with combined inputs through direct interactions of the organic and N fertilizers. They reported that combined application of mineral fertilizer with organic residue was superior to sole application of mineral fertilizer in influencing maize performance (Zerssa et al., 2021).

Surface soil removal had a negative impact on maize dry grain weight in Majeroku soil series. This decrease in production may be due to the loss of nutrients and soil organic matter caused by surface soil removal. This observation is consistent with the findings, who noted that removing the top 5 cm and 10 cm of soil from a cropped field by erosion resulted in a significant loss in crop production (Zhang et al., 2016). They reported an average reduction in crop productivity of 26.6% per 10 cm of soil loss with the top soil removal method (Bakker et al., 2004). They showed an average soybean yield reduction of 14.9% for every 10 cm increase in eroded soil depth (Wang et al., 2009). Their analysis supported the overarching hypothesis and illustrated that crop yield was substantially reduced with an increase in soil erosion depth (Zhang et al., 2021).

In this study however, grain weight in Itagunmodi soil series was not significantly affected by soil depth. They found that crop yields did not change significantly when erosion affected < 5 cm of soil, which agreed with the results of previous studies (Sui et al., 2009; Reiman and Iglik, 2010; Zhang et al., 2021). Combined application of inorganic and organic fertilizers was more effective in improving maize grain weight in both soil series than sole NPK. This is similar to the observation of previous workers who opined that it was due to the higher nitrogen use efficiency and consequently higher grain yield in the combined application than sole NPK (Sileshi et al., 2019; Asaye et al., 2022).

After harvest, the acidity decreased with soil depth, and soils treated with organic residues had higher pH than soils treated with NPK fertilizer and the control. Different mechanisms have been suggested to explain the initial rise in soil pH when organic residues are applied to soils. These include oxidation of organic-acid anions present in the decomposing residues, ammonification of residue organic N, specific adsorption of organic molecule produced during residue decomposition and reduction reactions induced by anaerobiosis (Haynes and Mokolobate, 2001). The observation that soil pH increased with depth is supported by the study conducted by (Maneesh et al., 2019) which noted that the soil pH increased with increase in soil depths. This is linked to leaching of soluble salt from surface to sub-surface soil. This may be related to the fact that organic residues release nutrients slowly, decreasing the rate of acidification. They demonstrated that organic residues solely and in combination with mineral fertilizer have a high potential for soil fertility improvement (Ogunjimi et al., 2017). The increased soil pH observed agrees with the findings who reported that increase in soil pH with the decomposition of organic residues applied is due to nitrogen transformation and release of basic cations (Cong and Merckx, 2005; Opala et al., 2012).

Soil organic carbon content decreased as soil depth increased. The drop in SOC with soil depth is caused by a decrease in organic matter input and an increase in organic matter breakdown with increasing soil depth. This agrees with the study conducted in China (Genxing et al., 2008). Similarly, they reported that SOC decreased with increasing soil depth (Corey et al., 2015). They ascribed the decline in SOC with soil depth to causes such as decreased organic matter input, decreased soil biological activity and weathering activities, and increased organic matter leaching with depth.

Soil available P content was not affected by soil depth for both soils. This observation is in consonance with the observation who reported that organic matter and total N were highly significantly affected by soil depth but soil pH and phosphorus were not (Emiru and Gebrekidan, 2013). Application of tithonia compost and poultry manure or their combination improved post-harvest soil exchangeable P content and tithonia compost was superior to poultry manure in improving soil P content. Poultry manure has been reported to have higher P content than tithonia compost (Kolawole and Oyeyiola, 2012; Kolawole, 2016). Both organic residues have potential as source of plant available P (Kolawole, 2016). The higher P content of poultry manure in this study did not translate to better post-harvest soil available P than tithonia compost. This observation is not in tandem with the report of Kolawole, (2016) that poultry manure enhanced higher available P compared with tithonia compost probably due to its higher P content (Kolawole, 2016). Nevertheless, the inherent nutrient release pattern of individual organic residue regardless of their initial N and P contents might have been responsible for the variations observed. They observed that tithonia compost showed better potential than NPK mineral fertilizer to ameliorate degraded soil, improve maize growth and nutrient uptake (Ogunjimi et al., 2017).

Application of the organic residues had different effects on K availability in the soils. While tithonia compost enhanced K content in Itagunmodi soil, it had no significant effect in Majeroku soil. This may be due to the conclusion that the nutrient release pattern of the residues varied with soil types and are dependent on soil characteristics (Kolawole, 2016).

4. Conclusion

Itagunmodi soil was more acidic than Majeroku soil which supported better maize growth than Itagunmodi soil. Surface soil removal had adverse effect on maize growth, dry grain weight and soil chemical properties. This effect was however dependent on the soil types. Tithonia compost, poultry manure or their combination were superior to NPK mineral fertilizer in mitigating the adverse effects of surface soil removal on maize performance and soil chemical properties.

References

Akinci, H., Özalp, A. Y., and Turgut, B., 2013. Agricultural land use suitability analysis using GIS and AHP technique. Computers and Electronics in Agriculture, 97, Pp. 71–82. https://doi.org/10.1016/J.COMPAG.2013.07.006

Dhakal, G., 2025. Evaluation of wheat and maize cropland suitability using gis and remote sensing technologies: the case of naraharinath rural municipality, karnali, nepal. Plant Physiology and Soil Chemistry (PPSC). https://doi.org/10.26480/PPSC.01.2025.21.26

FAO., 1976. Chapter 3 : Land suitability classifications. A Framework for Land Evaluation. Soils Bulletin 32., Pp. 1–9. http://www.fao.org/3/X5310E/x5310e00.htm

Foote, K.E. and Lynch, M., 2018. Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions. The Geographer's Craft Project, Department of Geography, The University of Colorado at Boulder. https://www.colorado.edu/geography/gcraft/notes/intro/intro.html

Perveen, M., Nagasawa, R., Uddin, M., and Delowar, H. (2007). Crop-land suitability analysis using a multicriteria evaluation and gis approach.

Saaty, T. L., 1980. Analytic Hierarchy Process Planning, Priority Setting, Resource Allocation. Advanced Optimization and Decision-Making Techniques in Textile Manufacturing, 287. https://books.google.com/books/about/The_Analytic_Hierarchy_Process.html?id=Xxi7AAAAIAAJ

Saaty, T. L., 2008. Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process. Revista de La Real Academia de Ciencias Exactas, Fisicas y Naturales - Serie A: Matematicas, 102(2), Pp. 251–318. https://doi.org/10.1007/BF03191825/METRICS

Tavana, M., Soltanifar, M., and Santos-Arteaga, F. J., 2023. Analytical hierarchy process: revolution and evolution. Annals of Operations Research, 326(2), Pp. 879–907. https://doi.org/10.1007/S10479-021-04432-2

Trigoso, D. I., López, R. S., Rojas Briceño, N. B., Silva López, J. O., Fernández, D. G., Oliva, M., Huatangari, L. Q., Terrones Murga, R. E., Castillo, E. B., and Barrena Gurbillón, M. Á., 2020. Land suitability analysis for potato crop in the jucusbamba and tincas microwatersheds (Amazonas, NW Peru): AHP and RS-GIS approach. Agronomy, 10(12). https://doi.org/10.3390/AGRONOMY10121898