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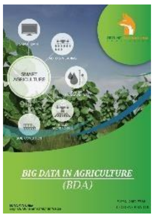

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RESEARCH ARTICLE

EFFECTS OF LIME, VERMICOMPOST, AND BLENDED FERTILIZER ON MAIZE (*ZEA MAYS* L.) POSTHARVEST SELECTED SOIL CHEMICAL PROPERTIES IN ASSOSA DISTRICT, NORTH WESTERN ETHIOPIA

Abdisa Abebe[a]*, Markku Yli-Halla[b], Lemma Wogi[c] and Abdissa Bekele[d]

[a]Department of Soil resource and watershed management, University of Assosa, P.O. Box 18, Ethiopia.
[b]Department of Agricultural Sciences, University of Helsinki, P.O. Box 27,
[c]School of Natural Resources Management and Environmental Sciences, University of Haramaya, P.O. Box 138, Dire Dawa, Ethiopia.
[d]College of Agriculture and Environmental Sciences, Oda Bultum University, P.O. Box 226 Chiro, Ethiopia
**Corresponding Author Email: abdisaabebe3@gmail.com*

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ABSTRACT

Integrated application of lime, vermicompost, and blended fertilizers are conducive to higher crop yields but its impacts on the nitisols of the study area have not been investigated. Therefore, this study was conducted to evaluate the response of selected soil chemical properties to lime, blended fertilizer, and vermicompost after harvest. The experiment consisted of three vermicompost levels (0, 2.5, and 5 t ha^{-1}), and three blended NPSZnB fertilizer levels (0, 100, and 200 kg ha^{-1}) with and without lime that are arranged in a randomized complete block design with three replications. The study showed that integrated application of 5 t ha^{-1} vermicompost with lime increased the pH from 5.27 to 6.03, organic carbon, and total nitrogen from 1.56% and 0.15% to 2.95% and 0.22%, respectively. Integrated applications of vermicompost and lime increased exchangeable calcium, magnesium, and potassium by 19%, 34%, and 50% respectively while exchangeable acidity and exchangeable Al significantly decreased. Similarly, the combined application of 200 kg ha^{-1} NPSZnB fertilizer and 5 t ha^{-1} vermicompost with lime significantly increased available phosphorus, sulfur, and extractable micronutrients. From this result, it can be concluded that integrated soil fertility management of vermicompost and blended fertilizer with lime is a feasible approach to overcome soil acidity problems and fertility constraints of study area.

KEYWORDS

Blended fertilizer, integrated application, Lime, Sole, Vermicompost

1. INTRODUCTION

Minimum supply and fertilizers use, soil acidity, the poor attitude of farmers towards modern technology use, minimum supply and use of improved seed varieties, and conflict were the major problems of crop production identified in Ethiopia (Benyam et al., 2021). In tropical Africa where the population has increased rapidly over the past years soil fertility maintenance is very important to achieve food security (Dagne, 2016). Integrated application of organic and chemical fertilizers improves crop productivity and soil fertility status at the same time (Biramo, 2018). Zerihun et al. (2022) found that the integrated application of organic fertilizer with blended fertilizer can increase potato postharvested soil pH from 4.92 to 6.75 in western Wellega.

The integrated application of organic fertilizer with lime increases the degree of base saturation as well as the buffering capacity of acid soil (Zerihun et al., 2022). Jafer (2021) noted that the integrated application of compost and manure improved soil physicochemical properties directly or indirectly and provided high quantities of available nutrients. Integrated application of organic and inorganic fertilizers with lime has the potential to amend the acidity of the soil and improve the status of soil fertility, which in turn increases crop yields (Abdissa et al., 2018). The postharvested soil organic carbon, available phosphorus, total nitrogen, available sulfur, potassium, CEC, and pH of the soil increase with increasing the sole and integrated application of blended fertilizer and vermicompost levels (Zerihun et al., 2022).

Low agricultural productivity due to soil nutrient depletion is a serious problem in Ethiopia (Melkamu et al., 2020). From the total area of Ethiopian land, about 40.9% of the area is covered by strongly to weakly acidic soils (Negassa and Wogi, 2023). In western Ethiopia, the integral application of organic and inorganic fertilizers to solve the soil fertility problem, improve soil physicochemical properties, and create optimum soil conditions to improve crop yield in acidic soil has been growing (Getahun et al., 2020). Western Ethiopia soil was characterized by the deficiency of B and Zn (Wondwosen and Sheleme, 2011; Abebe and Endalkachew, 2012). Similarly, N, P, S, Zn, and B nutrient deficiencies were widely spread at nitisols of Assosa (EthioSIS, 2016).

In the north-western Ethiopia in general and Assosa area in particular, soil acidity is considered as a critical problem limiting crop productivity (Dereje et al., 2019) and there is a cost reduction when organic fertilizer is adopted, and there is an increase in farm income (Bidzakin et al., 2023). The low crop productivity of in the area exposes the farmers to food insecurity. The reasons for the yield reduction due to soil fertility decline and acidity problem and their integrated management practices have not been identified and described for the Asossa area. Therefore, this study was done to evaluate the effects of integrated application of lime with organic and chemical fertilizers on selected post harvested soil chemical properties.

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2. MATERIALS AND METHODS

2.1. Description Of The Study Area

The experiment was conducted at Assosa University's experimental field station in the Benshangul Gumuz region , Assosa under rainfed during 2020-2021. The experimental station is located in a lowland area of Ethiopia with an altitude of 1560 meters above sea level (Figure 1). The mean monthly minimum and mean maximum temperatures in the study area were 13.2⁰C and 30.4⁰C, respectively, during the experimental season while the average annual rainfall was 1244 mm (Figure 2).

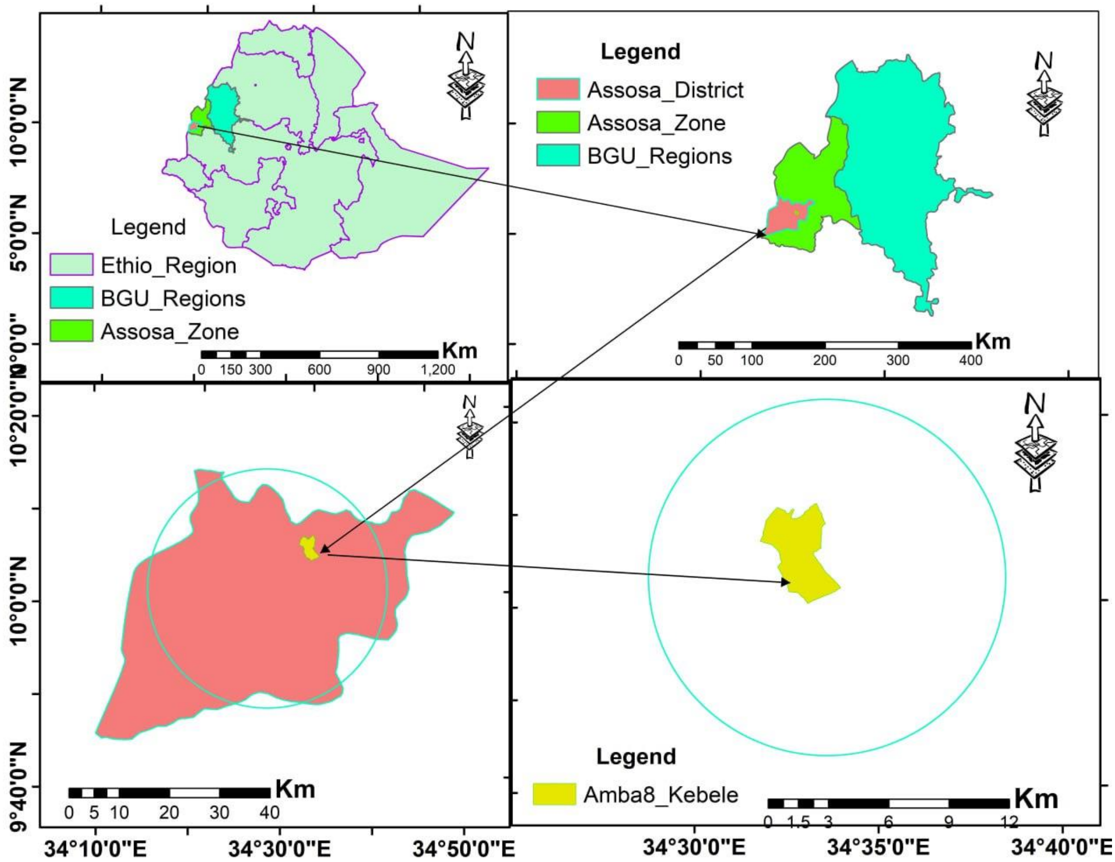

Figure 1: Location map of the study area

The meteorological data during the experiment was very similar to the long-term data. The study area is dominated by nitisol which is highly exposed to leaching due to high rainfall, which in turn activates the soil acidity problem.

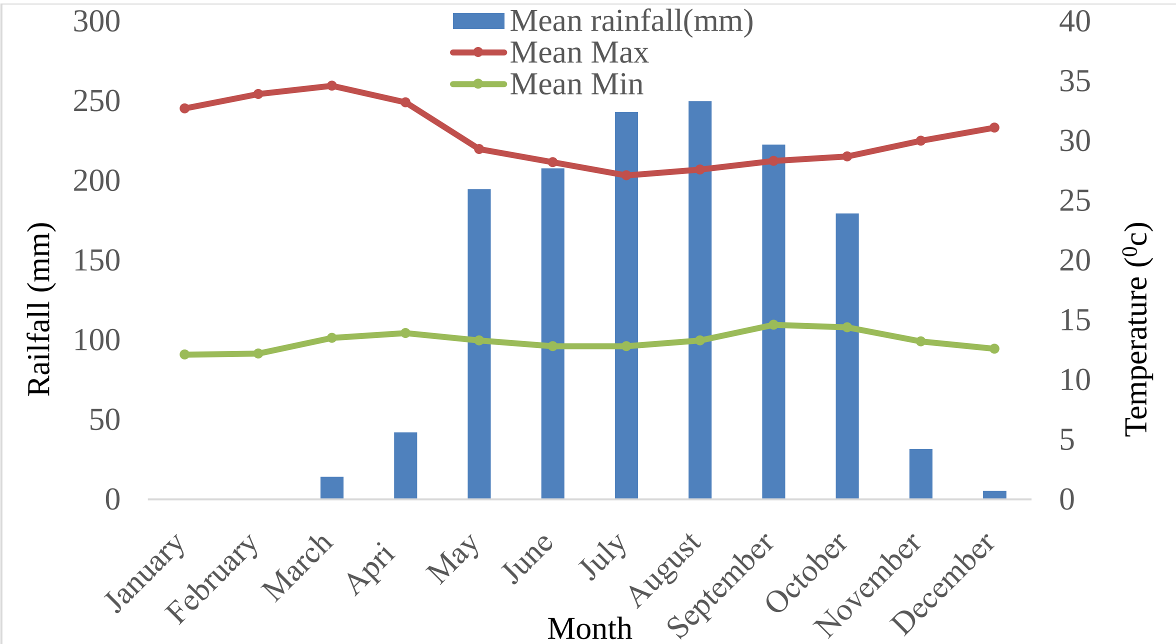

Figure 2: Mean monthly rainfall, and minimum and maximum temperatures of the study area from 2011– 2020.

2.2. Experimental set-up and soil sampling

The experiment consisted lime (0 and 4 t ha^{-1}), vermicompost (VC) (0, 2.5, and 5 t ha^{-1}), and NPSZnB (0, 100, and 200 *kg ha^{-1}*) factorially combined. Treatments were arranged in RCBD with three replications. Lime and VC were well- mixed and incubated in the soil for three weeks as per treatment level to minimize loss from rain and wind and increase decomposition before planting. The remaining two-third of urea was added at the knee height of the crop through incorporation into the soil. In the two years, the experiment was done in the same field. The plots were placed in different blocks in the two seasons to avoid residual effects of the first-year fertilizer over the second year.

2.3. Soil Sampling And Analysis

Before adding the soil amendments and planting, surface (0–20 cm) soil samples in the experimental field were collected from each block, composited, and analyzed to determine selected soil physicochemical properties at Assosa University and Hawassa Regional Research Center. A total of 18 postharvest soil samples were collected after two consecutive cropping seasons with three replications. The collected soil samples were air-dried and sieved for organic carbon (OC) and total N and a sieve 0.5 mm for other parameters and analyzed for chemical properties such as pH, OC, total N, available P, available S, exchangeable Ca, Mg, Na and K, CEC, Exchangeable acidity and extractable micronutrients (Fe, B, and Zn). Soil pH (1:2.5 soils: H_2O) was measured potentiometrically using a pH meter (Chopra and Kanwar, 1976).

Exchangeable acidity by titrating with 0.02M NaOH after saturating with 1 M KCl solution according to Rowell (1994). Organic carbon content was analyzed by Walkley and Black (1934) procedure. Total nitrogen content was determined by the Kjeldahl method (Bremner and Mulvaney, 1982) and Bray II (Bray and Kurtz, 1945) method was used for available P. Following William and Steinberg, (1959), a turbidimetric method was used to determine Available S. Ca and Mg were determined using AAS, while exchangeable Na and K were determined using a flame photometer. Jackson's (1967) method was used to determine the CEC of the soil. Extractable micronutrients were determined using an AAS. Soil exchangeable B was estimated using the colorimetric Azomithene H method (Page et al., 1982).

2.4 Analysis of Vermicompost

Vermicompost has a higher level of available nutrients like C, N, P, K, Ca, and Mg derived from the wastes (Manohar et al., 2016). The VC was prepared by decomposing cow dung, sheep and goat manure, crop and home residues, weeds, and grasses by using red earthworm (*Eisenia fetida*). Selected parameters of the VC were determined using dried samples which were ground to pass through a 2 mm sieve as described by (Pisa and Wuta, 2013). The pH was determined from a suspension of 1:10 VC: H_2O as described by Ndegwa and Thompson (2001). Total OC was estimated by wet digestion and rapid titration method (Walkey and Black, 1934). The total N content of the VC was determined by the wet-oxidation procedure of the Kjeldahl method (Bremner and Mulvaney, 1982). Ca, Mg, K, and Na were extracted by wet digestion using concentrated sulphuric acid (H_2SO_4), selenium (Se) powder, lithium sulfate (Li_2SO_4), and hydrogen peroxide (H_2O_2) mixture (Okalebo et al., 2002). The concentrations of Ca and Mg were determined by the atomic absorption spectrophotometer (AAS) while K and Na were estimated by flame photometer. Total P was extracted using concentrated H_2SO_4, Se powder, salicylic acid ($C_7H_6O_3$), and H_2O_2 mixture and was finally read by using UV spectroscopy (Okalebo et al., 2002). Available S was extracted with de-ionized water and 0.025 M KCl and determined by the turbidimetric method (William and Steinberg, 1959) using a Cecil-2000 spectrophotometer. Micronutrients (Fe, Mn, Zn, and Cu) were extracted using concentrated H_2SO_4, Se powder, $C_7H_6O_3$, and H_2O_2 mixture, and their concentrations were determined from the wet digested samples by AAS while exchangeable B was extracted with hot water and estimated using the Azomithene H method (Page et al., 1982).

2.5 Statistical Analysis

The combined analysis of variance (ANOVA) for the two-season data was subjected to analysis of variance (two-way ANOVA) according to SAS Version 9.4 (SAS Institute, 2013). Interpretations were made following the procedure of Gomez and Gomez (1984). Duncan's Multiple Range test was employed to test the significance of the differences between the means of treatment ($P \leq 0.05$). The coefficient of variation (CV), standard error (SE), and the least significant difference (LSD) at a 5% risk level were also calculated.

3. Results

3.1. Chemical Composition of Vermicompost Used in the Experiment

The results showed that the average pH of the VC was 6.96, which is neutral in the reaction. Moreover, the mean OC and TN contents of the VC were 12.6 and 1.63%, respectively while the C: N ratio was 8:1 which is very narrow (Table 1). The narrow C to N ratio in the VC indicates that the compost is well decomposed and N can be released into the soil for plant use. In line with this, Abdissa et al. (2018) stated that nutrients could be emanated by the activities of microorganisms during the decomposition of VC and could decrease soil acidity.

Table 1: Chemical composition of vermicompost used in the experiment

Parameters	Value
pH (H_2O)	6.96
Total OC (%)	12.6
Total N (%)	1.63
C: N	8:1
Total P (g kg^{-1})	63.56
Ca ($cmol_c$ kg^{-1})	36.3
Mg ($cmol_c$ kg^{-1})	19.2
K ($cmol_c$ kg^{-1})	27.2
Na ($cmol_c$ kg^{-1})	14.2
S (g kg^{-1})	43.22
B (mg kg^{-1})	94
Fe (mg kg^{-1})	196
Mn (mg kg^{-1})	286
Zn (mg kg^{-1})	173
Cu (mg kg^{-1})	75

**OC = Organic Carbon; Total N = Total nitrogen; Total P = Total phosphorus; C: N = Carbon to Nitrogen ratio; CEC = Cation exchange capacity*

3.2. Pre-Planting Soil Physicochemical Properties

The experimental soil was clay (66% clay, 23% sand, and 11% silt) based on the soil textural triangle. The bulk density (1.23 g cm^{-3}) of the soil was below the critical value of bulk density for plant growth according to the rating set by (Jones, 1983). Similarly, the particle density (2.28 g cm^{-3}) is lower than the average particle density value for a mineral soil material according to the rating set by Jones (1983). The soil of the experimental site was strongly acidic in reaction and rated as strongly acidic to low (Murohy, 19680). The TN content was 0.15% and the OC content was 1.48%. Available phosphorus (3.3 mg kg^{-1}) and available sulfur (3.8 mg kg^{-1}) of the experimental site soil rates were low and very low, respectively, whereas soil cation exchange capacity (CEC) (23.8 $cmol_c$/kg) of the experimental site was rated as medium according to the rating of soil fertility classification by (Landon, 1991). Selected extractable micronutrients of the experimental soil were found to be B (0.26 mg kg^{-1}) and Zn (0.38 mg kg^{-1}) which are low and very low, respectively according to Lindsay and Norvell (1978). These results indicate that the soils of the experimental site require an additional supply of plant nutrients to enrich the soil and make them available to plants at optimum levels.

Table 2: Selected physicochemical properties of the experimental soils before planting

Parameters	Contents	Rating	Reference
Sand (%)	23		
Silt (%)	11		
Clay (%)	66		
Textural class		Clay	
BD (g/cm^3)	1.23		
PD (g/cm^3)	2.28		
TP (%)	54		
pH (H_2O)	5.38	Strongly acidic	Murphy (1968)
Exc. acidity (cmol$_c$/kg)	2.12		
Exc. Al (cmol$_c$/kg)	1.52		
OC (%)	1.48	Low	Tekalign (1991)
Total N (%)	0.15	Low	Murphy (1968)
AvP by Bray II (mg/kg)	3.3	Very Low	Bray and Kurtz (1945)
AvS (mg/kg)	3.8	Very Low	EthioSIS (2014)
Exc. Ca (cmol$_c$/kg)	2.74	Low	FAO (2006)
Exc. Mg (cmol$_c$/kg)	1.74	Medium	FAO (2006)
Exc. K (cmol$_c$/kg)	0.16	Very Low	FAO (2006)
Exc. Na (cmol$_c$/kg)	0.12	Low	FAO (2006)
CEC (mg/kg)	23.8	Medium	Landon (1991)
Fe (mg/kg)	34.3		
Zn (mg/kg)	0.38	Very Low	Jones (2003)
Mn (mg/kg)	28.3		
B (mg/kg)	0.26	Low	Jones (2003)
Cu (mg/kg)	2.3		

**OC = Organic Carbon; TN = Total Nitrogen; AVP = Available P; AvS = Available Sulphur; Exc. Ca = Exchangeable Ca; Exc. Mg = Exchangeable Mg; Exc. K = Exchangeable potassium; Exc. Na = Exchangeable Sodium; CEC = Cation exchange capacity.*

3.3 Soil pH, Exchangeable Acidity, and Exchangeable Aluminum

Soil pH, exchangeable acidity, and exchangeable aluminum were significantly ($P = 0.05$) affected by lime and VC treatments. The exchangeable acidity showed a significant ($P = 0.05$) difference due to the integrated use of lime and vermicompost (VC).

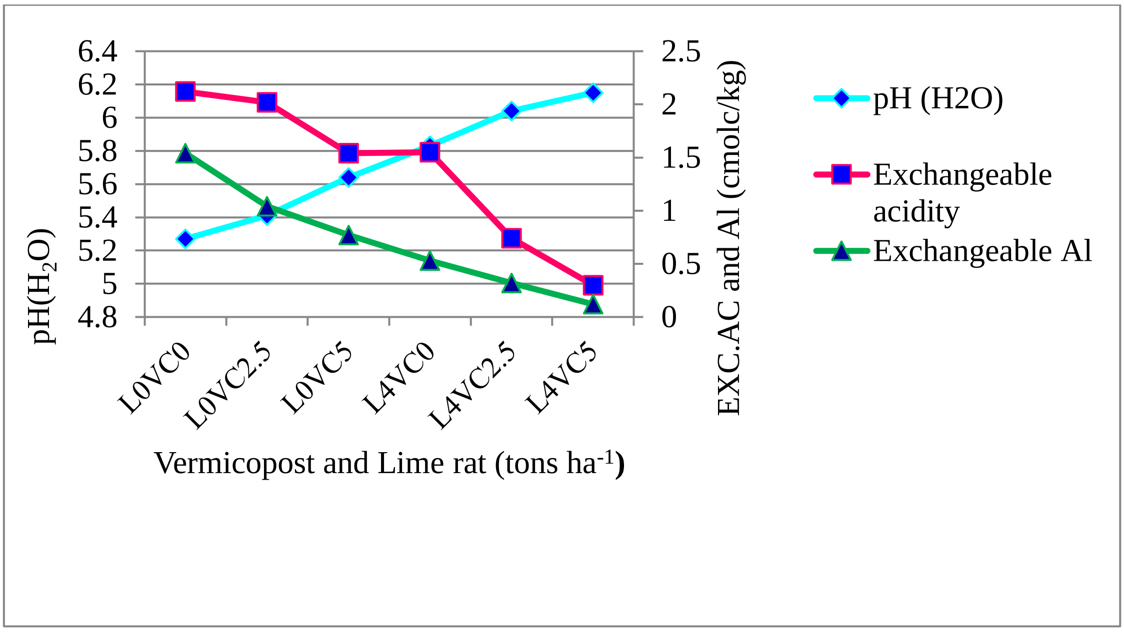

Figure 3: Effect of lime, vermicompost, and blended fertilizer on post-harvested PH, exchangeable acidity, and exchangeable aluminum

Similarly, sole and integrated application of lime and VC decreased exchangeable Al. The highest (92%) reduction of exchangeable Al was observed in the treatment that received 4 t ha^{-1} lime + 5 t ha^{-1} VC, while the lowest reduction was observed from the treatment that received 2.5 t ha^{-1} of VC in the absence of lime and blended fertilizer.

3.4 Exchangeable Bases and Cation Exchange Capacity of Postharvest Soil

The exchangeable calcium, magnesium, and potassium content of the soil were increased by 19%, 34%, and 50% in response to the integrated application of 4 t ha^{-1} lime + 5 t ha^{-1} VC (Table 3). The application of lime and VC at different rates significantly ($P = 0.05$) affected the cation exchange capacity of the soil. The CEC of the experimental soil increased from 25.9 cmol$_c$/kg in the control treatment to 33.1 cmol$_c$/kg with the application of 4 ton/ha lime + 5 ton/ha VC (Table 3). The application of lime and VC alone and combined increased the soil CEC continuously.

Table 3: Effect of lime and VC on exchangeable bases and cation exchange capacity of post-harvest soil					
Lime and VC (ton/ha)	Soil parameters				
		Exch. Ca	Exch. Mg	Exch. K	CEC
Lime	VC	------------------------($cmol_c/kg$) ------------------------------			
	0	2.6^e	1.7^e	0.17^f	25.9^f
0	2.5	2.7^d	2.0^d	0.23^d	29.5^d
	5	2.8^c	2.10^c	0.33^b	30.8^c
	0	2.8^c	1.9^d	0.16^e	28.3^e
4	2.5	2.9^b	2.2^b	0.29^c	32.1^b
	5	3.2^a	2.6^a	0.35^a	33.1^a
CV (5%)		2.410	1.194	0.302	1.755
LSD (5%)		0.094	0.028	0.029	0.223
SE (±)		0.055	0.020	0.002	0.337

*Means in the column within a parameter followed by the same letter(s) are not significantly different at P = 0.0

3.5 Organic Carbon and Total Nitrogen

The OC of postharvested soil was significantly (*P = 0.05*) affected by the application of VC. Sole application of lime and VC increases soil carbon by 2.2% and 12%, respectively over the control while the integrated application of half (50%) of the recommended VC and lime shows a 15.2% increment over the control (Figure 4). Melkamu et al. (2020) suggested that the highest soil OC content was obtained from the application of 50% VC and conventional compost based on N equivalency with 50% recommended NP fertilizer ha^{-1}, respectively. The TN of the soil showed a significant (*P* = 0.05) difference due to sole and integrated applications of lime and VC.

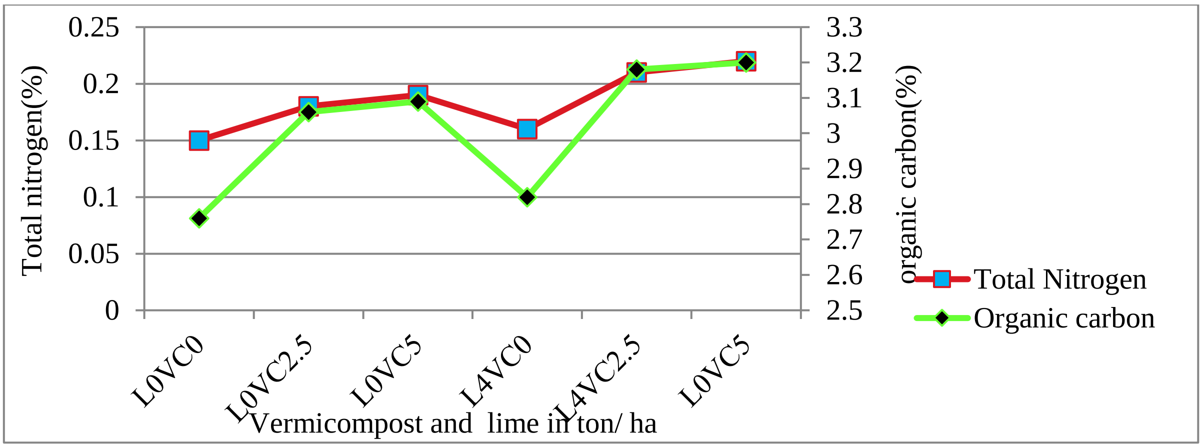

Figure 4: Effect of lime, vermicompost, and blended fertilizer on postharvest organic carbon and total nitrogen

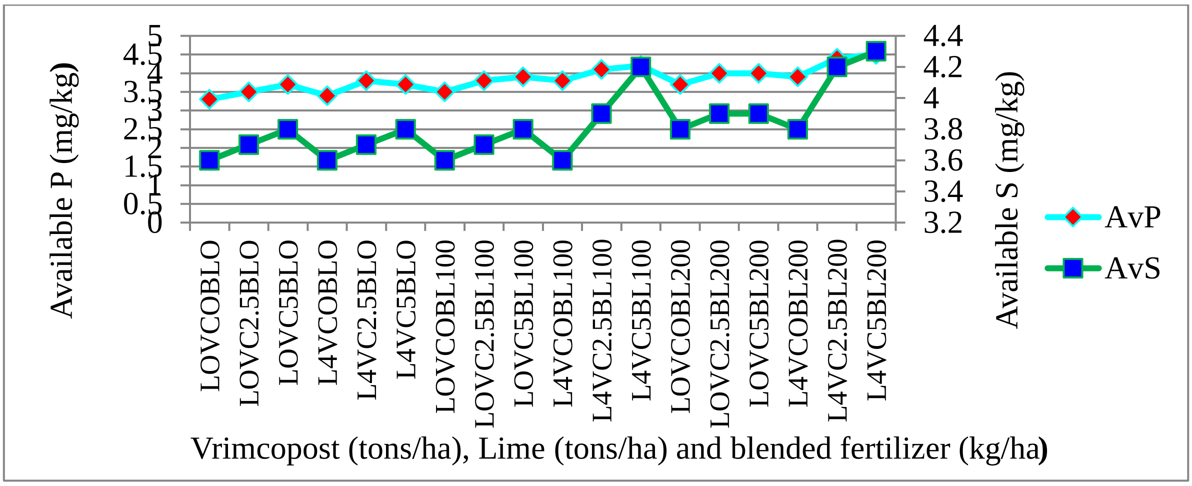

Figure 5: Effect of lime, vermicompost, and blended fertilizer on postharvest available phosphorus (AvP) and available sulfur (AvS)

3.6. Available Phosphorus and Sulphur

Applications of organic amendments and blended fertilizer significantly (*P = 0.05*) influenced the available P content of the soils. The highest (4.6 $mgkg^{-1}$) available P was observed in treatment that received (4 t ha^{-1}) lime; (5 t ha^{-1}) VC and (200 $kgha^{-1}$) NPSZnB which showed a 26% increment from the control (Figure 5). The available S of the experimental soil shows increment with the application of VC and blended fertilizer in sole and combination. The highest (4.4 $mgkg^{-1}$) available S was observed in treatment received recommended (5 t ha^{-1}) VC and (200 $kgha^{-1}$) NPSZnB with (4 t ha^{-1}) lime which showed an 18% increment from the control (Figure 5).

3.7. Extractable Micronutrients (Zn, B, and Fe)

The extractable zinc and boron of the soil showed significant differences (*P = 0.05*) due to the sole and integrated effects of lime, blended fertilizer, and VC (Table 4). Integrated applications of lime, blended fertilizer, and

VC at a level of 4 t ha^{-1}, 200 kgha^{-1} + 5 t ha^{-1} increased extractable zinc and boron by 85% and 25%, respectively. Integrated application of 50% of the recommended blended fertilizer and VC showed an increase in soil zinc by 75% and 20% over the control, respectively.

Table 4: Effect of lime, VC, and blended fertilizer on Extractable Zn, B, and Fe of postharvest soil

Lime and VC (t ha^{-1})		Soil Parameters								
		Extractable Zn			Extractable B			Extractable Fe		
		------------------------------(mg kg^{-1}) ---------------------------------								
		Blended fertilizer (kg ha^{-1})								
Lime	VC	0	100	200	0	100	200	0	100	200
	0	0.36^{i}	0.41^{i}	1.78^{ef}	0.27^{l}	0.3^{i}	0.34^{fe}	34.1^{b}	34.9^{a}	35.1^{a}
0	2.5	0.93^{h}	1.52^{g}	2.18b^{ac}	0.29^{k}	0.31^{hg}	0.36^{c}	31.9^{d}	33.6^{b}	33.9^{b}
	5	1.56^{gf}	1.96^{edc}	2.20^{ba}	0.31^{hg}	0.34^{e}	0.37^{C}	31.1^{e}	32.7^{c}	33.6^{b}
	0	0.76^{h}	0.42^{i}	1.93^{ed}	0.27^{l}	0.3^{hi}	0.34^{e}	29.3^{gf}	28.9^{g}	29.6^{f}
4	2.5	1.38^{g}	1.46^{g}	2.27^{ba}	0.3^{j}	0.33^{f}	0.38^{b}	27.6^{ih}	26.9^{j}	27.8^{h}
	5	1.42^{a}	2.09^{bdc}	2.34^{a}	0.31^{g}	0.36^{d}	0.39^{a}	25.5^{k}	24.5^{l}	27.1^{ij}
CV (5%)	9.7				57.84			1.15		
LSD (5%)	0.1				0.15			0.11		
SE (±)	0.9				0.02			0.29		

**Means in the column within a parameter followed by the same letter(s) are not significantly different at P = 0.05; VC= vermicompost*

The post-harvesting extractable iron showed a significant (*P = 0.05*) difference due to sole and integrated applications of lime, blended fertilizer, and VC (Table 4).

4. Discussion

The integrated application of lime and VC at the rate of 4 tons/ha and 5 tons/ha showed an increment of 0.88 pH units over the control. However, the sole application of lime and VC increased the soil pH only by 0.56 and 0.37 units respectively (Figure 3). This indicated that the integrated application of VC with lime was more efficient than the sole application of lime or vermicompost to improve soil acidity. The increase in soil pH with the application of lime and vermicompost (VC) could be due to a reduction in H^+, Fe^{2+}, Mn^{2+}, and Al^{3+} concentrations in the soil by the neutralizing and buffering ability of the amendments. In line with this, stated that the integrated application of organic and inorganic fertilizers is more efficient in decreasing soil acidity and improving soil fertility as well as crop productivity (Wegene et al., 2021; Dawar et al., 2022).

Combined application of lime and VC at rates of 4 t ha^{-1} + 5 t ha^{-1} reduced exchangeable acidity by 86% while the sole applications of lime (4 t ha^{-1}) and VC 5 t ha^{-1}both reduced by 27%. The reduction in soil exchangeable acidity and exchangeable Al with increasing application rates of lime and VC alone or in combination could be due to a reduction in H^+ and Al^{3+} concentration in the soil solution. Wegene et al. (2021) reported that a significant reduction in soil exchangeable acidity and Al was observed when lime was applied which leads to precipitation of Al as $Al(OH)_3$. The addition of organic fertilizer to acidic soils increased soil pH, decreased Al saturation, and thereby improved soil conditions for plant growth (Tigist, 2017).

Application of recommended rates of lime alone increased soil exchangeable Ca and Mg by 11% and 10% over the control respectively; similarly, sole application of recommended rates of VC increased soil exchangeable Ca, Mg, and K by 7%, 18%, and 18% over the control (Table 3). This indicated that soil exchangeable bases were more efficiently improved with the combined application of lime with vermicompost. Increased exchangeable bases with increased rates of VC and lime may be associated to the release of Ca^{2+}, Mg^{2+}, and K^+ ions from lime through its dissolution and from the mineralization of VC, which adsorbed on exchange sites and a considerable number of basic cations, may be released from VC. The treatments received organic fertilizer with mineral fertilizer in integration shows increment in exchangeable bases due to increased root biomass, crop residues, and OM content (Workineh et al., 2021). Similar studies by Gizachew et al. (2019) and Workineh et al. (2021) also suggested an increase in the exchangeable base as a result of addition of organic fertilizer either alone or combined with lime.

The sole application of the recommended amount of VC (5 t ha^{-1}) increased the soil CEC by 16% while the sole application of lime (4 t ha^{-1}) increased soil CEC by 9% this might be because the VC increased pH and at higher pH values, the increasing amount of the -COOH groups in OM are dissociated to COO-, thus serving as new CEC sites and increase CEC of the soil. However, the application of half the recommended amount of VC with lime increased soil CEC by 19%. This increment might be attributed to the integrated application of lime with VC, which resulted in improved soil properties, like soil pH, soil OC, and reduced exchangeable acidity. The findings of also suggested application of organic fertilizer alone or integrated with inorganic fertilizers raises the CEC of the soil compared to sole inorganic fertilizer application (Agegnehu et al., 2016).

Initially, the OC content of the soil was 1.48%. Using the BD of 1.23, the plough layer contains 27 326 kg of OC while from the analysis the VC contained 12.6% OC. If 5 t ha^{-1} of VC is applied, the dose contains 630 kg OC. This indicates that 2.3% addition to the original amount of OC. This addition theoretically increases OC concentration by 0.034%, i.e., from 1.48% to 1.51%. If the VC is applied in two consecutive years, and no decomposition is assumed, the addition can be 0.068%. However, the amounts were rather small compared to the original amount of soil OC because crop residues also add some OC in addition to the amendments. Integrated application of lime and VC at a rate of 4 t ha^{-1}+ 5 t ha^{-1} increased total N by 32% over the control. The sole application of lime (4 t ha^{-1}) and VC (5 t ha^{-1}) increased total N by 6% and 21%, respectively over the control. The high levels of total N in these soils could be attributed to the high natural OM returns and mineralization of plant residue and N-containing fertilizer application.

The sole application of VC and blended fertilizer with lime increased available P by 16 and 9 % respectively, while half (50%) of the recommended amount of blended fertilizer and VC increased the available P of the soil by 18% over the control. The increment of available P was related to the synergistic effects of VC and lime which enhance the mineralization of P by quick action in improving soil acidity, and hence, increasing the bio-availability of P (Abdissa et al., 2018). Even after the p fertilization, the available P level was still very low which indicates that to reach the optimum level of available P it needs to require much more p application. So it requires several repeated applications that available P concentration can be elevated into higher ratings. Wegene et al. (2021) suggested the increment of soil organic matter with the application of lime and VC individually and in integration.

The sole application of VC and blended fertilizer with lime increases available S by 7% and 6%, respectively while the integrated application of half (50%) blended fertilizer and VC increased the soil by 10% over the control. The increment in available sulfur content under treatment with integral application of organic and chemical fertilizers might be due to the application of S-containing inorganic fertilizers and better mineralization of sulfate from organic fertilizer. Available sulfur showed much more increment over the control due to the integral application of organic and inorganic fertilizers (Admas, 2015).

The sole application of NPSZnB and VC increased soil zinc and boron after harvesting 75% and 14% over the control, respectively. The finding showed that the integrated application of organic fertilizers with inorganic fertilizers is more effective than the sole application of either of the two. The increment in soil zinc and boron with the application of lime, blended fertilizer, and VC might be due to the blended fertilizer and VC containing zinc and boron, and part of them remained in extractable forms in the soil. An increase in boron availability by liming may be attributed to the neutralization of soil acidity which may have released boron into the soil solution (Sarkar et al., 2015). The decrease in iron content after harvesting might be due to the increase in pH due to the effect of the amendments because the availability of extractable iron decreases with an increase in soil pH. In line with this, Wael et al. (2011) and Abdissa et al. (2018) suggested the extractability of Fe tends to decrease as soil pH increases.

5. Conclusion And Recommendation

When vermicompost and lime were applied on maize farm site exchangeable acidity and Al were reduced, but pH, OC, TN, calcium, magnesium, potassium, and CEC were all enhanced. Integrated application of lime, with organic and inorganic fertilizer improve available phosphorus, sulfur, extractable boron, and extractable zinc.. Because of this circumstance, integrated soil management is created through the use of blended fertilizer and mixed vermicompost, which is a workable solution to soil acidity issues and chemical composition restrictions. The exchangeable acidity and Al changed significantly as a result of the significant pH increase. However, there was very little change in available phosphorus with integral application of lime, VC and blended fertilizer, and numerous treatments are required to fully increase the soil P status. Since sulfur is readily leached out of the soil, a rise in available sulfur is challenging. Therefore integrated soil fertility management of vermicompost and blended fertilizer with lime is a feasible approach to overcome soil acidity problems and fertility constraints of study area. From this study it could be recommended integrated soil fertility management should be practiced to overcome acidity problems and soil fertility decline to increases maize productivity on sustainable base of the study area and similar agroecology.

Authors' contributions

AA conceived the study and design, collected the data, performed the analysis on all samples, interpreted the data, wrote the manuscript, and acted as the corresponding author. M Yli-H, LW, and AB assisted in the analysis and interpretation of data and drafting of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The authors want to declare that they can submit the data at whatever time based on your request. The data used for the current study are available from the corresponding author upon reasonable request.

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