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Research Article

Effect of Coffee Husk Compost and NPSB Fertilizers on Selected Soil Chemical Properties of Potato Field in Chora District, South West Ethiopia

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Field experiment was conducted in Chora District of south western Ethiopia, to evaluate the effect of different rates of coffee husk compost (CHC) and 18.9N + 37.7P + 6.94S + 0.15B (NPSB) in the form of NH_4, P_2O_5, SO_4^-, and B_2O_5, repectively, blended fertilizer on selected soil chemical properties of potato field during 2021. The treatment consisted of four rates of CHC (0, 2.5, 5, and 7.5 t ha^{-1}) and four rates of blended NPSB fertilizer (0, 112.5, 150, and 187.5 kg ha^{-1}). The experiment was laid out in randomized complete block design with three replications. Postharvest soil data were collected and subjected to ANOVA using SAS version 9.4. All the soil parameters analyzed were significantly ($P < 0.05$) affected by the main factors of CHC and NPSB blended fertilizer except exchangeable K^+ and Na^+ which were affected by main factors but not by factors interaction. The maximum pH (5.3), OC (6.0%), and CEC (14.10 meq $100g^{-1}$) were obtained from application of sole 7.5.t CHC ha^{-1} which is at par with combined 7.5.t CHC and 112.5 kg NPSB ha^{-1}, while the maximum TN (26%), Av. P (3.57%), and Av. S (4.36%) were obtained from combined application of 7.5.t CHC and 112.5 kg NPSB ha^{-1}. The sole application of either of 150 kg or 187.5 kg NPSB ha^{-1} was resulted in high exchangeable acidity. Therefore, combined application of CHC and NPSB fertilizers raised the pH, improves the OC%, total N, available P and S, reduced the exchangeable acidity, and raises the CEC and exchangeable bases of potato field soil as compared to the control and sole NPSB fertilizer.

1. Introduction

The Ethiopian economy heavily relies on agriculture [1] and the sector has contributed approximately 44% to the GDP of the country [2]. Soil resource degradation and nutrient depletion of agricultural soil are the major challenges in agricultural production in developing nations, such as Ethiopia and Chora District in particular [3]. Potato *(Solanum tuberosum L.)* is the world's most important tuber crop and is the fourth most important food crop in terms of human consumption and cultivation in the world next to wheat, maize, and rice [1, 4]. Potato ranks first among root and tuber crops grown in Ethiopia in terms of area coverage, total production, and consumption followed by taro, sweet potato, and onion [5].

Ethiopia, particularly south western part, faces a wide set of soil fertility issues (poor in fertility; soil acidity; low soil pH; significantly depleted organic matter; leaching of N, K, and micronutrients; and phosphorus (P) fixation) that require approaches that go beyond the application of chemical fertilizers [6, 7]. Beside this, inadequate application of organic and inorganic nutrient sources of fertilizers to replenish the nutrient depletion is challenge to crop production and productivity in Ethiopia including south western [8].

Ethiopian farmers are using mostly inorganic fertilizers like diammonium phosphate (DAP), urea and N, P, and S with the proportion of 19% N, 38% P_2O_5, and 7% S (NPS) while organic fertilizers are not such commonly used for the production of potato and other crops [9]. Sole application of mineral fertilizers may increase soil acidity and depletion of essential micronutrients [10, 11]. Organic fertilizers serve as a source of soil organic matter; improve buffering capacity of a soil; release nutrients gradually over the crop growth period and excellent supplier of balanced nutrients to plants, and also improve soil chemical, physical, and biological properties [8, 12]. Even if it has multiple benefits, there are also several problems limiting the use of organic fertilizers by farmers to enhance soil fertility. Among the major problems, low availability of organic fertilizers, having variable quality making them difficult to standardize, and low in their nutrient contents (cannot provide the full ranges of nutrients required by crops) and high labor demand for preparation and transporting are reported by different scholars [8, 11, 12].

Integrated soil fertility management method which involves combined application of organic and inorganic fertilizers is the best method for overcoming the shortcoming of sole use either of inorganic or organic fertilizers [8, 9, 11]. The reduction in mineral fertilizer application through their supplementation with organic sources such as coffee husk makes the use of soil nutrient amendments affordable to small holder farmers for sustainable crop production and improvement of soil health [13]. Previous research efforts focused on the effect of different combination of organic fertilizers, compost from different feedstock with different inorganic fertilizers in different area to improve potato yield and soil physiochemical properties. Wet processing of coffee constitutes around 40% of the wet weight of the fresh fruit as by-product [14] (Kivaisi and Assefa, 2010). The disposal of by-product as waste by dumping into the natural water systems or agricultural land in Ethiopia has been the major health challenges to coffee farmers living in the surroundings of coffee processing plants [15] (Weldesenbet et al., 2016). Most of the coffee pulp waste remains underutilized in many countries [16] (Nayak and Harshitha, 2012). Therefore, large amount of unutilized biomass need to be changed into value-added bioproducts such as CHC which could also minimize environmental problems arising from waste disposal. Coffee wastes are utilized in other coffee producing countries as soil amendments [13, 17, 18] and researchers have shown coffee husk is rich in organic agricultural waste and K was good material for composting process and can be composted, made in to useful organic fertilizer, and significantly improved the supply of total N, avail. P, Ca, Mg, and K [18, 19]. However, in Chora District of Buno Bedele zone there are a number of coffee processing industries and that led to accumulation of huge amount of wasted by-product (coffee husk) deposited for a long time which have been contributing to the environmental problem. Despite these facts, almost no research has been conducted on the effect of combined use of coffee husk compost (CHC) and NPSB fertilizer on soil physicochemical properties of potato yield in general and the study area in particular. Therefore, the current study is designed to evaluate the effect of different rates of CHC and NPSB on selected soil chemical properties of potato field.

2. Materials and Methods

2.1. Description of Study Area. The field experiment was conducted at Chora District, Oromia regional state south western Ethiopia during 2021 under supplementary irrigation. The district is located 8° 9′, 49° 51′ in the North and 35° 6′ and 35° 38′ East with an elevation ranging from 1450–2300 m.a.s.l and situated at about 515 km from Addis Ababa capital city of the country to the south western direction [3]. The experimental field is located at an elevation of 1858 m.a.s.l. and geographic coordinate of 92° 71′ 70″ N and 19° 11′ 15″ E (Figure 1). The experimental field land use history shows it was cultivated twice a year by irrigation and main rainy season for more than five years. The district has a mono modal type of rainfall and the short rainy season (the "Belg" rain) which occurs during March, April, and May and the main rainy season ("Kremt" rain) occurs in the months of June, July, and August [20]. The annual rainfall ranges between 1500 and 2200 mm, and daily mean temperature ranges between 9 C and 31 C [1821]. The dominant agricultural soil group of the district is Nitisol [20]. Agroecology of the district is divided into three ecological zones, namely, low altitude (Kola) 1.5%, mid-altitude (woyinadega) 95.1%, and high altitude (Dega) 3.4% [21]. Potato is cultivated in the District both under irrigation and rain fed condition, but more it is produced by irrigation. From irrigated crops, it ranks first in terms of land coverage [21] and soil chemical properties of potato field.

2.1.1. Preplanting Selected Physicochemical Properties of Experimental Soil. The soil analysis result of the study area before planting indicated that it is dominated by clay soil fraction with moderate bulk density for agricultural use. The soils chemical properties of the site also revealed very strong acidity with pH (4.25 H2O) and relatively high content of exchangeable acidity. It also had medium CEC, low amounts of organic carbon, medium in total N, very low in available P and low to medium in exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}), and generally poor in soil fertility. This may be attributed to the poor nutrient management coupled with continuous cultivation of the soils of the study area. The result of preplanting soil analysis is presented in Table 1.

2.2. Experimental Materials. A potato local seed tuber variety known as Aba-damu was used as test crop. The variety was evaluated by participatory variety selection in North West Ethiopia. It was preferred and cultivated by many farmers in the study District. It is characterized by medium early maturity; high water use efficiency; nice looking tubers; and long-term storability and it is predominant variety in submoist agroecology and adaptation to low soil fertility [27].

Blended NPSB fertilizer (18.9N + 37.7P + 6.94S + 0.15B in the form of NH_4, P_2O_5, SO_4^-, and B_2O_5) was used as a mineral fertilizer source. The blended fertilizer is recommended for the soils of the District by ATA (soil fertility status and fertilizer recommendation map available at District) [28]. Coffee husk compost was used as an organic fertilizer source. It is cocomposted with bioslurry in the ratio of 3 : 1 coffee husk to bioslurry in the pit.

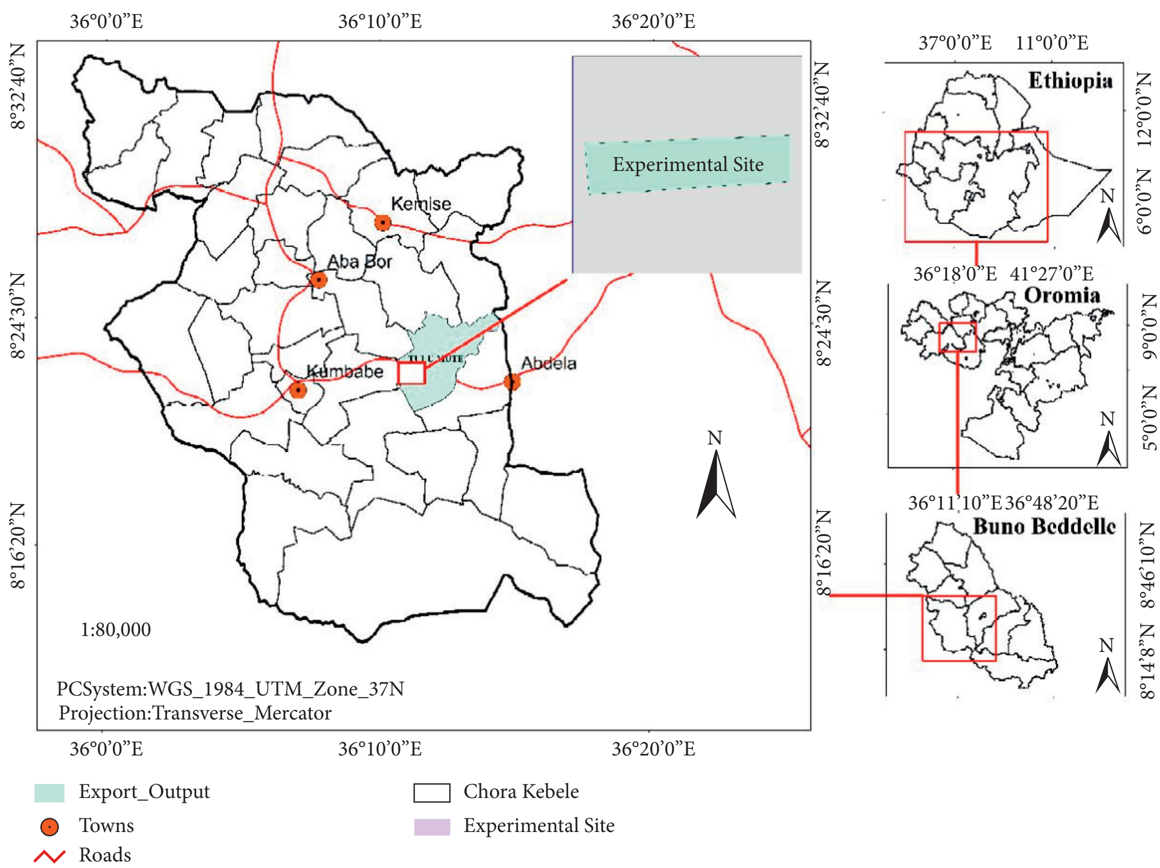

Figure 1: Map of study area.

Table 1: Preplanting selected soil physicochemical properties of experimental soil.

Physicochemical properties		Value	Rating	Source
	Chemical properties			
pH (H_2O)		4.25	Highly acidic	Tadese [22]
Organic carbon (%)		4.54	Moderate	Tadese [22]
Total nitrogen (%)		0.14	Medium	Murphy [23]
Avail. P (ppm or mg kg^{-1})		0.95	Low	Olsen et al. [24]
Avail. sulfur (ppm)		2.98	—	
Exchangeable acidity (meq 100 g^{-1})		0.60	—	
CEC (meq 100 g^{-1})		12.05	Low	Hazelton and Murphy [25]
Exchangeable base	Ca^{2+} (meq 100 g^{-1})	18.42	High	FAO [26]
	Mg^{2+} (meq 100 g^{-1})	8.09	High	FAO [26]
	Na+ (meq 100 g^{-1})	0.02	Very low	FAO [26]
	K+ (meq 100 g^{-1})	0.61	Medium	FAO [26]
	Physical properties			
Particle size distribution	Clay%	52.50		
	Silt%	27.50		
	Sand%	20.00		
	Soil textural class		Clay	
	Bulk density (g $cm^{3\ -1}$)	1.23	Moderate	Hazelton and Murphy [25]

Source: soil laboratory analysis result report for preplanting physicochemical properties.

2.3. Chemical Composition of CHC before Planting. Coffee husk compost was used as an organic fertilizer source. The CHC used in this study is cocomposted with bioslurry to shorten the decomposition period of coffee husk and to minimize N loss from bioslurry. It is prepared with the ratio of 3 : 1 coffee husk to bioslurry in the pit, turned two times, and incubated for decomposition for 60 days. The chemical compositions of CHC prior to planting were 7.86 pH (1 : 10 H_2O), which is moderately alkaline in reaction, 11.7%, 0.371%, and 30.34 ppm organic carbon, total N, and total P content, respectively, and 23.85 meq 100 g^{-1} CEC as presented in Table 2.

Table 2: Chemical properties and nutrient concentrations of utilized CHC value.

Chemical properties	Mean value
pH (H_2O)	7.86
Total organic carbon (%)	11.7
Total *N* (%)	0.37
Available P (ppm)	30.34
Available sulfur (ppm)	213.28
Cation exchange capacity (meq100 g^{-1})	23.85
Exchangeable base	
Na^+ (%)	0.06
K^+ (%)	3.40
Exch. Ca^{2+} (meq 100 g^{-1})	27.49
Exch. Mg^{2+}(meq100 g $^{-1}$)	16.43

2.4. Treatments and Experimental Design. The treatment consisted of four rates of blended NPSB (0, 75%, 100%, and 125% of 150 kg of NPSB) and four rates of well-prepared CHC (0, 2.5 t ha^{-1}, 5 t ha^{-1},and 7.5 t ha^{-1}); that is, 0, 151.9, 202.5, and 253.1 g NPSB per plot and 0, 3.375, 6.750, and 10.125 kg per experimental plot (13.5 m^2) was applied. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental plot size was 3m length with 4.5 m width accommodating six rows, 10 potatoes in each row. The planting space was 0.75 m and 0.3 m between rows and plant, respectively [29]. The spacing between adjacent blocks and adjacent plots were 1.0 m and 0.50 m, respectively.

2.5. Experimental Procedures and Management. Coffee husk compost was applied and incorporated a month before planting as per the treatment. The plots were irrigated just after incorporation of the CHC and monitored at field capacity till potatoes planting to facilitate decomposition and mineral release. The inorganic fertilizer NPSB was applied once at planting time as per the treatment by hand drilling in the open furrow. The potato seed tubers were planted by sprouts facing upwards in the prepared open rows manually maintaining recommended planting space and depth on January 21/2021. All the required management practices were done uniformly for all plots as per farmer's experience.

2.6. Data Collection

2.6.1. Soil Sampling and Analysis. The preplanting and the postharvest soil data were collected. The preplanting soil samples were taken and analyzed for the selected soil physicochemical properties. The samples were randomly taken using auger to a depth of 0–30 cm from 20 spots of entire experimental field in zigzag pattern. The bulk density of the soil was measured from the undisturbed soil using core sampler. At harvest, one composite sample was taken from each plot making a total of 48 samples. The collected and composited soil samples were bagged, labeled, and taken to laboratory for preparation and analysis of the selected soil properties. The subsamples of composite samples were air dried and then ground with a pestle and mortar, to pass through 2 mm sieve in preparation except for soil organic carbon (SOC) and total N which passes through 0.5 mm sieve for the analysis. The samples were analyzed for selected soil chemical properties: pH, organic carbon, total N, available P, available S, CEC, exchangeable acidity, exchangeable base (Ca^{2+}, Mg^{2+}, K^+, and Na^+), and the physical soil properties: bulk density and particle size distribution. Except for available S, exchangeable Na^+, exchangeable K^+, and texture analyzed at Holeta Research Center, all other parameters were analyzed at Bedele Research Center soil laboratory, Ethiopia.

The soil pH was measured in 1 : 2.5 soils: water ratio using a combined glass electrode by digital pH meter [30]. Soil organic carbon was determined by wet oxidation procedure of Walkley Black method [31], and total N content of the soil was determined by wet-oxidation procedure of the Kjeldahl method [32]. Available P was determined by Olsen method [24]. Available S was determined by turbidity and colorimetry [33]. Exchangeable acidity (Al^+ and H^+) was determined by saturating the soil samples with 1 M KCl at pH 7 solution and titrated with 0.02 M NaOH as described by Rowell [34]. Cation exchange capacity (CEC) and exchangeable bases were extracted by saturating the sample with 1N ammonium acetate (NH_4O) at pH 7. Exchangeable Ca and Mg were determined by using atomic absorption spectrophotometry (AAS), while exchangeable Na and K were analyzed by ammonium acetate extraction using atomic absorption spectrophotometry (AAS) [35].

Soil texture was determined using Bouyoucos hydrometer method [36] and soil bulk density (ρb) was measured and determined by measuring the volume of undisturbed soil sample collected using a core sampler and sample was weighed after oven dried at temperature of 105°C. Then, the result was calculated by using the formula (equation (1)) as procedure described by Jamison et al. [37].

$$\rho b = \frac{\text{mass of soil in gram}}{\text{volume of soil in cm}^3}. \quad (1)$$

2.6.2. Coffee Husk Compost Sampling and Analysis. The CHC samples were analyzed for the chemical parameters such as pH, organic carbon, total N, available P, available K, and available S contents as per standard procedures. Composite sample of 10 gram with three replicates per pile was taken, dried, and ground to pass through a 2 mm sieve as described by Pisa and Menas [38]. Soil pH was determined from a suspension of 1 : 10 CHC : H_2O as described by Ndegwa and Thompson [39]. The total OC was estimated by wet digestion and rapid titration method [31]. The total N content of the CHC was determined by wet-oxidation procedure of the Kjeldahl method (Bremner and Mulvaney, 1982). Total P was extracted using concentrated H_2SO_4, Se powder, salicylic acid ($C_7H_6O_3$), and H_2O_2 mixture and finally read by using the UV spectroscopy [40]. Total Ca, Mg, K, and Na was extracted by wet digestion using concentrated sulfuric acid (H_2SO_4), selenium (Se) powder, lithium sulfate (Li_2SO_4), and hydrogen peroxide (H_2O_2) mixture [40]. Total Ca and Mg were determined from the wet digested samples by AAS while exchangeable Na and K were analyzed by ammonium acetate extraction using atomic absorption spectrophotometry [35].

2.7. Statistical Analysis. Collected postharvest soil data were subjected to analysis of variance (ANOVA) using SAS software (version 9.4). The Generalized Liner Model (GLM) procedure was employed to detect variation among treatments. Mean separation of significant treatments performed using the Least Significant Difference test (LSD) ($p < 0.05$).

3. Result and Discussion

3.1. Postharvest Soil Chemical Properties

3.1.1. Soil pH. The soil pH was high significantly ($p < 0.05$) affected by the main factors of CHC and NPSB fertilizers as well as their interaction (Table 3). The result of the analysis revealed that the highest soil pH (5.30 H_2O) was recorded from application of 7.5 t ha^{-1} CHC alone, while the lowest soil pH (4.03 H_2O) was recorded from sole application of NPSB fertilizer at a rate of 187.5 kg ha^{-1}. The result shows improvement in soil pH by 24% and 31.5% due to application of 7.5 t ha^{-1} CHC alone with reference to the control and highest rate of NPSB fertilizer applied treatment. On the other hand, the highest rate of CHC improved the soil pH by 24.7% while the highest rate of blended chemical fertilizer dropped the soil pH by 5.2% when compared to initial soil pH (Tables 1 and 3).

This might be because of the amendment of the soil with CHC and its ability to raise soil pH due to addition of basic cations, ammonification and production of NH_3 during decomposition of added compost, adsorption of H^+ ions, and increased microbial activity as a result of organic matter application and break down of organic matter for energy source and nutrient recycling [41]. The beneficial effect of CHC application to the soil is its potential to increase the soil pH [13]. The result is in agreement with the finding of Dzung et al. [18] who reported application of compost prepared from coffee husk improved the fertility of the soil and pH of the soil. The present result is also consistent with the finding of Islam *et al.* [42] that investigate maximum increase in acidity in treatments having the highest dose of inorganic fertilizers and treatments amended with the poultry manure (PM) resulted in raised soil pH. The lowering of soil pH in the plot that received high rate of blended chemical fertilizers as compared to the preplanting soil pH in this experiment might be due to uptake of base cations with the crops and the simultaneous increase of leaching which takes place when soils are disturbed and worked [43, 44]. During growth, crops absorb basic elements such as Ca, Mg, and K to satisfy their nutritional requirements which results in increasing soil acidity [45].

3.1.2. Soil Organic Carbon (OC). The soil analysis result revealed that soil organic carbon content was significantly ($p < 0.01$) affected by the main factor CHC and its interactions with NPSB fertilizer (Table 3). Coffee husk compost amended plot in all rates (sole and combined) showed improvement in organic carbon content and the highest soil organic carbon content (6%) was obtained from sole application of CHC at a rate of 7.5 t ha^{-1} which is statistically similar with plots amended with combined application of either of 5 and 7.5 t ha^{-1} CHC with 112.5, 150, and 187.5 kg ha^{-1} fertilizers while the lowest soil organic carbon (4.1 and 4.5) was recorded from the plot supplied with high rate of sole NPSB fertilizer and control plots, respectively. Also the highest rate of CHC application improved the soil organic carbon content of preplanting soils by 32% (from 4.54 to 6.00) while the highest rate of blended chemical fertilizer application reduced the soil organic carbon content by 9.7% (from 4.54 to 4.1) (Tables 1 and 3). This might be attributed to high amount of organic matter in compost increases OC content in soil and application of CHC to soil improves OC%. Dzung et al. [18] also reported in particular, application of compost prepared from coffee husk enhanced OC% significantly in comparison with the control. Getinet [46] also reported that application of CHC to soil improves OC%.

3.1.3. Total Soil Nitrogen (N). The total soil N was significantly ($p < 0.05$) influenced by the application of the main factors of CHC and NPSB fertilizer and their interaction (Table 3). The highest soil total N (0.26%) was recorded from the combined application of 7.5 t ha^{-1} CHC and 187.5 kg ha^{-1} NPSB fertilizer followed by the combined application of 7.5 t ha^{-1} CHC and 150 kg ha^{-1} NPSB fertilizer while the lowest soil total N (0.12%) was recorded from control treatment. It is also observed from the experimental result that total soil N improved by 85.7% (from 0.14 to 0.26%) while depleted by 14% (from 0.14 to 0.12%) when compared to initial total soil N content (Tables 1 and 3).

This might be resulted from potential of incorporated CHC to increase total N content due to ammonification and production of NH_3 during decomposition of the added compost [41]; the N content in the CHC is more N than the N content in common organic fertilizers [17]; release and mineralization of N over a time as a result of decomposed CHC applied [13] increased activities of soil microbes that enhances release of N [47] and decreased leaching of N as a result of compost application [41] and also due to use of balanced fertilizers (integration of CHC and NPSB) as balanced fertilization is the key to maintain soil health and improve nutrient availability [48]. The result is in agreement with Chali [49]; Dzung et al. [18]; and Solomon et al. [50] who reported that CHC do release N into soil when used alone or in combination with inorganic fertilizer and improve soil total N.

3.1.4. Soil Available Phosphorus (P). The analysis result also indicated that soil available P was significantly ($p < 0.01$) affected by the main factors of CHC and NPSB fertilizer and their interaction (Table 4). The highest available P (3.57 ppm) was obtained from the combined application of 7.5 t ha^{-1} CHC and 187.5 kg ha^{-1} NPSB fertilizer while the lowest available P (0.95 ppm) was recorded from control treatment. The combined application 7.5 t ha^{-1} CHC and

Table 3: Interaction effect of CHC and NPSB fertilizer on soil chemical properties of potato field soil.

Treatment CHC	NPSB	pH (H_2O)	OC (%)	TN (%)	Av. P (ppm)	Av. S (ppm)	Ex. acidity (meq $100\,g^{-1}$)
0	0	4.26^{g}	4.52^{f}	0.12^{i}	0.95^{j}	3.01^{f}	0.76^{b}
0	112.5	4.27^{g}	5.22^{cde}	0.15^{h}	1.02^{j}	3.60^{de}	0.80^{b}
0	150.0	4.20^{g}	4.87^{ef}	0.17^{efg}	1.47^{i}	3.64^{cde}	0.84^{a}
0	187.5	4.03^{h}	4.10^{g}	0.15^{gh}	2.09^{h}	3.72^{bcde}	0.85^{a}
2.5	0	4.52^{ef}	5.30^{bcd}	0.16^{fgh}	1.12^{j}	3.51^{e}	0.53^{de}
2.5	112.5	4.51^{ef}	5.00^{de}	0.20^{de}	2.42^{g}	3.72^{bcde}	0.65^{c}
2.5	150.0	4.53^{ef}	5.60^{abc}	0.18^{e}	2.63^{efg}	3.82^{bcd}	0.58^{d}
2.5	187.5	4.49^{f}	5.67^{ab}	0.19^{de}	2.50^{fg}	3.85^{bc}	0.52^{e}
5	0	4.72^{d}	5.80^{a}	0.16^{fgh}	1.17^{j}	3.72^{bcde}	0.33^{g}
5	112.5	4.63^{de}	5.70^{ab}	0.18^{ef}	2.57^{fg}	3.79^{bcd}	0.32^{g}
5	150.0	4.62^{de}	5.77^{a}	0.18e	2.69^{def}	4.13^{a}	0.52^{e}
5	187.5	4.57ef	5.73^{a}	0.21^{cd}	2.83^{cde}	4.23^{a}	0.53^{de}
7.5	0	5.30a	6.00^{a}	0.18^{e}	2.90^{cd}	3.84^{bc}	0.32^{g}
7.5	112.5	5.22ab	5.87^{a}	0.23bc	3.02^{c}	3.92^{b}	0.44^{f}
7.5	150.0	5.13 b	5.93^{a}	0.24^{ab}	3.31^{b}	4.15^{a}	0.44^{f}
7.5	187.5	4.97c	5.90^{a}	0.26^{a}	3.57^{a}	4.36^{a}	0.55^{de}
F-test		*	***	*	***	*	***
LSD (0.05)		0.11	0.38	0.02	0.24	0.21	0.05
CV (%)		1.46	4.16	7.511	6.22	3.25	5.71

Means sharing the same letter within a column are not significantly different according to LSD at 5% level of significance; CV = coefficient of variation; * = significant at p = 0.05; ** = significant at p = 0.01; *** = significant at p = 0.001; OC = organic carbon; TN = total nitrogen; Av. P = available phosphorus; Av. S = available sulfur; Ex. acidity = exchangeable acidity.

Table 4: The main effect of CHC and NPSB fertilizers on exchangeable K^+ and Na^+ of soils of potato field.

Treatment	Exch.K^+ (meq $100\,g^{-1}$)	Exch. Na^+ (meq $100\,g^{-1}$)
	CHC (t ha^{-1})	
0	0.61^{d}	0.032^{d}
2.5	1.56^{c}	0.036^{c}
5	1.87^{b}	0.040^{b}
7.5	2.12^{a}	0.054^{a}
F test	***	***
	NPSB (kg ha^{-1})	
0	1.72^{a}	0.040^{a}
112.5	1.62^{a}	0.039^{a}
150	1.50^{b}	0.041^{a}
187.5	1.32^{c}	0.041^{a}
F test	***	NS
LSD	0.097	0.002
CV (%)	7.54	6.24

Means sharing the same letter within a column are not significantly different according to LSD at 5% level of significance; CV = coefficient of variation; *** = significant at p = 0.001; NS = not significant; Exch. K^+ = exchangeable potassium; Exch. Na^+ = exchangeable sodium.

187.5 kg ha^{-1} NPSB fertilizers also improved the soil available P by more than 100% (from 0.95 to 3.57) while in control plot soil available P was depleted by 1% (from 0.95 to 0.94 ppm) when compared to initial soil available P (Tables 1 and 3).

This result might be related to significantly increased soil pH due to the application of CHC and released available P and other basic cations from the compost to the soil [17] and also due to the beneficial effect of CHC application preventing P fixation in the soil [13]. The result is in agreement with Bikila [51] who reported application of CHC increase in available P contents of the soil. Dzung et al. [18] and Solomon et al. [50] also reported that CHC release P into soil when used alone or in combination with inorganic fertilizer and improve soil available P.

3.1.5. Available Sulfur (S). The analysis result also revealed that soil available S was significantly ($p < 0.05$) influenced by the main factors of CHC and NPSB fertilizer and their interaction (Table 3). The highest available S (4.36 ppm) was obtained from the treatment supplied with combined application of 7.5 t ha^{-1} CHC and 187.5 kg ha^{-1} NPSB fertilizer which is statistically similar with the treatments received combination of 5 t ha^{-1} CHC with either of 150 and 187.5 kg ha^{-1} NPSB fertilizer as well as 7.5 t ha^{-1} CHC and 150 kg ha^{-1} NPSB fertilizer while the lowest available S (3.01 ppm) was recorded from control treatment. On the other hand, the initial soil available S was improved by 46% (from 2.98 to 4.36 ppm) with combined application of 7.5 t ha^{-1} CHC and 187.5 kg ha^{-1} NPSB fertilizers (Table 3 and Table 1). This result might be related to balanced fertilization of the applications of blended NPSB fertilizer and CHC influence apparent nutrient recovery of soil [11]. The result is in agreement with the result of Gemechu [49] who suggested moderate applications of CHC and NPS fertilizer supply adequate soil S levels to soil.

3.1.6. Exchangeable Acidity. The exchangeable acidity was also significantly ($p < 0.01$) affected by the main factors of CHC and NPSB fertilizer and their interaction (Table 3). The result of the analysis indicates that the highest exchangeable acidity (0.85 meq $100\,g^{-1}$) was recorded from treatment supplied with 187.5 kg ha^{-1} NPSB fertilizer alone and this is statistically similar with plot supplied with 150 kg ha^{-1} NPSB fertilizer alone while the lowest exchangeable acidity (0.32 meq 100 g^{-1}) was recorded from treatment supplied with 7.5 t ha^{-1} CHC alone which is statistically similar with treatment received sole application of 5 t ha^{-1} CHC and combined application of 5 t ha^{-1} CHC with 112.5 kg ha^{-1} NPSB fertilizer (Table 3). The highest rate of CHC reduces the soil exchangeable acidity value by 87.5% (from 0.60 to 0.32) while the highest rate of blended chemical fertilizer increased the soil exchangeable acidity value by 30% (from 0.60 to 0.85) when compared to initial soil exchangeable acidity (Tables 1 and 3).

The result indicated improvement in exchangeable acidity over sole application of NPSB fertilizer and control plot with application of sole CHC and in combination with NPSB fertilizer while medium and highest rate of sole NPSB fertilizer application increases exchangeable acidity. This might be because of raised soil pH as a result of CHC application (in sole and combined) that reduces exchangeable acidity and potential effect of sole application of inorganic fertilizer in increasing exchangeable acidity. The result is consistent with the result of Bikila [51] that recommended organic amendment sources which are easily available (coffee husk) should be encouraged to increase productivity of the acidic soils in western Ethiopia. It also similar with the result of Gemechu [49] who reported application of CHC along with inorganic fertilizers minimizes exchangeable acidity. Kasongo et al. [17] and Nduka et al. [13] also suggested application of CHC to tropical soils has shown that it has the potential to be used as a liming material and as inorganic fertilizer because of its mineral content compositions such as N, P, K, Mg, Ca, and Na.

3.1.7. Cation Exchange Capacity (CEC). The cation exchangeable capacity of the soil was significantly ($p < 0.05$) influenced by the main factors of CHC and NPSB fertilizer and their interactions (Table 5). The highest CEC (14.08 meq 100g^{-1}) was obtained from the combined application of 7.5 t ha^{-1} CHC and 150 kg ha^{-1} NPSB fertilizers which is statistically similar with combination of 7.5 t ha^{-1} CHC with either of 112.5 and 187.5 kg ha^{-1} and sole application of 7.5 t ha^{-1} CHC while the lowest CEC (12.05 meq 100 g^{-1}) was recorded from the treatment supplied with highest rate of NPSB fertilizer which at par with treatment supplied with sole NPSB fertilizer and control (Table 5). Moreover, the highest rate of CHC application improved the initial soil CEC by 17% (from 12.05 to 14.10) (Tables 1 and 5).

This might be related to the increase in organic matter contents and available nutrients with the applied CHC and also direct correlation between organic matter and cation exchange capacity of the soil. It may also due to high content of CEC of compost and thus increase soil CEC when incorporated [41]. Compost amended soil resulted in an increase of CEC due to input of stabilized organic matter (CHC) [11]. The result is consistent with the findings of Dzung et al. [18] and Chali [49] and those reported application of CHC to soil increases soil cationic exchange capacity. Takala Dibaba et al. [52] also reported promising potential of CHC amendment alone or in combination with conventional lime to ameliorate soil acidity, CEC, and improve nutrient availability on acidic soil.

3.1.8. Exchangeable Calcium (Ca^{2+}). The exchangeable Ca was significantly ($p < 0.01$) influenced by the application of the main factors CHC and NPSB fertilizers and their interaction (Table 5). The highest exchangeable Ca (23.22 meq 100 g^{-1}) was recorded from the combined application of 7.5 t ha^{-1} CHC and 150 kg ha^{-1} NPSB fertilizer, while the lowest exchangeable Ca (18.17 meq 100 g^{-1}) was recorded from the plot supplied with 112.5 kg ha^{-1} NPSB fertilizer alone which is statistically similar with sole application of NPSB fertilizer and control (Table 5). On the other hand, the combined application of 7.5 t ha^{-1} CHC and 150 kg ha^{-1} NPSB fertilizer improved the initial soil exchangeable Ca^{2+} by 26% (from 18.42 to 23.22) (Tables 1 and 5).

The improvement in exchangeable Ca over control and sole NPSB fertilizer with the application of sole CHC and in combination with NPSB fertilizer might be due to release of Ca^{2+} from applied CHC to soil and potential effect of CHC in nutrient retention. Kasongo et al. [17] also investigated the efficiency of coffee waste to significantly improve supply of Ca whereas it immobilized the phytotoxic micronutrient Mn. The present result is in line with the finding of Chali [49] who reported highest exchangeable Ca result from the application of 10 t coffee husk compost ha^{-1} and the lowest value from the control plot.

3.1.9. Exchangeable Magnesium (Mg^{2+}). The soil exchangeable magnesium also significantly ($p < 0.01$) affected by the application of the main factors of CHC and NPSB fertilizers and their interaction with (Table 5). The highest soil exchangeable magnesium (14.31 meq 100 g^{-1}) was recorded from the application of 5 t ha^{-1} CHC and 112.5 kg ha^{-1} NPSB fertilizer which is statistically similar with the combined application of 7.5 t ha^{-1} CHC and 112.5 kg ha^{-1} NPSB fertilizer, while the least value exchangeable magnesium (7.62 meq 100 g^{-1}) was recorded from treatment applied with highest rate of NPSB fertilizer alone which is at par with other plots applied with sole NPSB fertilizers and control (Table 5). Furthermore, the combined application of 5 t ha^{-1} CHC and 112.5 kg ha^{-1} NPSB fertilizer improved the soil exchangeable Mg^{2+} by 61% (from 8.89 to 14.31) while the highest rate of blended chemical fertilizer reduced the soil exchangeable Mg^{2+} by 14% (from 8.89 to 7.62) when compared to initial soil exchangeable Mg^{2+} (Tables 1 and 5).

This result might be because of increase in Mg^{2+} availability with increasing pH as a consequence of the alkalinity of applied CHC and the lowest exchangeable magnesium in the plots amended with sole NPSB fertilizers might be attributed with leaching of Mg^{2+}. Duong [38] reported that compost have high CEC and have a potential to increase basic cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) of soils when incorporated. This result is in agreement with finding of Chali [49] and Kasongo et al. [53] who reported increase in exchangeable Mg^{2+} in soil with application of coffee waste to soil.

Table 5: Interaction effect of CHC and NPSB fertilizer on CEC and exchangeable bases of soils of potato field.

Treatment CHC	Treatment NPSB	CEC (meq 100 g^{-1})	Exch.Ca^{2+} (meq 100 g^{-1})	Exch.Mg^{2+} (meq 100 g^{-1})
0	0	12.12^{fg}	18.57^{e}	7.95^{g}
0	112.5	12.17^{fg}	18.17^{e}	7.94^{g}
0	150	12.15^{fg}	18.30^{e}	7.91^{g}
0	187.5	12.05^{g}	18.27^{e}	7.62^{g}
2.5	0	12.35^{efg}	18.47^{e}	10.71^{e}
2.5	112.5	12.43^{efg}	19.09^{e}	11.00^{e}
2.5	150	13.27^{b}	20.53^{d}	10.14^{f}
2.5	187.5	12.73^{cde}	20.45^{d}	10.00^{f}
5	0	13.10^{bc}	22.10^{bc}	11.66^{d}
5	112.5	12.95^{bcd}	20.55^{d}	14.31^{a}
5	150	13.08^{bc}	21.40^{cd}	12.42^{c}
5	187.5	12.57^{def}	21.24^{cd}	13.36^{b}
7.5	0	14.10^{a}	21.84^{bc}	13.30^{b}
7.5	112.5	14.05^{a}	21.60^{bc}	14.06^{a}
7.5	150	14.08^{a}	23.22^{a}	12.35^{c}
7.5	187.5	13.98^{a}	22.47^{b}	11.99^{cd}
F-test		*	**	***
LSD (0.05)		0.41	0.95	0.56
CV (%)		1.91	2.80	3.06

Means sharing the same letter within a column are not significantly different according to LSD at 5% level of significance; CV = coefficient of variation; * = significant at p = 0.05; ** = significant at p = 0.01; *** = significant at p = 0.001; CEC = cation exchange capacity; Exch.Ca^{2+} = exchangeable calcium; Exch.Mg^{2+} = exchangeable magnesium; meq = mill equivalent.

3.1.10. Exchangeable Potassium (K^+). The soil exchangeable K was significantly ($p < 0.01$) affected by the application of CHC and NPSB fertilizer while did not influenced by their interaction (Table 4). The highest soil exchangeable K (2.12 meq 100 g^{-1}) was resulted from the application of 7.5 t ha^{-1} CHC alone, while the least exchangeable K result (0.61 meq 100 g^{-1}) was recorded from unfertilized plot. On the other hand, the highest soil exchangeable K (1.72 meq 100 g^{-1}) was resulted from unfertilized plot with NPSB fertilizer which is statistically similar with plot supplied with 112.5 kg ha^{-1} NPSB fertilizer alone, while the lowest exchangeable K result (1.32 meq 100 g^{-1}) was recorded from application of 187.5 kg ha^{-1} NPSB fertilizer alone (Table 4). Application of the highest rate of CHC tended to improve the initial soil exchangeable K^+ by more than 100% (from 0.61 to 2.12) (Tables 1 and 4).

The improvement in exchangeable K over the sole NPSB fertilizer and control might be related to exchangeable K release to soil as result of mineralization from CHC and also the beneficial effect of coffee waste application in its capacity to supply soil exchangeable K [13, 17]. The lowest exchangeable K result from application of highest rate of NPSB fertilizer alone might be attributed with leaching of K^+. This finding is in agreement with the result of Chali [49] and Kasongo et al. [50] and those reported increase in soil exchangeable K as a result of CHC applied to acid soils alone and in combinations.

3.1.11. Exchangeable Sodium (Na^+). Exchangeable sodium of the experimental soil after harvest was also significantly ($p < 0.0001$) affected by the application of the main factors of CHC and not influenced by the application of main factors of NPSB fertilizer and its interactions with CHC (Table 4). The highest soil exchangeable Na^+ (0.054 meq 100 g^{-1}) was recorded from treatment applied with the 7.5 t ha^{-1} CHC alone, while the lowest soil exchangeable Na^+ (0.032 meq 100 g^{-1}) was recorded from unfertilized plots (Table 5). On the other hand, the highest rate of CHC improved the soil exchangeable Na^+ by more than 100% (from 0.02 to 0.054) when compared to initial soil exchangeable Na^+ value (Tables 1 and 4). This result might be because of released Na^+ from applied CHC to soil and coffee waste application promoted the retention of cations [17]. Takala Dibaba et al. [52] also reported the improvement of exchangeable Na^+ due to addition of compost to the soils.

4. Conclusion

This research was carried out with the objective of evaluating effects of different rates of coffee husk compost (CHC) and NPSB fertilizer on selected soil chemical properties of potato field during 2021 under supplemental irrigation. The result showed that combined application of CHC and NPSB fertilizer raises the soil pH by 24%, OC by 31% and improved the total N by 117%, improves the available P of the soil, reduces the exchangeable acidity, and raises the CEC and exchangeable bases of the experimental soil when compared to the control as well as the initial soil. In general, the result of current experiment indicated that combined application of CHC and NPSB blended fertilizers improves the chemical properties of the soils of potato field demonstrating the important role of combined application of organic and inorganic fertilizers in soil fertility management and thus improvement of potato crop growth and yield. Therefore, from the current findings, combined application of 5 t ha^{-1}

CHC and 187.5 kg ha^{-1} NPSB fertilizers could be recommended for its positive impacts on soil chemical properties to improve potato production and productivity.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding this paper.

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