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Response of Coffee Husk Biochar on Growth of Faba Bean on Nitisol and Soil Nutrients

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Abstract
Soil fertility depletion and the associated soil acidity has become a serious problem to crop production in most highlands of Ethiopia. Fortunately, such problems can be reclaimed by the application of biochar as soil amendments which can be sequestered in the soil for several years. A pot experiment was conducted to investigate the effects of biochar on growth response and nutrient uptake of faba bean and soil nutrients. The design employed was a randomized complete block with four replications. Collected Composite soil from (0-20 cm) depths at different distance in the zigzag pattern and prepared, analyzed before conducting the pot experiment and after harvesting following the standard laboratory procedures. Prepared biochar samples were collected from Jimma University collage of agricultural and veterinary medicine. The parameters analyzed includes: Trace Metals using DTPA extraction, macronutrient using 1 N ammonium acetate (pH =7) extraction. Dry ashing method was used to determine nutrient uptake of plant samples. The treatments included control, recommended inorganic phosphorus fertilizer (RPF), 10 t h^{-1} coffee husk biochar (CHB) + RPF ,20 t h^{-} CHB+ RPF,10 t h^{-1} CHB+50% RPF,20 t h^{-} CHB+50% RPF, lime+ RPF, lime+50% RPF,50% lime+RPF+10 t h^{-1} CHB and 50% lime+50% RPF+10 t h^{-1} CHB. The studied soil and plant data were collected and subjected to analysis of variance and treatment means were compared at the 0.05 probability level using list significant difference test. The results revealed that application of biochar significantly improved growth of faba bean and soil nutrient content. The highest values for soil chemical parameters such as total nitrogen, available phosphorus and exchangeable cations were obtained from the application of 20 t/ha CHB. Likewise, the highest growth performance of faba bean including plant height, leaf number, chlorophyll content, nodulation number, root and shoot biomass, uptake of N, P and K were recorded from biochar-amended soil.
Keywords: Amelioration, coffee husk biochar, faba bean, Nitisols
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1. INTRODUCTION

Agricultural soils have major constraints related to soil fertility and plant nutrient managements likewise deficiencies of essential trace elements and macro-nutrients and these deficiencies can affect the nutritional quality of edible crops with direct consequences for human health (Roberts *et al*., 2015). Soil degradation processes caused by soil erosion, organic matter, and plant nutrient depletion, nutrient imbalances, application of inorganic fertilizer, Soil acidity and P fixation in the highlands are among the major challenges affecting agricultural productivity and food security (Agegnehu *et al*., 2015, 2016,2019). Fortunately, such problems can be tackled by the application of biochar as soil amendments that can be sequestered for hundreds of years in the soil. Recent studies have suggested that the soil amended with biochar can potentially enhance agronomic productivity (Akhtar *et al*., 2014). The term biochar refers to the carbonaceous product obtained by thermal decomposition of plant or animal biomass in an oxygen-limited environment and when applied to soil as an amendment (Maia *et al.,* 2011) to retain nutrients for plant uptake and soil fertility, enrich plant growth and yield (Major *et al*., 2010) . Biochar helps to improve agricultural productivity by reducing P- fixation and to change biological activity and other pysico- chemical property of soil owing enhancing soil pH , soil porosity, CEC, fertilizer-use efficiency and decreasing bulk density (Agegnehu et al.,2016; Steiner *et al.* 2008; Chan and Xu ,2009), soil porosity increased, with soil base saturation , nutrient retention and availability and decreasing fertilizer need and nutrient leaching (Agegnehu et al.,2015,2016) water retention capacity (Downie, 2011) and plant-available water content (Tammeorg *et al*., 2014), and by creating a habitat for beneficial soil microorganisms (Thies and Rillig, 2009).

Faba bean (*Viciafaba*L.) is considered one of the most important legumes plants play a key role in sustainable agriculture production and present economic and environmental benefits due to their important capacity to fix nitrogen from the atmosphere in the root nodules in a symbiotic relationship with rhizobia. Symbiotic rhizobia can increase yields, accelerate flowering/fruit ripening and contribute to the improvement of the soil nitrogen balance for the benefit of legumes and associated species (Jia and Gray, 2008). Also, Faba bean is among the major grain food legumes cultivated in a different part of Ethiopia and used in worldwide as an important source of protein for human and animal nutrition (Cazzato et al., 2012).

Thus the productivity of this crop is constrained by low P availability associated with low soil P^{H}. Acid soils occur widely in the highlands of Ethiopia where the rainfall intensity is high and the land has been under farming for many years. These soils have P^H values of less than 5.5; availability of P and other soil nutrients are fixed which result in low faba bean yields compared to other faba bean growing areas of the country. The low yields in such soils could mainly be either due to the deficiency of nutrients, such as P, K, Ca and Mg (Sommer, 2000; Berry *et al*., 2003; Dodd and Mallarino, 2005), or toxicity of Al, Fe and Mn (Sharma, 2004). As a result, P deficiency is one of the most widespread soil constraints in these soils. Furthermore, Agegnehu *et al*. (2005) who reported that acid soils could expose faba bean to greater chocolate spot infection thereby reducing yield.

Acidic soil problems can be managed by the application of lime and Al^{+3} toxicity has also ameliorated by the use of P-containing fertilizers. However, limestone material is relatively expensive and unaffordable to the farmers, the supply has limited in Ethiopia, can only amend exchangeable calcium, magnesium, and phosphorus.

Due to this, researchers have recently started using biochar and organic matter as an alternative soil amendment mechanism. The material can increases crop yield, it's locally available, cheaper compared to limestone and environmentally friend. So, the potential of biochar as a soil nutrient amendment, soil acid management in agricultural fields is a recently recognized and yet it is underutilized technology. The aims of this study were, Therefore, to test the application of coffee husk biochar on nitisol 1) improves faba bean growth and nutrient uptake, 2) enhances soil nutrient properties.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted at Holetta agricultural research center and located at 09°N, 38°E at an altitude of 2400 m above sea level and characterized with a mean annual rainfall of 1044 mm, mean relative humidity of 60.6% and mean maximum and minimum temperature of 22.1°c and 6.2°c, respectively.

2.2. Sample collection and preparation

Before sampling, there was done assessment for identification of exact nutrient depilation area of the soil and soil acidity by measuring soil pH in laboratory. Then for pot experiment and Pre-planting soil nutrients analysis composite soil sample (0–20 cm depth) at five points in zigzag pattern was collected using an auger, core samplers were used for bulk density sampling separately from the place of soil pH below 5. The collected sample kept in polyethylene bags. Coffee husk biochar was collected from Jimma University College of Agriculture and Veterinary Medicine and used for pot experiment studies. Before applying for the soil amendment the collected soil and biochar sample were transferred to plastic trays and break up the large clods to speed up drying. The sample was air-dried, crushed with mortar and pestle and passed through a 2 mm opening stainless steel sieve (Reeuwijk, 2002).

All analytical measurement was performed in Agricultural Research Laboratory. Exchangeable K, Na, Ca and Mg were determined using 1M ammonium acetate extraction buffered at pH 7 using mechanical shaking and followed by measuring the concentration in atomic absorption spectrophotometer,. Nitrogen content in shoot part and soil was determined by digesting the samples in sulfuric acid (H_2SO_4) by the Kjeldahl method (BREMNER and MULVANEY, 1982). Available Phosphorus was determined by Olsen and berry 2 methods using 1 g of air dry soil in 20 ml of 0.5 M NaHCO3 (pH 8.5) shaking for 30 minutes [19] and by shaking 2 g of air dry soil in 20ml of extracting solution (0.03M NH_4F and 0.1MHCl) followed by measuring the Phosphorus concentration in the spectrophotometer.

2.3. Experimental setup

The type of soil used for all pots was nitisols and 3 kg of soil was filled in plastic pots. Each pot has four holes at the bottom and was equipped with a sealable plastic bag. All amendments applied on the plastic pot before planting and mechanically mixed into soil and the treatments were incubated for three weeks at 50% water holding capacity. During the incubation period, the pots were employed in a greenhouse experiment in a randomized complete block design (RCBD). Eight faba bean seeds (cultivar *Tumsa*) were sowed to a depth of 4 cm in the pots and thinned to four plants per pot after seedling emergence. The moisture content of the trial pots was maintained at field capacity by adding water until soil samples were collected after harvest time. For this study ten treatments were used; each treatment was replicated four times, giving a total of 40 pots. The treatments were:1) Control soil ; 2) Recommended phosphorus fertilizer only(RPF) as positive control; 3) Coffee husk biochar (10 t h^{-1}) + RPF); Coffee husk biochar (20 t h^{-1}) + RPF ; 4) Coffee husk biochar (10 t h^{-1}) + 50% RPF ; 5) Coffee husk biochar (20 t h^{-1}) + 50% RPF; 6) Lime + RPF; 7) Lime + 50% RPF; 8) 50% lime + biochar 10 t h^{-1} + RPF ; 9) 50% lime + biochar 10 t h^{-1} + 50% RPF ;10)

2.4. Growth parameters data collection and measurement

Agronomic data was recorded on a random sample of twenty plants, taken from all four replicates of each treatment. Plant height was recorded from the base of the stem at soil level to the final shoot of the plant of a fully opened leaf on the main shoot and the mean height was expressed in cm. Plant height was recorded at flowering stage of Days after germination. A number of leaves and nodulation No on each tagged plant were counted manually at the flowering stage. Relative leaf chlorophyll content was measured using a chlorophyll meter (SPAD-502). For each chlorophyll measurement, duplicate readings were made on the second fully expanded leaf from the top of the Main plant stem. The dry weight of root and total above ground biomass were measured after 48–72 hrs. Dried in the oven at 70 °C and after these shoot part of the plant taken for elemental analysis.

3. RESULTS AND DISCUSSIONS

3.1. Elemental analysis and pH measurement of Soil and Biochar before planting

Table 1: studied soil nutrients and coffee husk biochar before planting (Mean ± SD)

	Nutrients		
Element	Unit	soil	Biochar
pH	Soil(H_2O1:2.5) biochar (1:5)	4.89	11.05
Ca	cmol$_c$ kg $^{-1}$	7.283 ± 0.5	16.23 ± 0.169
Mg	cmol$_c$ kg $^{-1}$	3.865 ± 0.035	7.63 ± 0.09
K	cmol$_c$ kg $^{-1}$	2.09 ± 0.21	243 ± 1.17
Na	cmol$_c$ kg $^{-1}$	0.296 ± 0.004	0.0388 ± 0.0006
Cu	Mg kg $^{-1}$ soil	4.32 ± 0.07	0.55 ± 0.008
Fe	Mg kg $^{-1}$ soil	263.9 ± 1.15	56.4 ± 1.49
Mn	Mg kg $^{-1}$ soil	117.69 ± 1.7	0.286 ± 0.09
Zn	Mg kg $^{-1}$ soil	1.1 ± 0.03	0.23 ± 0.02
TN	%	0.11	0.62
available p	Mg kg $^{-1}$ soil	7	1109

The concentration of micronutrients in the soil such as Fe, Mn, Cu, and Zn are 263.9, 117.69, 4.32 and 1.1 Mg kg $^{-1}$ soil respectively. The value of macronutrients such as Ca, K, Na, and Mg are 7.28, 2.1, 0.296 and 3.86 Mg kg $^{-1}$ soil respectively. In biochar sample use as amendment, the values of available K (243 Cmol (+) kg $^{-1}$), P (1109 Mg kg $^{-1}$) is approximately similar with the report of our finding with which is observed by (Dume *et al.*, 2016). Ca and Mg and Na value is 16.23, 7.63, and 0.039, respectively.

3.2. Effect of Biochar on Vegetative Growth Parameters of Faba Bean

Table 2: Effect of biochar on the growth parameter of faba bean (Mean ± SD)

	Growth parameter					
Treatment	Leaf number	Plant height (cm)	Root biomass (g)	Shoot biomass (g)	Chlorophyll content	Nodule number per plant
Con	26.78 ± 0.28^{h}	57.01 ± 0.53^{f}	1.995 ± 0.017^{j}	2.62 ± 0.099^{h}	28.70 ± 0.54^{e}	34.25 ± 1.70^{e}
RPF	29.63 ± 0.25^{g}	58.87 ± 0.7^{ef}	2.17 ± 0.03^{i}	2.73 ± 0.04^{g}	29.7 ± 0.30^{e}	35.25 ± 0.95^{e}
CHB (10 t h^{-1}) + RPF	32.28 ± 0.55^{ed}	61.0 ± 0.85^{cd}	2.61 ± 0.038^{e}	2.94 ± 0.033^{de}	34.65 ± 0.57^{c}	41 ± 1.83^{c}
CHB (20 t h^{-1}) + RPF	38.83 ± 2.73^{a}	65.0 ± 0.97^{a}	3.59 ± 0.013^{a}	3.72 ± 0.024^{a}	39.18 ± 0.29^{a}	79 ± 0.82^{a}
CHB (10 t h^{-1}) +50% RPF	31.37 ± 0.52^{edf}	60.35 ± 0.48^{d}	2.55 ± 0.04^{f}	2.87 ± 0.02^{ef}	34.58 ± 0.49^{c}	40 ± 0.95^{cd}
CHB (20 t h^{-1}) + 50% RPF	37.1 ± 0.33^{b}	63.03 ± 1.09^{b}	3.52 ± 0.022^{b}	3.59 ± 0.30^{b}	39.08 ± 0.67^{a}	78.25 ± 1.63^{a}
Lime + RPF	31.32 ± 0.85^{ef}	59.03 ± 0.91^{e}	2.22 ± 0.009^{g}	2.87 ± 0.07^{ef}	33.43 ± 0.26^{d}	39.25 ± 1.70^{d}c
Lime + 50% RPF	30.58 ± 0.72^{gf}	58.82 ± 0.3^{e}	2.15 ± 0.061^{h}	2.83 ± 0.02^{f}	33.50 ± 0.33^{d}	38 ± 0.81^{fd}
CHB (10 t h^{-1}) + 50% lime + RPF	33.48 ± 0.94^{c}	62.20 ± 1.1c^{b}	2.9 ± 0.01^{c}	3.06 ± 0.05^{c}	35.65 ± 0.12^{b}	50.25 ± 1.26^{b}
CHB (10 t h^{-1}) + 50% lime + 50% RPF	32.37 ± 0.25^{d}	61.25 ± 0.75^{cd}	2.86 ± 0.01^{d}	2.96 ± 0.02^{d}	35.38 ± 0.37^{b}	50.25 ± 2.22^{b}
LSD (0.05)	1.006	1.2	0.04	0.08	0.67	2.1
CV (%)	2.13	1.35	0.98	1.69	1.34	2.95

LSD; least significant difference, CV; the coefficient of variation. Within columns, means followed by the same letter are not significantly different at $P = 0.05$

Effect of biochar on Leaf number, plant height, Root and shoot biomass

The application of biochar combined with mineral fertilizer in nitisol can improve on the most growth parameters of faba bean as compared to untreated soil. Leaf number, plant height, Chlorophyll content, Nodule number per plant, Root and shoot biomass were significantly higher at ($P<0.05$) in the application of 20 t h^{-1} CHB + RPF and 20 t h^{-1} CHB + 50% RPF than other treatments. The highest values of leaf number and plant height increase by 31 and 12%, as compared to the control and 23% and 9% as compared to mineral fertilizer only respectively and increasing value of shoot and root biomass respectively 2-28% and 2-44% as compared to the control. The observed increase value due to the addition of biochar in the presence of containing a greater amount of primary nutrient (k and p), due to liming effect to making available P to the plant growth or due to improving chemically, physically and biological properties of soil leads to good aeration, porosity, and transportation of available nutrient through the root system, in addition to supplying nutrient to reduced exchangeable acidity (Aluminum toxicity) and some micronutrient to be detrimental to root and plant growth and favorable pH range (> 5.5) for faba bean growth. These improvements in crop performance are corresponding with other studies (Anteneh, 2015; Nduka *et al.,* 2015).

Effect of biochar on Chlorophyll content

Chlorophyll is a light-absorbing pigment (chloroform molecules), and it actually gets its green color since it absorbs blue and red wavelengths of light. The green wavelengths are reflected, giving that particular color to plants and also they related to the N content in green plants and helps as a measure of the response of crops to N fertilizer application and soil nutrient status subsequently deficiency of nitrogen leads to loss green color in the leaves, decrease leaf area and intensity of photosynthesis. Data in Table 2 show that effect of biochar application to soil; significantly change at ($p \leq 0.05$) increased the mean values of chlorophyll in a plant grown as compared with the untreated plants.

Similarly, chlorophyll content on the application of lime in acid soil showed significant change but not mineral fertilizer alone is insignificant. In other words; the highest values were recorded in the application of 20 t h^{-1}CHB and increased by a factor of 27% than control. The increase in leaf chlorophyll content with the plant due to the addition of biochar better to the availability of nutrients and improvement of soil structure such as surface area, porosity, soil reaction, and such properties to makes suitable condition for soil microbial activity. Microbial activity is good decomposer of organic materials that increased N content of faba bean. So this result endorsed in Chlorophyll content, a pointer of photosynthetic activity is related to the N content in green plants and serves as a measure of the response of crops to N fertilizer application and soil nutrient status. The report of this finding is similar with the result which is observed by (Adekayode and Olojugba, 2010; Agegnehu *et al.,* 2015, 2016).

Effect of biochar on nodulation number

Table 2 has shown that all faba bean plants under the different rate of treatments including control showed nodulation may be the inoculation of their seeds with rhizobia, which were responsible for nodulation. The lowest values of nodulation parameters were observed in faba bean under no-biochar application. On the other hand, higher values of nodule number were observed under the treatments of 20 t h^{-1} CHB + RPF and 20 t h^{-1} CHB + 50% RPF. Range of nodulation number in plant cultivated in amended soil with biochar was found 6% to 57% increase compared to control. Addition of lime combines with mineral fertilizer also shows significant value on nodulation number of faba bean.

The positive effect of the application of biochar due to the result of promoting the efficiency of inoculants or native microorganisms, and increasing soil pH also enhanced mediated microorganisms. The report of this finding is similar with the result which is observed by (Lehmann *et al*., 2011; Quilliam *et al*., 2013; Singh and Cowie, 2014), possibly through the release of its labile organic matter, which may have caused immobilization of N (vanZwieten *et al*., 2010).

3.3. Effect of Biochar on Nutrient (N, P, and K) Uptakes of Faba Bean

Results of the shoot part of analyses for their N, P and K contents (%) have listed in Table 3. From the table the application of the different amount of biochar amendments on the nutrient uptake of N, P, and K is a significantly at ($p \leq 0.05$) positive effect as compared to control**.** These indicate that the application of different treatment supported nutrient uptake of faba bean in the soil solution .N, P, K is the primary nutrient for plant. Most agricultural plants primarily take up inorganic N, P, K which comes from the conversion of organic form to inorganic form (mineralization), although a few crop species like faba bean were observed to directly take up organic N for energy and growth.

Table 3: Nutrient uptake of faba bean under different treatment (Mean ± SD)

Treatment	nutrient uptake of plant		
	%N	%P	%K
Con	1.43 ± 0.13^{e}	0.084 ± 0.013^{g}	2.32 ± .023^{f}
RPF	1.423 ± 0.1^{e}	0.109 ± 0.011^{f}	2.35 ± 0.029^{f}
CHB (10 t h^{-1}) + RPF	2.23 ± 0.04^{c}	0.13 ± 0.01^{e}	4.15 ± 0.034^{d}
CHB (20 t h^{-1}) + RPF	3.28 ± 0.008^{a}	0.16 ± 0.054^{a}	4.71 ± 0.099^{a}
CHB (10 t h^{-1}) + 50% RPF	2.22 ± 0.05^{c}	0.12 ± 0.005^{e}	4.12 ± 0.02^{d}
CHB (20 t h^{-1}) + 50%RPF	3.28 ± 0.08^{a}	0.15 ± 0.003^{b}	4.65 ± 0.04^{b}
Lime + RPF	1.83 ± 0.03^{d}	0.113 ± 0.001^{ef}	3.97 ± 0.02^{e}
Lime + 50% RPF	1.78 ± 0.12^{d}	0.105 ± 0.005^{f}	3.95 ± 0.03^{e}
CHB (10 t h^{-1}) + 50% lime + RPF	2.51 ± 0.01^{b}	0.146 ± 0.001^{bc}	4.28 ± 0.02^{c}
CHB (10 t h^{-1}) + 50% lime + 50% RPF	2.46 ± 0.02^{b}	0.14 ± 0.003^{c}	4.25 ± 0.02^{c}
LSD (0.05)	0.12	0.009	0.057
CV (%)	3.58	4.85	1.01

LSD; least significant difference; CV the coefficient of variation. Within columns, means followed by the same letter are not significantly different at *P* = 0.05.

Both 20 t h- 1 CHB + RPF and 20 t h^{-1} CHB + 50% RPF were showed highest value of %N content than with the other treatments but does not showed a statistically significant difference between them. Generally the application of biochar and lime showed a statistically significant difference on the value of %N content compared to control. The lowest value of N uptake obtained from the control (1.43) and highest value 3.28 at the rate of 20 t h^{-1} biochar. The positive effect of this result indicated due to the addition of biochar to improve soil nutrient solubility, availability, porosity, surface area, soil reaction, water uptake and transportation by the plants through root systems. Since acid soil toxicity of Al^{3+} is one of the major limiting factors for crop production by inhibiting root cell division and elongation, reducing water and nutrient uptake. The functions of Biochar not only provide nutrients but also improve physical, chemical and biological aspects of soil fertility and crated optimum condition for active microorganism. The report of this finding is similar with the result which was observed by (Chen *et al*., 2013; Dil and Oelbermann, 2014; Domene *et al*., 2014; Agegnehu *et al*., 2015, 2016). Since the solubility of a complex form of iron and aluminum phosphate in soil solution and , due to microbial activity conversation of organic N to the inorganic form of No_3^-- N and $NH4^+$-N increase with soil pH. In acidic soil solubility of Al increase can be toxic to rhizobia and plant roots, limiting legume production of N.

Similar result is observed on P-uptake of faba bean as compared to the control experiment (Table 3). This might be due to increased soil pH as a result of lime application of biochar, which enhances the release of phosphate ions fixed by Al and Fe ions into the soil solution in addition to its Capacity to supply soil nutrients and increased the absorption of P by faba bean compared to the control. Similarly, application of lime together with full and half recommended mineral fertilizer (p) increased P-uptake of faba bean treated with the respective levels as compared to control.

Table (3) shown positive increment indicated due to the acid neutralizing capacity of lime. Related to N–uptake, the highest P-uptake 0.16%, 0.15% was obtained from the application of Biochar at the rate of treatment 20 t h^{-1} CHB + RPF and 20 t h^{-1} CHB + 50% RPF respectively, while, the lowest (0.084%) was obtained from the control (Table 3). Phosphorus content of the shoot biomass recorded from 20 t h^{-1} CHB + RPF and 20 t h^{-1} CHB + 50% RPF greater by a factor of 48 and 44 respectively that of the control. These result indicated both treatments between the combination of biochar and lime with mineral fertilizer and mineral fertilizer alone are shown P uptake of faba bean due to direct transport of available phosphors through root system from it.

Like to the % content of N available K was shown a significant change in the application of the rate of biochar and lime at ($P < 0.05$) compared to control and mineral fertilizer alone. The increment of the result due to the addition of biochar supply K nutrient to plant root and may be due to the rise of soil pH, Plant macronutrient dependent on soil pH. Similar explanations were reported by (Dume *et al*., 2016); Agegnehu *et al*., 2015; Nigussie *et al*., 2012)

3.4. Effect of biochar on Soil nutrient after harvesting

ANOVA result was used to assess differences in soil exchangeable base under different treatments. Table 4 has shown that the application of the different amount of biochar amendments in the study of acidic soil had a significantly positive effect on the soil exchangeable base when applied together with standard fertilizer rate compared to control.

Table 4: soil nutrient after harvesting (Mean ± SD)

Treatments	Exchangeable cations (Cmole kg^{-1})					
	Ca	Mg	Na	K	TN (%)	P (mg kg^{-1})
Con	5.88 ± 0.087^{f}	4.22 ± 0.06^{f}	0.292 ± 0.003^{a}	1.03 ± 0.11^{g}	0.11 ± 0.0^{d}	7.48 ± 0.75^{H}
RPF	6.1 ± 0.54^{f}	4.2 ± 0.06e^{f}	0.298 ±0.002^{a}	1.2 ± 0.05^{f}	0.11 ± 0.0^{d}	8.388 ± 0.014^{g}
CHB (10 t h^{-1}) + RPF	6.45 ± 0.06^{dc}	4.77 ± 0.02^{c}	0.293 ± 0.003^{a}	2.89 ± 0.03^{c}	0.135 ± 0.003^{c}	9.48 ± 0.199^{e}
CHB (20 t h^{-1}) + RPF	7.5 ± 0.16^{a}	5.04 ± 0.03^{a}	0.292 ± 0.0002^{a}	6.7 ± 0.06^{a}	0.165 ± 0.006^{a}	13.564 ± 0.32^{a}
CHB (10 t h^{-1}) + 50% RPF	6.58 ± 0.04^{cb}	4.78 ± 0.05^{c}	0.296 ± 0.004^{a}	2.86 ± 0.02^{c}	0.135 ± 0.016^{c}	9.169 ± 0.022^{ef}
CHB (20 t h^{-1}) + 50% RPF	7.55 ± 0.03^{a}	4.99 ± 0.01^{a}	0.293 ± 0.03^{a}	6.58 ± 0.28^{a}	0.147 ± 0.005^{b}	11.97 ± 0.32^{b}
Lime + RPF	6.21 ± 0.06^{ed}	4.47 ± 0.02^{e}	0.279 ± 0.031^{a}	1.61 ± 0.06^{d}	0.113 ± 0.005^{d}	9.17 ± 0.021^{ef}
Lime + 50% RPF	6.25 ± 0.086^{ed}	4.54 ± 0.06^{d}	0.295 ± 0.003^{a}	1.6 ± 0.03^{d}	0.113 ± 0.005^{d}	8.822 ± 0.096^{fg}
CHB (10 t h^{-1}) +50% lime + RPF	6.77 ± 0.04^{b}	4.84 ± 0.02^{b}	0.286 ± 0.004^{a}	3.47 ± 0.04^{b}	0.13 ± 0.008^{c}	10.944 ± 0.49^{c}
CHB (10 t h^{-1}) + 50% lime + 50% RPF	6.73 ±0.10^{b}	4.86 ± 0.02^{b}	0.293 ± 0.006^{a}	3.37 ± 0.07^{b}	0.13 ± 0.005^{c}	10.393 ± 0.016^{d}
LSD (0.05)	0.28	0.059	0.021	0.16	0.007	0.471
CV (%)	2.89	0.86	4.97	3.55	4.11	3.266

CHB; Coffee husk biochar; RPF; Recommended phosphorus; LSD, least significant difference; CV, the coefficient of Variation. Within columns means followed by the same letter are not significantly different at *P* = 0.05.

Our results indicated enhance of soil exchangeable base such as K, Ca and Mg but the application of biochar in soil was not a significantly positive effect on the property of soil exchangeable Na^{+}. The treatment of biochar in soil, exchangeable K more improves when compared to the other three elements. The application rate of biochar increase with increased availability of soil exchangeable K. Addition of 20 t h^{-1} CHB the highest value of exchangeable K^{+} compare to inorganic fertilizer (P) alone and control and increased by a factor of 82% and 85% respectively.

In other word, addition of mineral fertilizer for each treatment is not shown a statistically significant difference on the property of soil available nutrient. However, acid soil amended with lime positively influenced on the nutrient availability of soil. These increment of nutrient availability may be due to the liming effect of the addition of biochar and lime to retained nutrients (reduced leaching of nutrient) and also due to the presence of a maximum amount of available K in the biochar to release into the soil system due to decomposition and mineralization. The report of this finding is similar with the result which is observed by (Kasongo *et al.,* 2011; Kasongo *et al.,* 2013). Coffee husk compost contains high organic agricultural waste and potassium was good material for composting process in agricultural products further designate by (Solomon, 2006; Dzung *et al*. 2013; Henok and Tenaw, 2014).

Table 5: soil micronutrients after harvesting (Mean ± SD)

	soil micronutrients (mg kg^{-1})			
Treatment	Fe	Cu	Mn	Zn
Con	256.3 ± 1.2^{a}	4.31 ± 0.2^{a}	112.9 ± 0.3^{a}	1.68 ± 0.05a
RPF	254.9 ± 1.1^{b}	4.26 ± 0.03^{a}	113.88 ± 1.84^{a}	1.55 ± 0.03^{b}
CHB (10 t h^{-}) + RPF	181 ± 0.4^{e}	3.21 ± 0.06^{fg}	92.1 ± 0.3^{c}	0.83 ± 0.07^{e}
CHB (20 t h^{-}) + RPF	175.7 ± 0.6^{g}	3.08 ± 0.03^{h}	82.1 ± 1.5^{e}	0.34 ± 0.02^{h}
CHB (10 t h^{-}) +50% RPF	181.6 ± 0.3^{e}	3.29 ± 0.05^{ef}	92 ± 1.6^{c}	0.88 ± 0.03^{d}
CHB (20 t h^{-}) + 50% RPF	174.9 ± 0.03^{g}	3.13 ± 0.04^{gh}	80.5 ± 0.8^{e}	0.45 ± 0.05^{g}
Lime + RPF	222.7 ± 0.4^{c}	3.81 ± 0.07^{b}	103.8 ± 1.4^{b}	1.16 ± 0.04^{c}
Lime + 50% RPF	220.7 ± 1.22^{d}	3.66 ± 0.05^{c}	102.2 ± 1.4^{b}	1.17 ± 0.01^{c}
CHB (10 t h^{-}) + 50% lime + RPF	178.6 ± 0.7^{f}	3.47 ± 0.12^{d}	87..2 ± 0.84^{d}	0.64 ± 0.03^{f}
CHB (10 t h^{-}) + 50% lime + 50% RPF	178.9 ± 1.3^{f}	3.38 ± 0.01^{ed}	86.8 ± 0.5^{d}	0.65 ± 0.05^{f}
LSD (0.05)	1.71	0.12	2.31	0.05
CV (%)	0.58	2.26	1.67	3.69

Our findings indicate that the effect of biochar on soil micronutrient was significantly reduced at ($P \leq 0.05$). micronutrient are trace elements used for plant as nutrient but may also pose a toxicity risk if present at elevated levels as their availability and mobility increases under acidic condition. Application of 20 t h^{-1} CHB reduced the Concentration of iron by 32% and manganese by 25% as compared to the control. This observation may be due to the liming effect of biochar addition immobilized the micronutrient in soil by precipitation which reduces the concentration of Fe, Cu, Mn, and Zn. From the above discussion of exchangeable acidity reduced due to the addition of biochar and increased soil p^{H}, as soil p^{H} increase rise availability (solubility) of macronutrient and formation of complexes with micronutrient increased. Our finding associated with Kasongo *et al.* (2013) reported that the application of coffee waste increased soil pH due to its liming effect. This brought about an increase in cation exchange capacity with a substantial reduction in phytotoxic Al and decrease in the availability of a number of metals (Cu, Zn, Mn, and Fe) and significantly reduced their uptake by ryegrass.

4. CONCLUSIONS

Initially the study soil was showed that deficient in plant- available nutrients and application of the biochar and lime significantly positive effect on soil nutrients in addition to nutrient supply, by increasing soil pH and reduced exchangeable acidity, in a way that enhanced the availability of plant nutrients. Applications of 20 t h^{-1} CHB were more efficient in improving soil nutrient availability, and nutrient uptake of faba bean than other treatment. The relatively high alkalinity and probably the proton consuming ability of ash materials, as well as the high nutrient contents in biochar, were considered the main factors responsible for the reduced soil acidity and improved nutrient supply of the amended soils. Generally, all the result of soil and plant nutrient obtained with the acceptable analytical methods which were evaluated by analytical method validation and quality control parameters such as precision accuracy, reliability by measurements of replication, method blank, spike recovery was taken.

The positive growth response of the faba bean to biochar and lime soil amendments than control indicated that the soil collected for this research was inherently low in some essential nutrients, hence the level of many essential nutrients in these soils was fixed and lower which was readily available and supplied by biochar and lime amendments. The faba bean was more responsive to the organic source (biochar) amendments compared to the lime, thus indicating there were some important nutrients that were being supplied to the faba bean beside its liming effect. While lime was not used as nutrient sources other than reducing the Aluminum toxicity effect and making the nutrients available for the growth. Liming acid soils result in the release of fixed macronutrients specially phosphorus for plant uptake by decreasing Al. Therefore this is particular importance as it indicates the value of biochar as alternative amendments to ameliorate soil nutrient and acid soils for small-scale farmers who cannot afford to regularly purchase lime and mineral fertilizers.

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