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Research Article

Effects of lime and coffee husk compost on growth of coffee seedlings on acidic soil of Haru in Western Ethiopia

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Abstract: A pot experiment was conducted to determine the effects of lime, coffee husk compost and their combinations on growth response of coffee (*Coffea arabica* L.) seedlings at Haru Research Sub-Center nursery site in West Ethiopia in 2016/17. The experiment was laid out in a factorial experiment arranged in Randomized Complete Block Design with three replications. The treatments included four levels of lime (0, 2, 4 and 6 g/2.5k g soil (pot)) and coffee husk compost (0, 6.25, 12.5 and 18.75 g/2.5 kg soil (pot)). The relevant shoot and root growth parameters data were collected and subjected to Analysis of Variance using SAS package and treatment means were compared at 0.05 probability using Duncan's Multiple Range Test. The results revealed that lime and coffee husk compost rates significantly ($p \leq 0.01$) affected the shoot and root growth of coffee seedlings. The highest growth performance of coffee seedlings (plant height, stem girth, leaf number and area, tap and lateral root length, lateral root number, root volume, stem, leaf and root dry matter) were obtained from the application of 18.75 g/pot coffee husk compost and combined lime and coffee husk compost at the modest levels of 4g/pot lime and 12.5 g/pot coffee husk compost with a non-significant variation. From the study, it can be concluded that application of 18.75 g/pot coffee husk compost or combining 12.5 g/pot of coffee husk compost and 4 g/pot of agricultural lime could be a promising alternative amendment for acid soil management and production of vigorous coffee seedlings in Haru areas. But, further investigations should be continued under field conditions across locations and seasons to evaluate the effects of liming and coffee husk composts in ameliorating soil acidity, and improving growth, yield and quality of coffee varieties and establish their profitable levels for sustainable soil fertility management and production of Wollega coffee in west Ethiopia.

Keywords: *coffee husk compost, coffee growth, lime and soil acidity*

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Introduction

Soil acidity has become a serious threat to crop production in most highlands of Ethiopia in general and in the western part of the country in particular (Taye, 2007; Wassie and Shiferaw, 2009; Achalu et al., 2012; Abdenna, 2013; Tigist et al., 2019). An earlier study by Mesfin (2007) estimated that about 41% of arable lands of Ethiopia are affected by soil acidity/Al^{3+} toxicity. An inventory was made in 2006 to determine the status of soil acidity of Nitisols occurring in western and central Ethiopia and the results revealed that all samples were acidic though the degree varied from location to location (Abdenna et al., 2007). Soil acidity is expanding both in scope and magnitude in Ethiopia; severely limiting crop production (Wassie and Shiferaw, 2009; Wassie and Shiferaw, 2011; Tamene et al., 2017). Recently, Eyasu (2016) also reported that 80% of the Nitisols and Luvisol subgroup soils found in the north-central and south western high lands of Ethiopia are very strong to strongly acidic soils having pH of 4.5-5.5. Also, the original ecology of the major coffee growing areas in western Ethiopia is being disturbed with the high intensity of deforestation and land degradation (Abdenna et al., 2007; Achalu et al., 2012). This and the prevailing high rainfall have resulted in severe erosion, exposure of the less fertile sub-soils and increased soil acidity in major coffee growing areas of western Ethiopia (Abdenna, 2013; Melke and Ittana, 2015). As a result of coffee production potential in western Ethiopia hardly exceeds 0.67 t/ha (CSA, 2016) despite the existence of enormous genetic diversity and importance of the crop in the national economy of the country. In addition, coffee cultivation mainly lies on the production of coffee seedlings with desirable characteristics under the recommended nursery management operations. Because any improper handling made at the early stage would remain to cause poor field performances and life span of coffee trees in the field (Anteneh et al., 2015). In this regard, reports (IAR, 1996; Yacob et al., 1996) indicated the use of appropriate potting media from forest soil to produce vigorous and healthy coffee seedlings. However, there is diminished accessibility to the sources, and the accelerated deforestation practices would also call for alternative nursery media preparations from available organic sources with due consideration of both physical and chemical conditions given the well-established cultural practices of using organic material under traditional crop production in Ethiopia (Taye, 1998; Anteneh et al., 2015).

As low pH affects the availability of nutrients particularly that of phosphorus and other macronutrients, correction of the low pH through liming, and/or application of organic materials is critical for sustainable management of these soils (Mesfin, 2007; Wassie and Shiferaw, 2009; Tigist et al., 2019). Agricultural liming is proved a good way of correcting soil pH along with supplying Ca to the soil (Wassie and Shiferaw, 2011). Likewise, the Ministry of Agriculture has also given special attention to demonstrate the beneficial effects of liming in reclaiming soil acidity for several crops across different locations in Ethiopia. As a result, farmers are being encouraged to increase productivity of the acidic soils by liming. However practical applicability by the Ethiopian farmers has been constrained by limited supply, long transportation distances between crushing and application sites and lack of research recommendations specific to crop types and soil conditions(i.e. soil buffering capacity) (Eyasu, 2016). So finding liming material from easily available organic materials is recommended (Tamene et al., 2017). Using compost and animal manures on crops almost always has a desirable effect since they contain substantial amounts of major and trace elements. Furthermore, they have a positive effect on the chemical and physical properties of the soil. Thus, they can be of tremendous benefit in heavily weathered coffee soils because they can improve the soil structure and its water holding capacity (Ano and Ubochi, 2007; Solomon et al.,2008). Also the need for renewable, locally available and cheaper options for supplying nutrient to crops is increasingly becoming important because of the need for sustainable agriculture (Ahmad et al., 2006; Tigist et al., 2019). With growing demands for sustainably produced agricultural products for environmental, social and food safety reasons, the use and recycling of organic matter is becoming inevitable, particularly for the export market, which depended on commodities such as coffee (Chemura, 2014)

There is thus the need to recognize other potential organic amendment sources such as the by-products from wet and dry coffee processing. The dry method is commonly practiced and easily available at coffee producing areas in Haru areas of Western Ethiopia. These coffee by-products are utilized in other coffee producing countries as soil amendments (Kasongo et al., 2011; Dzung et al., 2013; Kasongo et al., 2013; Nduka et al., 2015). While in Ethiopia enormous quantities are either dumped into streams or burnt in big piles, with contributions to environmental hazards (Solomon, 2006; Gezahegne et al., 2011; Henok and Tenaw, 2014). In addition, liming rate should be judiciously determined not to cause nutrient imbalances by increasing the already high level of exchangeable Ca^{2+} concentrations that might affect the availability and uptake of other nutrients. Therefore, the objective of this study was to determine the effects of lime, coffee husk compost and their combinations on the growth response of coffee (*Coffea arabica* L.) seedlings at Haru, western Ethiopia.

Materials and Methods

Description of the study area

The study was conducted at the Haru Agricultural Research Sub-Center (HARSC) in West Wollega zone, Oromia National Regional State, Western Ethiopia. Haru Agricultural Research Sub-center of the Jimma Agricultural Research Center was established in 1998 primarily to address the potentials and constraints in west Wollega speciality coffee growing areas. The center represents the sub-humid tepid to cool mid highlands coffee agro-ecological zone in West Ethiopia. It is found at 28 km from Gimbi town of

West Wollega zone and 466 km from Addis Ababa in western Ethiopia. The area is geographically located between the latitude of 8°54' 30" North and longitude of 35°52' 0" East at an elevation of 1750 m.a.s.l. The area is characterized by uni-modal rainfall pattern with an average annual rainfall of 1700 mm. The rainy season starts in March or May and extends up to October. The mean maximum and minimum air temperature is 27.8°C and 12.4°C, respectively. The soil type of the center is Acrisols and sandy clay loam (Zebene and Wondwosen, 2008).

Experimental materials and procedures

Fresh coffee husk was collected from the dry coffee processing site in Jitu town, Haru District. The compost was prepared by using 70% coffee husk, 20% animal manure and 10% top soil by volume following the procedure adopted by Solomon (2006). Top soil at a depth of 0-20cm was collected from open field which is less fertile and acidic soil to be amended with coffee husk compost and lime. Moreover, the different lime rates as powdered lime having a calcium carbonate equivalent of 98% was used and amount of lime applied at each was calculated on the basis of exchangeable acidity concentration of the soil and crop factor tolerant to soil acidity (Kamprath, 1984). Menesibu coffee variety was used as test crop. The variety was released in the year 2010 for Wollega speciality coffee producing areas (EIAR, 2015). Coffee seeds were hand harvested from the already established seed orchards at Haru center and prepared as per the standard procedures.

Experimental treatments and design

The treatments consisted of four coffee husk compost application rates (0, 6.25 g, 12.5 g and 18.75 g) and four lime rates (0, 2 g, 4 g, and 6 g) in 2.5 kg of acidic soil. The treatments were conducted using polythene bags of 12 x 22 cm size. The polythene bags were prepared and firmly filled with the treatment rates which were added and thoroughly mixed with the soil. A 4 x 4 factorial experiment arranged in a randomized complete block design with three replications was used for the study. The treatment combinations were shown in Table 1 and the numbers of seedlings per plot were 16 with a total of 768 coffee seedlings. The so prepared pots were arranged and on October 16/2016, two coffee seeds were directly sown in polythene bags (potted) at a depth of 1.00 cm. Thinning to one seedling was made in each pot after the emerged seedlings attained a butterfly growth stage and were uniformly managed until they attain desirable stage and end of the study. All other routines pre-and post- nursery management practices, including mulching, watering, shading, weeding and other activities were carried out as per the recommendation (IAR, 1996).

Table 1. Treatment combinations and their rates used for the study.

Treatment number	Treatment combinations and description
1	0 g L and 0 g CHC (Control)
2	2 g L and 0 g CHC
3	4 g L and 0 g CHC
4	6 g L and 0 g CHC
5	0 g L and 6.25 g CHC
6	2 g L and 6.25 g CHC
7	4 g L and 6.25 g CHC
8	6 g L and 6.25 g CHC
9	0 g L and 12.5 g CHC
10	2 g L and 12.5 g CHC
11	4 g L and 12.5 g CHC
12	6 g L and 12.5 CHC
13	0 g L and 18.75 g CHC
14	2 g L and 18.75 g CHC
15	4 g L and 18.75 g CHC
16	6 g L and 18.75 g CHC

Key: L = lime, CHC = coffee husk compost

Data collection

Growth of coffee seedlings

Non-destructive plant growth parameters such as plant height (cm), girth diameter (cm), number of true leaves and estimated leaf area (cm^2) were recorded from four coffee seedlings which are located at the middle of the plot. Estimated leaf area was measured using the procedure adapted by Yacob et al. (1996) as follows:

$$Y = K \times L \times B$$

where, Y is estimated leaf area; K is constant specific to cultivars and canopy classes (0.67); L is leaf length (cm) and B is maximum leaf breadth (cm).

Stem diameter (girth) was measured at the surface of the potting soil by using a caliper. Each seedling sampled for measurement of non-destructive growth parameters was brought to laboratory to measurement of destructive shoot and root growth parameters. The polythene bag containing the roots of the seedlings was immersed in a bucket filled with water and roots were allowed to separate carefully from the soil still being in water. The roots were subsequently washed with clean water and dried with water adsorbent cloth. Seedlings were then cut with scissor to separate the shoot from root parts. Then tap root length (cm), lateral root number, lateral root length (cm) and root volume (ml) were recorded. Finally the shoot and root dry matters were measured using sensitive balance after oven drying at 70ºC for 24 hours.

Statistical analysis

The collected soil and plant data were summarized and subjected to ANOVA (analysis of variance) using SAS software (version 9.3) (SAS, 2011). For significantly different treatments, the means were separated using Duncan's Multiple Range Test (DMRT) at p = 0.05. Simple correlation analyses were also conducted to assess the associations between some soil chemical parameters.

Results and Discussion

The shoot growth parameters of coffee seedlings

Addition of lime and coffee husk compost on acidic soil significantly ($p \leq 0.01$) affected plant height, stem diameter, leaf number and leaf area of coffee seedlings (Table 2).

Plant height and stem diameter

Plant height and stem diameter (girth) of coffee seedling was highly significantly ($p \leq 0.01$) affected by application of lime and coffee husk compost and their interaction (Table 2). Accordingly application of lime without compost increased by 24.2- 40% increments for plant height and 10.7-26.6% for stem girth over the control with increasing rate (Table 2). Similarly application of compost without lime increased by 43.4 -76% for plant height and 27-72.8% for stem girth over the control with increasing compost rate (Table 2). Accordingly, application of compost without lime, at the rate of 18.75 g/pot produced the highest mean value for plant height (14.27cm) which was about 76% increment over the control treatment (8.08cm) and stem diameter (3.70mm) which was about 72.8% increment over the control (2.14mm) (Table 2). This could be possibly due to the increased soil organic carbon, total nitrogen, available P and favorable pH range (> 5.5) for coffee plant growth.

Table 2. The interaction effects of lime and coffee husk compost rates on shoot growth of coffee seedlings.

Treatment number	Treatment combination	Parameters			
		Plant height (cm)	Girth (mm)	Leaf number	Leaf area (cm^2)
1	0 g L + 0 g CHC (Control)	8.08^{j}	2.14^{h}	6.33g	5.74^{i}
2	2 g L + 0 g CHC	10.04^{i}	2.37^{h}	8.39f	7.05^{h}
3	4 g L + 0 g CHC	11.21^{h}	2.68^{g}	8.94def	8.08^{g}
4	6 g L + 0 g CHC	11.33^{gh}	2.71^{g}	9.17def	8.01^{g}
5	0 g L + 6.25 g CHC	11.59^{fgh}	2.72^{g}	8.83ef	8.02^{g}
6	2 g L + 6.25 g CHC	11.68^{fgh}	2.87^{fg}	9.33de	8.47^{fg}
7	4 g L + 6.25 g CHC	11.92^{fg}	2.98^{efg}	9.83cd	9.16^{ef}
8	6 g L + 6.25 g CHC	12.76^{cd}	3.12^{def}	9.78cd	10.67^{d}
9	0 g L + 12.5 g CHC	12.08^{ef}	2.88^{fg}	9.33de	9.42^{e}
10	2 g L + 12.5 g CHC	13.05^{bc}	3.32^{bcd}	10.56bc	11.43^{cd}
11	4 g L + 12.5 g CHC	13.64^{ab}	3.57^{ab}	11.55a	12.34^{b}
12	6 g L + 12.5 g CHC	12.12^{def}	3.17^{cdef}	9.33de	9.13^{ef}
13	0 g L + 18.75 g CHC	14.27^{a}	3.70^{a}	11.67a	13.36^{a}
14	2 g L +18.75 g CHC	13.74^{a}	3.43^{abc}	11.17ab	11.77^{bc}
15	4 g L + 18.75 g CHC	12.60^{cde}	3.25^{cde}	9.11def	9.44^{e}
16	6 g L + 18.75 g CHC	11.60^{fgh}	3.11^{def}	9.50de	9.56^{e}
DMRT (5%)		**	**	**	**
CV (%)		3.08	5.48	5.03	4.98

Key: - DMRT = Duncan's Multiple Range Test; L=Lime; CHC=Coffee husk compost; **=highly significant at $p \leq 0.01$. Mean values followed by the same letters within a column are not different from each other at $p \leq 0.05$.

Nduka et al. (2015) also recorded significant increase in plant height and stem diameter on cashew seedling growth as a result of coffee husk application to acid soil. Furthermore, the combined application of lime and coffee husk compost showed significant differences in plant height and stem diameter among treatments, with increments of 68.8% for plant height and 66.8% for stem diameter over the control at combined application rate of 4g lime and 12.5 g/pot coffee husk compost (Table 2). This finding showed that there was a positive effect on plant height and stem diameter of coffee (*Coffea arabica* L.) seedlings by application of sole coffee husk compost and combined with lime. The soil of the experimental site was strongly acidic, low in N, P and other plant nutrients.

Therefore the application of coffee husk compost might be contributed not only by supplying nutrients (including N, P, K and micronutrients) through mineralization but also by making P available to the plant as a result of its liming effect. This finding agrees with Kasongo et al. (2013) and Nduka et al. (2015) who reported the liming effect of coffee husk amendments on tropical acid soils.

Leaf number and leaf area

Application of lime and coffee husk compost due to their main and interaction effects significantly ($p \leq 0.01$) affected leaf number and leaf area of coffee seedlings (Table 2). Accordingly, the improvement in coffee seedlings leaf number and area following the addition of lime without coffee husk compost were 32.5, 41.2 and 44.8% for leaf number and 22.8, 40.8 and 39.5% for leaf area over the control by the application of 2, 4 and 6 g/pot of lime rate respectively (Table 2). Also, the improvement in coffee seedlings leaf number and area following the addition of compost without lime were 39.5, 47.4 and 84.3% for leaf number and 39.7, 64.1 and 132.7% for leaf area over the control by the application of 6.25, 12.5 and 18.75 g/pot of coffee husk compost rate respectively (Table 2). The highest leaf number and area were observed by application of the highest rate of coffee husk compost without lime at 18.75g/pot with an increment of 84.3% for leaf number and 132.7 leaf area over the control and followed by combined application of lime and coffee husk compost at rates of 4g and 12.5 g/pot respectively with increment of 82.6% for leaf number and 114.9% leaf area, while the lowest leaf number and area were observed at control (Table 2). The significant increases in coffee seedling leaf number and leaf area with application of lime and coffee husk compost could be attributed to the general improvement of the soil environment in terms of decreased acidity and increased availability of plant nutrients. This finding was in line with Anteneh (2015) and Ewnetu et al. (2019) who reported the increased leaf number and area of coffee (*Coffea arabica* L.) seedlings by application of Lime and P fertilizer on acid soil of south western Ethiopia. Taye (1998), also reported various proportions of organic manures including decomposed coffee husk and farm yard manure mixed with top soils were significantly affected most of the coffee seedling growth parameters at Jimma, South West Ethiopia.

The root growth of coffee seedlings

Tap root and lateral root length

Application of lime and compost alone and their combination gave of highly significant effect ($p \leq 0.01$) on tap and lateral root length of coffee seedling (Table 3). Accordingly, application of lime alone increased tap and lateral root length of coffee seedling by 15- 25.9 % and 9.12-36.47%, respectively, over control with increasing lime rates (Table 3). Similarly, application of coffee husk compost alone increased tap and lateral root length of coffee seedling by 25.5-54.5% and 41.8-125%, respectively, over control with increasing rates (Table 3). The highest tap and lateral root length (21.96 and 7.16) cm were recorded for application of coffee husk compost at the highest rate (18.75 g/pot1) followed by the combined effect of 4 g/pot lime and 12.5 g/pot compost which gave 21.44 and 6.92 cm tap and lateral root length respectively, while the lowest tap root length (14.21 cm) and lateral root length (3.18 cm) were observed from the control treatment (Table 3).

Lateral root number and root volume

Analysis of variance revealed that lateral root number and root volume were highly significantly influenced ($p \leq 0.01$) by application of lime, coffee husk compost and their interaction effect (Table 3). Accordingly, application of lime without coffee husk compost increased lateral root number and root volume by 14.23-30.9% and 37.5- 60%, respectively, over the control with increasing lime rates (Table 3). Similarly, application of coffee husk compost without lime increased lateral root number and root volume of coffee seedling by 40.6-102% and 50-152.5%, respectively, over control with increasing rates (Table 3). The highest lateral root number and root volume (64.33 and 1.01ml) were recorded for application of coffee husk compost at the highest rate (18.75 g/pot) followed by the combined effect of 4 g/pot lime and 12.5 g/pot coffee husk compost which gave 64.33 and 0.94 ml lateral root number and root volume respectively, while the lowest (31.83 and 0.40 ml) lateral root number and root volume were observed from the control treatment (Table 3). The increased root growth of coffee seedlings because of lime and coffee husk compost amendment could be due to the reduced exchangeable acidity (Aluminium toxicity) and the compost improve physical conditions of soil that promote penetration with profound growth and development of the root systems. Also, lime and coffee husk compost amendment improved the nutrient availability of the soil which could be contributing for better root growth. This result was in line with Taye (1998), who reported coffee seedling grown on the different organic sources showed highly significant variations for all the root parameters considered, where by best responses were reported from treatment of decomposed coffee husk at Jimma, south west Ethiopia.

Table 3.The interaction effects of lime and coffee husk compost rates on root growth of coffee seedlings.

Treatment number	Treatment combination	Parameters			
		Tap root length (cm)	Lateral root length (cm)	Lateral root number	Root volume (ml)
1	0 g L + 0 g CHC (Control)	14.21[g]	3.18[i]	31.83[j]	0.40[g]
2	2 g L + 0 g CHC	16.35[f]	3.47[i]	36.36[i]	0.55[f]
3	4 g L + 0 g CHC	17.52[e]	4.30[h]	41.44[h]	0.61[def]
4	6 g L + 0 g CHC	17.89[de]	4.34[h]	41.67[h]	0.64[cdef]
5	0 g L + 6.25 g CHC	17.84[de]	4.51[gh]	44.75[gh]	0.60[ef]
6	2 g L + 6.25 g CHC	17.80[de]	5.05[fg]	47.58[fg]	0.69[cde]
7	4 g L + 6.25 g CHC	18.22[de]	5.03[fg]	50.78[ef]	0.71[cd]
8	6 g L + 6.25 g CHC	20.00[b]	6.33[bc]	57.64[cd]	0.74[c]
9	0 g L + 12.5 g CHC	18.63[cd]	5.12[efg]	48.92[f]	0.72[c]
10	2 g L + 12.5 g CHC	20.06[b]	6.51[bc]	63.63[ab]	0.86[b]
11	4 g L + 12.5 g CHC	21.44[a]	6.92[ab]	64.33[a]	0.94[ab]
12	6 g L + 12.5 g CHC	19.33[bc]	5.87[cd]	54.44[de]	0.70[cde]
13	0 g L + 18.75 g CHC	21.96[a]	7.16[a]	64.33[a]	1.01[a]
14	2 g L +18.75 g CHC	20.25[b]	6.90[ab]	61.75[abc]	0.94[ab]
15	4 g L + 18.75 g CHC	19.67[b]	5.71[de]	60.11[bc]	0.73[c]
16	6 g L + 18.75 g CHC	18.48[cde]	5.26[ef]	49.03[f]	0.70[cde]
DMRT (5%)		**	**	**	**
CV (%)		3.15	6.76	4.86	8.68

Key: - DMRT = Duncan's Multiple Range Test; L=Lime; CHC=Coffee husk compost; **=highly significant at $p \leq 0.01$; CV=Coefficient of Variation. Mean values followed by the same letters within a column are not different from each other at $p \leq 0.05$.

Shoot and root dry matter of coffee seedling

Leaf dry matter

Analysis of variance on coffee seedling leaf dry matter weight showed highly significant ($p \leq 0.01$) difference among the treatments. Accordingly application of lime without coffee husk compost produced a significant increase in leaf fresh and dry weight of coffee seedling with the magnitude of increment 25-108%, over the control with increasing lime rate (Figure 1). The results indicate that applying lime to the soil might considerably improve the nutrient availability, particularly phosphorus, since it improve soil pH under which maximum availability of the nutrient may be obtained. Similarly, application of coffee husk compost without lime increased coffee seedling leaf dry matter weight by 108.3-266.7%, over the control with increasing rate (Figure 1). The result was in line with Kasongo et al. (2013) who reported the application of coffee husk increased dry matter of rye grass on tropical acid soil. The highest leaf dry matter weight(0.44 g) was obtained from plots received the highest coffee husk compost rate without lime (18.75 g/pot) and followed by combined application of lime (4 g/pot) and coffee husk compost (12.5 g/pot) which gave 0.43 g leaf dry matter weight. While the lowest leaf dry weight (0.12 g) was obtained from untreated (control) plot (Figure 1). This could be due to the favorable chemical status of the media including increased organic carbon (organic matter), total nitrogen, available phosphorus and exchangeable bases contributed to better coffee seedling growth.

Stem dry matter

Application of lime and coffee husk compost and their interaction gave highly significance difference ($p \leq 0.01$) on stem dry weight (Figure 2). Accordingly, the highest stem dry weight (0.25 g) was obtained from plots received the highest coffee husk compost rate (18.75 g/pot) and followed by combined application of lime (4 g/pot) and coffee husk compost (12.5 g/pot) which gave 0.23 g stem dry matter weight. While the lowest stem dry weight (0.12 g) was obtained from untreated (control) plot (Figure 2). The results indicate that applying lime and compost to the soil might considerably improve the nutrient availability, particularly phosphorus since it improves soil pH under which maximum availability of the nutrient may be obtained and as a result, coffee seedling growth parameters were improved.

Root dry weight

The interaction of lime and coffee husk compost rates significantly affected ($p \leq 0.01$) root dry matter. The highest root dry matter weight (0.23 g) was obtained from plots received the highest coffee husk compost rate (18.75 g/pot) and followed by combined application of lime (4 g/pot) and coffee husk compost (12.5 g/pot) which gave 0.23 g/pot root dry matter weight (Figure 3). While the lowest root fresh and dry weight (0.57 and 0.09 g/pot) was obtained from untreated (control) plot (Figure 3). The significant effect obtained by the application of lime and compost on coffee seedling shoot and root dry matter weight could be because of more favorable chemical conditions of the media such as reduced Aluminum toxicity and increased nutrient availability which ultimately enhanced coffee seedling growth. Similar findings were reported by Taye (1998), Anteneh (2015) and Ewnetu et al. (2019) at Jimma, Southwest Ethiopia. Although the combination of lime up to 4 g/pot and coffee husk compost 12.5 g/pot significantly increased the coffee seedling growth, increasing lime and coffee husk compost rate in their combination above the mentioned rate (4 g/pot Lime and 12.5 g/pot coffee husk compost) retarded the coffee seedling growth.

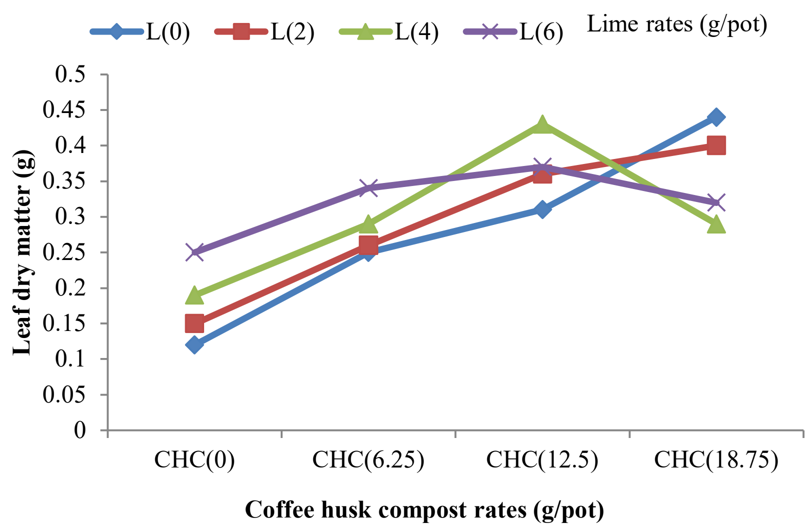

Figure 1. Interaction effects of lime and coffee husk compost rates on leaf dry weight of coffee seedlings.

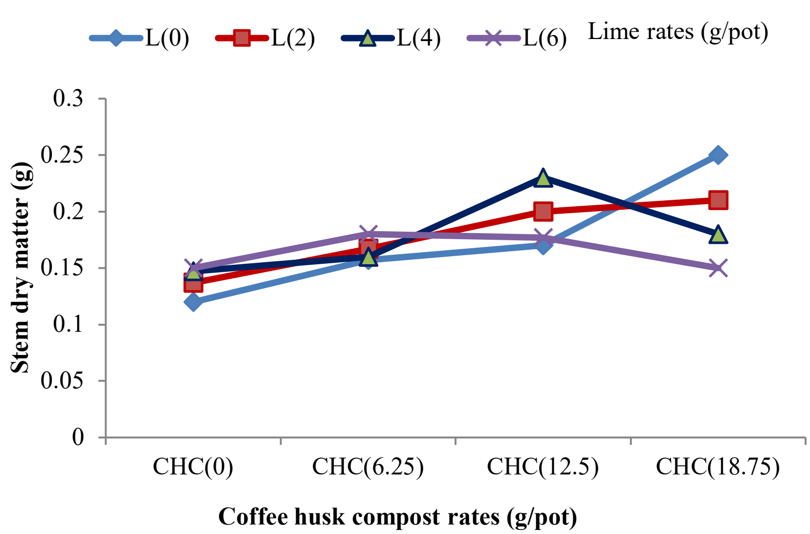

Figure 2. Interaction effects of lime and coffee husk compost rates on stem dry weight of coffee seedlings

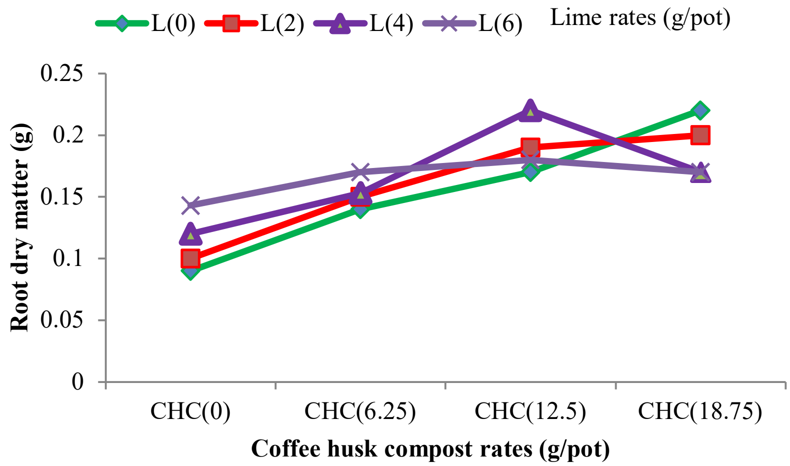

Figure 3. Interaction effects of lime and coffee husk compost rates on root dry weight of coffee seedlings

Also lime application on the highest coffee husk compost rate (18.75 g/pot) did not increased the shoot and root growth of coffee seedlings. This shows that the potential of the use of coffee husk compost to ameliorate soil acidity without lime as mentioned in the literatures (Kasongo et al., 2013; Nduka et al., 2015). As well as the reduction in shoot and root growth of coffee seedlings at increased rate of their combination attributed to a reduction in the solubility and availability of P to crops which might be caused by the formation of insoluble Ca-P compounds in the soil (Fageria and Baligar, 2008), to induced Fe, Mn, Zn and B deficiency (Fageria, 2009), to high level of Al in plant tissue and increased cation retention capacity of soil colloids and hence decreased availability of K and Mg (Fageria and Baligar, 2003). All these findings invariably illustrated that depending on the type of crop species, lime rates which only raise the pH to levels that neutralize exchangeable Al or reduced it to lower levels increase crop growth and yield.

Conclusion

In the evaluation of the response of coffee (*Coffea arabica* L.) seedlings growth following incorporation of agricultural lime and coffee husk compost amendments on acidic soil, the study found that application of lime and coffee husk compost rates and their interactions were enhanced shoot and root growth performances of coffee seedlings. Vigorous coffee seedlings were obtained by application of 18.75 g/pot coffee husk compost rate and combined application of lime (4 g/pot) and coffee husk compost (12.5 g/pot). Therefore this short-term study showed that a promising potential of coffee husk compost amendment alone or in combination with conventional lime to ameliorate soil acidity and improve nutrient availability for coffee seedling growth since it is easily available organic material in coffee producing areas.

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