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Exploring the Suitability of Coffee Pulp Compost as Growth Media Substitute in Greenhouse Production

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ABSTRACT

The current study was designed to evaluate (1) the feasibility of replacing commercial growing media with the different rates (0, 10, 50%) of coffee pulp compost on the height and above ground biomass of tomato in greenhouse bioassay and (2) the effect of top soil amendment with different rates (1, 5, 10% v/v) of coffee pulp composted with grass (CPCG) on the plant biomass of tomato in lath-house. Our results demonstrated that substitution of pro-mix by 10% coffee pulp compost significantly increased aerial biomass, seedling height and number of nodes per plant. Substitution of pro-mix with 10 and 50% coffee pulp compost increased seedling height by 20 and 4%, respectively, compared to pure pro-mix media. Unamended peat moss and peat moss substituted with lower rate (10%) of compost gave the lowest result in all response variables assessed. Top soil amended with 10% CPCG gave remarkably higher root fresh and dry weight and AGFW per pot compared with unamended top soil and top soil amended with 1% CPCG. In conclusion, substitution of Pro-mix media with coffee pulp compost up to 50% and amendment of top soil with 5 and 10% CPCG were found to be a good option for greenhouse/nursery tomato seedling production and field production of tomato, respectively. Furthermore, the possibility of managing coffee byproducts by utilization is demonstrated. However, the effects of substituting commercial growing media with different rates of coffee pulp compost on other commercially important crops worth investigation.

Key words: Byproduct, coffee, coffee pulp compost, peat moss, pro-mix, tomato

INTRODUCTION

Coffee is the second most traded commodity next to petroleum oil and the most widely consumed beverage worldwide (Vega, 2008). Ethiopia is the third largest Arabica coffee (*Coffeea arabica* L.) producer in the world (ICO, 2010) and coffee is still a major contributor to Ethiopian economy and plays a key role in the livelihood of about 1.5 millions of coffee growing households in Ethiopia. Over 15 million people depend directly or indirectly on coffee being involved in production, processing and marketing activities (Petit, 2007; Labouisse *et al*., 2008).

Following harvesting, coffee cherries need to be processed before use and/or marketing and this can be done via two methods: dry and wet methods of coffee processing. The by-products of coffee processing are mainly coffee pulp, processing effluent, parchment and coffee husks (Aranda *et al*., 2009). Endo-pectinase, an enzyme that catalyzes the breakdown of pectin substances, can be obtained from coffee pulp by the help of novel thermophilic fungi *Mycotypha* sp. Strain No. AKM 1801 (Venugopal *et al*., 2007). Because of their abundance, chemical composition and physical characteristics, coffee processing byproducts constitute a source of severe contamination and a serious environmental problem in Ethiopia and other coffee producing countries of the world. For instance, coffee byproducts of the wet method of processing such as pulp and mucilage constitute around 40% of the wet weight of the fresh fruit (Aranda *et al.*, 2009). These are commonly disposed by dumping into the natural water systems or pilling up onto nearby agricultural or grazing land in Ethiopia. Byproducts from dry processing (coffee husk) are usually pilled in the same way in nearby agricultural or grazing lands. Such ways of residue disposal have been the major health challenges to coffee farmers living in the surroundings of coffee processing plants. Moreover, such unsafe way of waste disposal has greatly affected terrestrial and aquatic biota. Hence, alternative ways of residue disposal that are safe to the environment and public health are highly needed in Ethiopia. However, the application of such disposal methods requires an understanding of the range of waste utilization, treatment and recycling options.

Composting of coffee by-products could be one mechanism of residue management by utilization. For instance, coffee by-products can be used as soil conditioner, organic fertilizer, mulch, animal feed, alcohol, biogas, caffeine, sugar, pectines, charcoal, heat energy, wax and acids (Mburu and Mwaura, 2006). Currently, there is huge interest from regional and federal government to convert these resources into usable end products such as compost and minimize environmental pollution. To this end, knowing the role of coffee byproducts' compost in greenhouse seedling or crop production has significance for their widespread use and better adoption by the end-uses.

Successful greenhouse and nursery production of container-grown plants is largely dependent on the physicochemical properties of the growing media (Grigatti *et al.*, 2007). Currently, most greenhouse floriculture industries in Ethiopia are introducing growing media such as cocopeat, peat moss and perlite from abroad. The cost and availability of these media are always great concern for commercial greenhouse producers. Besides, there has been increasing environmental and ecological concerns against the use of peat moss as its harvesting destroy endangered wetland ecosystems of the world (Ostos *et al.*, 2008). Likewise, the increasing concern in waste recycling worldwide promotes recycling and use of organic wastes and composts as soil amendments. This could be one of the wisest methods of solving the problem of waste disposal by utilization. Hence, in order to reduce costs and adopt more environmentally-friendly practices, study that explores alternative substrates is of great interest. Several alternatives have been proposed as partial substitute for peat by several workers including well-composted municipal solid waste and biosolid composts (Bugbee, 2002; Guerrero *et al.*, 2002; Ostos *et al.*, 2008). Compost, as organic fertilizer, plays a significant role in plant growth and development due to its high nutrient content and ability to improve the physicochemical properties of the soil to which they are applied (Grigatti *et al.*, 2007; Herrera *et al.*, 2008; Yadessa *et al.*, 2010). The feasibility of recycling coffee by-product as compost for use as a partial commercial growth media substitute in greenhouse and bedding plant cultivation and as source of nutrient to improve the growth and development of the plants of economic importance is clearly important. Studies have shown that properly composted organic residues such as urban solid wastes, sewage sludge and pruning waste can be used as growth media instead of peat (Garcia-Gomez *et al.*, 2002; Benito *et al.*, 2005). Several studies (Fitzpatrick, 2001; Sterrett, 2001) have analyzed the chemical, physical and biological properties of compost and confirmed its potential use in nursery plant production. According to Castillo *et al.* (2004), nursery grown tomato seedlings showed similar growth and development in mixture of perlite and municipal waste compost and standard peat mixture. Although a wide range of wastes have been investigated as potential substitute for commercial growing media such as peat, perlite, the potential use of coffee by products compost as alternative growing media substitute for nursery production of horticultural crops in Ethiopia is not yet documented. On the other hand, since there is no one standard growing medium recommended for all container growing crops under all growing conditions and each compost has its own quality and composition, it is crucial to determine the best quantity that ensure better growth and development of the crop under question. Hence, the objectives of the present study were (1) to explore the potential use of varying proportion of coffee pulp compost mixed with commercial substrates (Peat moss, Pro-mix), as growth medium substitute in the greenhouse or nursery production of tomato plant and (2) to assess the effect of top soil amendment with different rates of coffee pulp composted with grass on seedlings above and below ground biomass under lathhouse condition. To address these objectives, two independent experiments were executed. The first experiment was to see the potential of coffee pulp compost as a growth media substitute in greenhouse or nursery production and the second experiment was to assess the role of coffee pulp composted with grass in 1:1 (v/v) on seedling growth and development using tomato as a model plant.

MATERIALS AND METHODS

In order to investigate the role of coffee compost as a substitute and / or amendment of growth media, two separate experiments were conducted using tomato as a model plant. Experiment 1 was designed to investigate the feasibility of replacing commercial growing media by coffee pulp compost for the production of tomato seedlings in greenhouse while experiment 2 was designed to assess the effect of top soil amendment with different rates (1, 5, 10% v/v) of coffee pulp composted with grass (CPCG) on plant biomass in lath-house condition.

Experiment 1: Greenhouse experiment

Site description: The greenhouse experiment was conducted between July and August 2009 in the greenhouse facilities of the Environmental Sciences Department of Nova Scotia Agricultural College, Canada. The physical and chemical properties of coffee pulp compost prepared in Ethiopia were analyzed in the commercial soil analysis laboratory of the province of Nova Scotia, Truro, Canada.

Treatments and experimental design: In this study, a 2×3 factorial experiment in 4 blocks was executed to test the treatment effects. The factors were two levels of commercial growing media (pro-mix and peat moss) and three rates of coffee pulp compost (0, 10 and 50%) v/v. Both commercial growing media were obtained from Environmental Sciences Department of the Nova Scotia Agricultural College, Canada. They were initially purchased from commercial growing media producing company (Campbell J., Personal communication). Coffee pulp used for composting was obtained from a nearby coffee processing plant and transported to the composting site of Jimma University College of Agriculture and Veterinary Medicine (JUCAVM), Ethiopia and composted for 4 months following the common method practiced by farmers. Compost piles were turned twice at four weeks interval. The composted material was shipped to Nova Scotia Agricultural College, Truro, Canada. The physical and chemical properties of the compost used were presented in Table 2. One-liter pots with drainage holes at the bottom were used as experimental units. Six treatment combinations and a control, in total seven treatments were tested Table 1.

Pots were randomized and arranged on greenhouse tables. Three pots per treatment per replication were maintained. Initially three seeds per pot were sown and later thinned to one

Table 1: Potting mixtures used in the study

Treatment	Treatment combinations	Designation
1	100% Peat moss+ 0% coffee pulp compost	PM0
2	90% Peat moss + 10% coffee pulp compost	PM10
3	50% Peat + 50% coffee pulp compost	PM50
4	100% Pro-mix + 0% coffee pulp compost	PR0
5	90% Pro-mix + 10% coffee pulp compost	PR10
6	50% Pro-mix + 50% coffee pulp compost	PR50
7	Control (coffee pulp compost alone)	CP

Table 2: Physicochemical compositions of coffee pulp compost used as media substitute

Composition	Amount [a]
Dry matter (%)	95.813
Nitrogen (%)	2.635
Calcium (%)	0.980
Phosphorus (%)	0.153
P_2O_5 (%)	0.350
Potassium (%)	0.664
K_2O (%)	0.804
Magnesium (%)	0.214
Sodium (%)	0.018
Iron (PPM)	8810.991
Manganese (ppm)	636.498
Copper (ppm)	24.834
Zinc (ppm)	40.968
Boron (ppm)	23.314

[a]Triplicate samples were analyzed and average values are presented

seedling per pot. Seeds of tomato variety Scotia tomato were purchased from Halifax Seed Company (Halifax, Canada). Scotia tomato was is an open pollinated determinate cultivar that matures early (60 to 65 days from transplanting). Pots were uniformly watered twice per day for the first two weeks and once per day then after. Data were scored as average values of the three pots per treatment per replication. The response variables assessed were seedling height, number of nodes and above ground fresh and dry weight per pot and number of nodes. The experiment was repeated and average values of the two experiments were used for data analysis.

Experiment 2. Pot experiment

Site description: A pot experiment was conducted between September 2007 and January 2008 under lath-house condition at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM), Jimma, Ethiopia, located at 7°, 33'N and 360, 57'E at an altitude of 1710 m. Physical and chemical characteristics of the compost and the amended soils were analyzed at the Laboratory of Biological Farming Systems Groups, Wageningen University, The Netherlands.

Treatments and experimental design: The compost used to amend the top soil was prepared at the composting site of JUCAVM. The compost ingredients (coffee pulp and grass) were mixed in 1:1 (v/v) and composted to full maturity for 3 months following the common method practiced by farmers. Compost piles were turned twice at four-week intervals. Topsoil was dug from 0 to 20 cm depth from the agricultural lands to simulate actual field condition and transported to JUCAVM.

The soil was sieved using a 2 mm screen to remove soil clumps and roots before use. Three-liter pots with drainage holes at the bottom were used as experimental units.

The compost was added to topsoil at three rates (1, 5 and 10%) v/v. Non-amended soil was used as control. A total of four treatments were tested in completely randomized block design with seven replications. The pots were rotated twice per week to avoid unforeseen variation in the lathhouse. Seedlings of tomato cv. Heinz 1370 obtained from Melkassa Agricultural Research Center (Melkassa, Ethiopia) were grown following standard procedure in a field nursery and transplanted to each pot three weeks after sowing. Seven pots per treatment with two plants each were used to assess the effect of different rate of composted coffee pulp with grass on plant biomass. Watering was done using a hose with fine nozzles and pots were watered independently. Plant height, above ground fresh and dry weight per pot and root fresh and dry weight per pot were assessed two months after transplanting. The experiment was repeated once and average values of the two experiments were used for analysis.

Chemical and physical analysis of topsoil and compost: Plant available N-NO_3 and N-NH_4 were quantified according to Houba *et al.* (2000). Samples were extracted in 0.01 M $CaCl_2$ and analyzed using a segmented-flow system (Auto-analyzer II, Technicon, UK). Total N and organic C contents were determined using the Dumas Method with a CHN1110 Element Analyzer (CE Instruments, Italy). The pH was measured after 0.01 M $CaCl_2$ extraction using a pH/mV meter with a combined electrode (Houba and Novozamsky, 1998). Organic matter was determined by loss-on-ignition, i.e. by dry combustion of the organic material in a furnace at 500- 550°C so that the weight loss indicated the content of organic matter in the sample (Houba *et al.*, 1997). Electrical Conductivity (EC) was determined according to ISO 7888-1985 (water quality-determination of electrical conductivity) and ISO 3696-1987 (water for analytical laboratory use - specification and test methods). The C/N ratio was calculated from the total carbon and nitrogen contents. The physical and chemical compositions of the compost used are given in Table 3.

Statistical analysis: For each response variable, the validity of model assumptions was verified by examining the residuals as outlined in Montgomery (2008). Two phases of statistical analysis were employed in the case of greenhouse experiment. The first one involved determining whether the main and/or interaction effects of the fixed factors of interest were significant. The second one involved further analysis to compare means of the treatment combinations of significant interactions and main effect factors. In order to avoid the influence of unequal replications, data were analyzed in two phases, first as a 2×3 factorial in 4 blocks with the exclusion of control

Table 3: Physical and chemical characteristics of coffee pulp composted with grass and topsoil before mixing

Parameters	Composted coffee pulp with grass	Topsoil
OM (%)	47.6	13.6
PH ($CaCl_2$)	7.3	7.1
EC (uS cm^{-1})	2964.0	280.0
C (g kg^{-1})	259.4	42.3
N (g kg^{-1})	25.4	4.1
C/N	10.2	10.4
NO_3-N (mg kg^{-1})	1434.0	50.1
NH_4-N (mg kg^{-1})	19.4	4.5

[a]Duplicate samples were analyzed and average values are presented

treatment. Thus, the two levels of commercial media (pro-mix and peat moss) and coffee pulp compost at three levels (0, 10, 50%) were used as fixed factors of interest in the model. When the interaction effect of the fixed factors (media by rate) was significant ($p<0.05$), the response variables were subjected to one-way ANOVA analysis using GenStat for windows v 12 by including the control treatment. Fisher's protected least significant difference test was used to separate the means of significant fixed effects. In the pot experiment, one way ANOVA analysis was employed using GenStat for window V 12 to detect the differences among tested treatments. Then the means of significant variables were separated using Fisher's protected least significant difference test.

RESULTS

Greenhouse experiment

Effect of rate of coffee pulp compost on yield components: The effects of substituting commercial growth media with different proportions of coffee pulp compost on yield components and above ground biomass is presented in Table 4.

For seedling height per pot, two-way interaction between commercial media and rate of coffee pulp compost ($p<0.007$) and the main effects of media type ($p<0.001$) and rate of compost ($p<0.01$) were significant (Table 4). For number of node per pot, the interaction between media by rate of compost ($p\leq 0.008$) and the main effects of media ($p\leq 0.001$) and rate of compost ($p\leq 0.001$) were significant (Table 4). In the case of above ground fresh weight per pot, two-way interaction between media and rate of compost ($p<0.279$) and the main effect of rate of compost ($p<0.\ 279$) were not significant, but the main effect of media ($p\leq 0.001$) was significant. For above ground dry weight per pot, main effect of media ($p\leq 0.001$) was significant. However, the two-way interaction between media and rate of compost was marginally significant ($p<0.051$) whereas the main effect of rate of compost was not significant ($p<0.125$) (Table 4).

Effect of rate of coffee pulp compost on seedling height and number of nodes: There was no significant difference between unamended pro-mix and pro-mix substituted with 50% coffee pulp compost in influencing seedling height (Fig. 1). Pro-mix substituted with 10% coffee pulp compost gave higher (17 cm) seedling height than unamended pro-mix (14 cm). But, there was no significant difference between unamended pro-mix and pro-mix substituted with 50% compost. Substitution of pro-mix with 10 and 50% composted coffee pulp increased seedling height by 20 and 4%, respectively, compared to unamended pro-mix. There was no significant difference between 10 and 50% rate of compost in plant height and number of node per pot (Table 5).

Absence of significant difference between 10 and 50% rate of compost suggested the possibility of substituting commercial growing media by coffee pulp compost up to 50% to get comparable response.

Table 4: Mean square values of the main and interaction effects of media and its rate on plant height (PHt), above-ground fresh weight (AGFW), above-ground dry weight (AGDW) and number of nodes (NN) 35 days after sowing in greenhouse

Source of variation	df	Plant height	Number of node	AGFW	AGDW
Media	1	765.709**	33.8025**	11.6108**	0.724006**
Rate	2	11.062**	1.0556**	0.1498ns	0.012206ns
Media×Rate	2	12.469**	1.9321**	0.2176ns	0.019272ns
Residual	7	1.464	0.1296	0.1030	0.004732

**: Highly significant at $\alpha = 0.05$, Ns: Non significant at $\alpha = 0.05$, AGFW: Above ground fresh weight; AGDW: Above ground dry weight

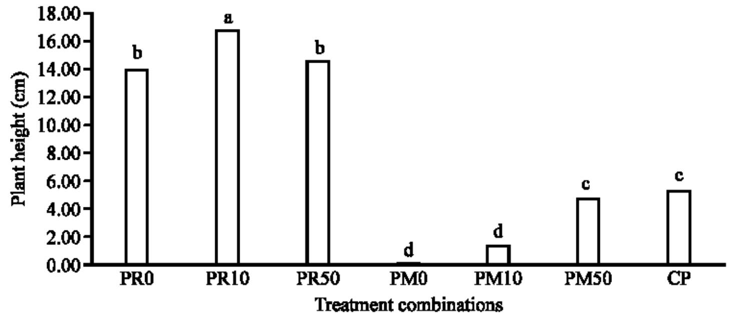

Fig. 1: Effect of treatment combinations: Composted coffee pulp (CP); 100% Pro-mix + 0% CP (PRO); 90% PR + 10% CP (PR10); 50% PR + 50% CP (PR50); 100% Peat moss +0% CP (PM0); 90% PM + 10% CP (PM10); and 50% PM + 50% CP (PM50) on seedling height 35 days after sowing. There was a significant difference among the treatments tested ($p \leq 0.001$). Means followed by different letters differ significantly ($p<0.05$) as established by Fisher's protected LSD-test

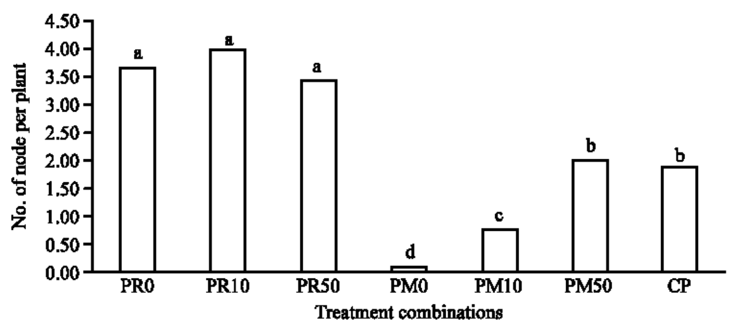

Fig. 2: Number of node as affected by different substrate mixtures 35 days after sowing. (CP = composted coffee pulp ; PR0 = 100% Pro-mix + 0% CP; PR10 = 90% PR + 10% CP; PR50 = 50% PR + 50% CP; PM0 = 100% Peat moss + 0% CP; PM10 = 90% PM + 10% CP and PM50 = 50% PM + 50% CP). There was a significant difference between the treatments tested ($p \leq 0.001$). Means followed by different letters differ significantly ($p<5\%$) as established by Fisher's protected LSD-test

Table 5: Effect of rate of coffee pulp compost on plant height and number of nodes 35 days after sowing

Rate of compost	Plant height (cm)	No. of nodes
0	7.06b	1.89b
10	9.02a	2.29a
50	9.64a	2.72a
LSD	1.556	0.4632

Means followed by different letters within the same column differ significantly ($p<5\%$) as established by Fisher's protected LSD-test

Substitution of commercial media with different rate of coffee pulp compost resulted in higher node number. Though pro-mix substituted with lower rate (10%) of compost still resulted in higher node number, there was no significant difference between pro-mix substituted with 10 and 50% coffee pulp compost and unamended pro-mix (Fig. 2), indicating the possibility of substituting pro-mix with coffee pulp compost up to 50% to achieve comparable seedling growth performance with pure pro-mix at reduced cost of production.

Substitution of coffee pulp compost seems to be more appropriate for pro-mix than peat moss in enhancing number of node per plant (Fig. 2). Composted coffee pulp alone resulted in better number of nodes than commercial peat moss and peat moss substituted with 10% compost. However, unamended peat moss gave the poorest result in all parameters assessed.

Effect of different proportion of composted coffee pulp substitution on above ground biomass: Higher above ground fresh (Fig. 3a) and dry weight (Fig. 3b) per pot was obtained by substituting of pro-mix with 10% coffee pulp compost than the rest of the tested treatments. There was no significant difference between unamended pro-mix and pro-mix amended with 50% coffee pulp compost.

Pot experiment

Effect of different proportions of coffee pulp composted with grass (CPGC) on biomass

Root fresh weight: There was a highly significant variation among treatments in case of root fresh weight per pot ($p<0.005$). Top soil amended with 10% (CPCG) gave higher root fresh weight (RFW) than top soil amended with 1% CPCG but there was no significant difference between control (unamended top soil) and top soil amended with 1% CPCG (Fig. 4). However, non-significant difference among treatments was observed in terms of plant height per pot.

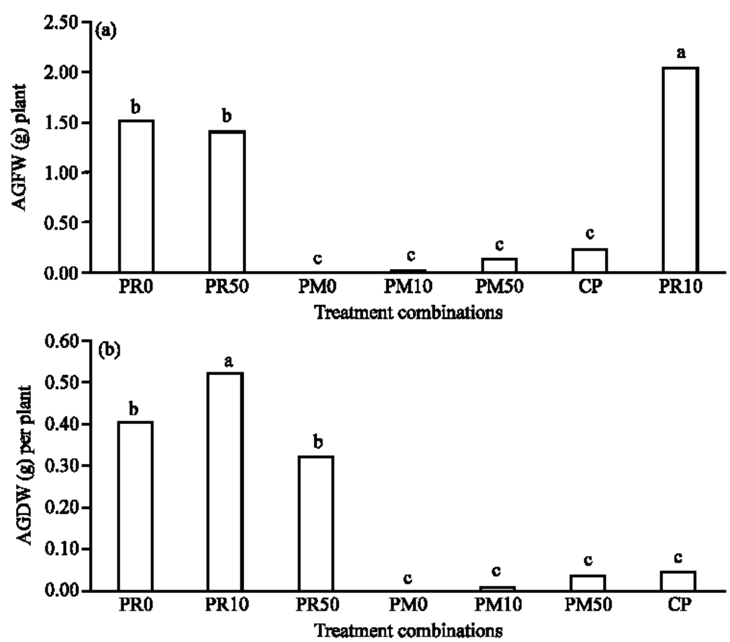

Fig. 3: Effect of different substrate mixtures on above ground fresh weight (a) and above ground dry weight (b) 35 days after sowing (CP = composted coffee pulp; PR0 = 100% Pro-mix + 0% CP; PR10 = 90% PR + 10% CP; PR50 = 50% PR + 50% CP; PM0 = 100% Peat moss + 0% CP; PM10= 90% PM + 10% CP and PM50 = 50% PM + 50% CP). There was a significant difference between the treatments tested ($p\leq0.001$). Means followed by different letters differ significantly ($p<5\%$) as established by Fisher's protected LSD-test (b)). AGFW= above ground fresh weight; AGDW = above ground dry weight

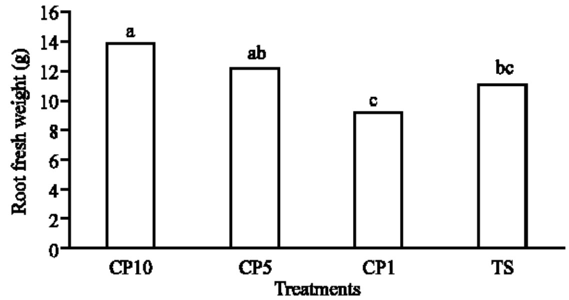

Fig. 4: Effect of top soil amendment with coffee pulp composted with grass on root fresh weight per pot two months after transplanting (CP1 = Top soil + 1% CPCG; CP10 = top soil + 5% CPCG; CPCG = top soil + 10% CPCG; TS = Top soil). There was a highly significant difference between the treatments tested ($p \leq 0.005$). Means followed by different letters differ significantly ($p<5\%$) as established by Fisher's protected LSD-test

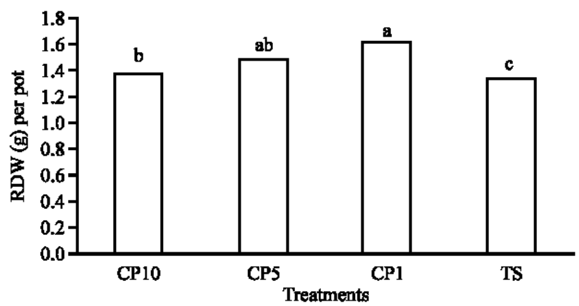

Fig. 5: Effect of topsoil amendment with different rates of coffee pulp composted with grass (CPCG) on root dry weight per pot two months after transplanting (CP1 = Top soil + 1% CPCG; CP10 = top soil + 5% CPCG; CPCG = top soil + 10% CPCG; TS = Top soil). There was a highly significant difference between the treatments tested ($p \leq 0.003$). Means followed by different letters differ significantly ($p<5\%$) as established by Fisher's protected LSD-test

Root dry weight: A highly significant difference ($p<0.003$) among treatments was observed in terms of root dry weight per pot. Higher root dry weight per pot was obtained on top soil amended with 10% CPCG compared to unamended soil (control) and soil amended with 1% CPCG (Fig. 5).

Above ground fresh and dry weight: Significant difference ($p<0.01$) among the tested treatments was observed in terms of above ground fresh weight (AGFW). Top soil amended with 10% CPCG gave remarkably higher AGFW compared to unamended soil and soil amended with 1% CPCG (Fig. 5). However, there was no significant difference between topsoil amended with 5% CPCG and 10% CPCG in terms of above Ground Fresh Weight (AGFW), Root Dry Weight (RDW) and Root Fresh Weight (RFW). On the other hand, non- significant difference among the tested treatments was observed in terms of above ground dry weight per pot.

DISCUSSION

Despite its merits, compost from coffee byproducts was not widely used in nursery and field production of crops and ornamental plants in Ethiopia. This study clearly showed that the

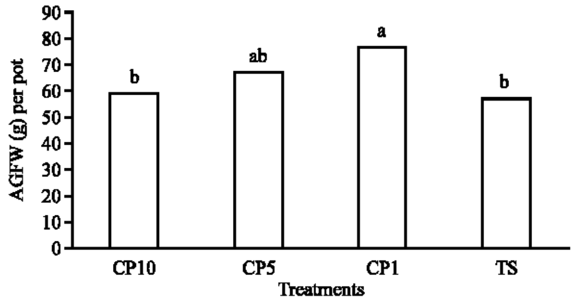

Fig. 6: Effect of topsoil amendment with different proportions of coffee pulp composted with grass (CPCG) on above ground fresh weight (AGFW) per pot two months after transplanting. (CP1 = Top soil + 1% CPCG; CP10 = top soil + 5% CPCG; CPCG = top soil + 10% CPCG; TS = Top soil). There was a highly significant difference between the treatments tested ($p \leq 0.01$). Means followed by different letters differ significantly ($p<5\%$) as established by Fisher's protected LSD-test

utilization of coffee pulp compost for commercial growing media (pro-mix and peat moss) substitution at nursery has proven to be useful method to obtain suitable growing media for tomato seedling production. Amendment of top soil with coffee pulp composted with grass improved physico-chemical properties of the amended soil thereby enhanced yield of tomato and the effects were rate dependent with the higher rate of coffee pulp composted with grass (CPCG) in top soil, the higher plant biomass (Fig. 4-6). Substitution of commercial growing media by coffee pulp compost increased seedling height in tomato plant, but the effects of the rates of compost were different depending on the amended substrate (Table 3). Seedling height increased with increased rate of compost substitution in peat moss but not in pro-mix media. Substitution of pro-mix with 10% coffee pulp compost gave higher seedling height than pro-mix substituted with 50% compost. This might be due to improvement in physicochemical and biological properties of the media following the application of compost. Previous studies indicated that amending agricultural soils and soilless growing media with organic matter such as compost supplies plant nutrients and improve physicochemical and biological characteristics (Veeken *et al*., 2005; Janvier *et al*., 2007; Lazcano *et al*., 2009; Yadessa *et al*., 2010). Atiyeh *et al*. (2000) and Hashemimajd *et al*. (2004) reported that addition of lower dose (up to 30%) vermicompost to potting media significantly increased growth and development of tomato plant in agreement with the findings of the present study.

Substitution of pro-mix by 10 and 50% compost produced significant increases in the number of node as compared to the other treatments, but the difference was small compared to unamended pro-mix (Table 3). A decrease in this parameter was observed with the lowest rate of compost (10%) in peat moss media even compared to control (compost alone) (Fig. 1). Unamended peat moss and peat moss substituted with lower rate (10%) of coffee pulp compost gave the poorest result in all response variables assessed. This could be attributed to poor nutrient composition of peat moss media. Upon application of the adequate rate (50%) in this experiment, significant improvements in plant growth were observed as compared to the pure peat-moss media substantiating the poor nutrient content of peat moss to support plant growth and development. Peat is usually included in potting media mix to increase the water-holding capacity or to decrease the weight. Peat moss is the least decomposed form of the peat types characterized by lightweight, high in moistureholding capacity and very acidic (pH 3.8 to 4.3). The significantly lower growth of seedling in unamended peat moss and almost complete inhibition of seedling germination could be due to lower pH of the media as compared to crop requirement which is in the range of 6- 6.8 (Jones, 2007). The higher nutrient content of coffee byproducts' compost as compared to peat moss could allow the reduction of the mineral fertilizers used and hence reducing the expenses of the nursery operations.

Replacement of the commercial growing media with different rates of coffee pulp compost enhanced above ground biomass production in tomato seedling. Substitution of pro-mix by 10% coffee pulp compost produced significant increases in aerial biomass. This could be due to improvement in physicochemical and biological properties of the media following compost application. Similar increment in above ground biomass in tomato seedling was observed in the study of Lazcano *et al.* (2009) when peat-based substrate is amended with compost or vermicompost prepared from municipal solid wastes.

Congruent to our expectation, effects of CPCG on biomass of the tomato plant were realized. Top soil amended with 10% CPCG gave remarkably higher root fresh and dry weight and AGFW per pot compared with unamended top soil and top soil amended with 1% CPCG (Fig. 4, 5), indicating the potential use of coffee byproducts composted with grass as alternative bio-fertilizer source in tomato production. There was no significant difference between topsoil amended with 5% and 10% CPCG in terms of root dry weight, root fresh weight and above ground fresh weight per pot confirming rate dependent effect of compost application with higher rates (5 and 10%) of the compost used being the best in enhancing plant biomass per pot in the current study. These enhancing effects could be due to improvement in physico-chemical properties of the amended soil to the advantages of crop growth. Abbasi *et al.* (2002) reported a 33% increase in marketable yield of tomato due to compost addition. The yield increment in the study of Abbasi *et al.* (2002) was rate-dependent with the higher compost rate increasing fruit yield more compared to the unamended control. Enhancing effect of FYM (farm yard manure) compost at 5 and 10% on tomato yield was also reported by Yadessa *et al.* (2010). Similarly, Azarmi *et al.* (2008) reported significant increment in tomato yield following application of vermicompost at rate of 15 t ha^{-1}. Generally, our results indicated that amending topsoil with different rates of CPCG can enhance plant biomass, with higher CPCG rates being the most effective except 1% CPCG.

In conclusion, the use of coffee pulp compost constitute a good alternative to the use of peat moss and pro-mix in plant nurseries due to the environmental benefits involved and the observed improvement in tomato seedling growth in this study, hence replacement of commercial growing media for the production of tomato seedlings in nurseries (greenhouse) by coffee pulp compost is plausible. Application of higher rate of coffee pulp compost to peat moss and lower does to pro-mix media greatly improved seedling growth compared with the pure peat moss and pro-mix based substrate, respectively. This study also demonstrated the possibility of residue management by utilization. Moreover, given the high cost of pro-mix media, abundant availability of coffee byproducts in Ethiopia and the comparable results demonstrated in the current study between pure pro-mix and pro-mix substituted with higher rate (50%) of coffee pulp compost (Table 5), substitution of pro-mix media with coffee pulp compost up to 50% would be good option for greenhouse/nursery tomato seedling production. Application of 10% coffee pulp composted with grass to agricultural soil can enhance yield of tomato and reduce dependence on commercial fertilizers which are not eco-friendly. Application of CPCG at 5 and 10% were best in enhancing biomass of tomato plant and would be good rates of compost application rate in field tomato production. However, the effects of substituting commercial growing media with different rates of coffee pulp compost on other commercially important crops need to be investigated. For wider adoption of the use of coffee by-product compost in the farming practices of the country, alternative technologies that possibly reduce the lengthy composting time requirement of coffee pulp compost such as vermicomposting, Effective Microorganism (EM) technologies needs to be explored.

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REFERENCES

Abbasi, P.A., N. Soltani, D.A. Cuppels and G. Lazarovits, 2002. Reduction of bacterial spot disease severity on tomato and pepper plants with foliar applications of ammonium lignosulfonate and potassium phosphate. Plant Dis., 86: 1232-1236.

Aranda, E.D., L.O. Duran and E.P. Escamilla, 2009. Vermicomposting in Coffee Cultivation. In: Coffee: Growing, Processing, Sustainable Production, Wintgens, J.N. (Ed.). Wiley-VCH, Weiheim, pp: 25-55.

Atiyeh, R.M., N. Arancon, C.A. Edwards and J.D. Metzger, 2000. Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes. Bioresour. Technol., 75: 175-180.

Azarmi, R., P.S. Ziveh and M.R. Satari, 2008. Effect of vermicompost on growth, yield and nutrition status of tomato (*Lycopersicum esculentum*). Pak. J. Biol. Sci., 11: 1797-1802.

Benito, M., A. Masaguer, R. De Antonio and A. Moliner, 2005. Use of pruning waste compost as a component in soil-less growing media. Bioresource Technol., 96: 597-603.

Bugbee, J.G., 2002. Growth of ornamental plants in container media amended with biosolids compost. Comp. Sci. Utili., 10: 92-98.

Castillo, J.E., F. Herrera, R.J. Lopez-Bellido, F.J. Lopez-Bellido, L. Lopez-Bellido and E.J. Fernandaze, 2004.. Municipal solid waste (MSW) compost as a tomato transplant medium. Compost. Sci. Util., 12: 86-92.

Fitzpatrick, G.E., 2001. Compost Utilization in Ornamental and Nursery Crop Production System. In: Compost Utilization in Horticultural Crooping Systems, StoVella, P.J. and B.A. Kahn (Eds.). Lewis Publication, Boca Raton, FL, pp: 135–150.

Garcia-Gomez, A., M.P. Bernal and A. Roig, 2002. Ornamental plants growth in substrates using composts from agroindustrial wastes. Bioresour. Technol., 83: 81-87.

Grigatti, M., M.E. Giorgonni and C. Ciavatta, 2007. Compost-based growing media: Influence on growth and nutrient use of bedding plants. Bioresource Technol., 98: 3526-3534.

Guerrero, F., J.M. Gasco and L. Herna´ndez-Apaolaza, 2002. Use of pine bark and sewage sludge compost as components of substrates for Pinus pinea and *Cupressus arizonica* production. J. Plant Nutr., 25: 129-141.

Hashemimajd, K., M. Kalbasi, A. Golchina and H. Shariatmadari, 2004. Comparison of vermicompost and composts as potting media for growth of tomatoes. J. Plant Nutr., 27: 1107-1123.

Herrera, F., J.E. Castillo, A.F. Chica and L. Lopez-Bellido, 2008. Use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Bioresource Technol., 99: 287-296.

Houba, V.J.G., J.J. van der Lee and I. Novozamsky, 1997. Soil Analysis Procedures, Other Procedures (Soil and Plant Analysis, part 5B). Wageningen Agricultural University, The Netherlands, pp: 38-40.

Houba, V.J.G. and I. Novozamsky, 1998. Influence of storage time and temperature of dry soils on pH and extractable nutrients using 0.01 mol/l CaCl2. Fresenius J. Anal. Chem., 360: 362-365.

Houba, V.J.G., E.J.M. Temminghoff, G.A. Gaikhorst and W. van Vark, 2000. Soil analysis procedure using 0.01M calcium chloride as extraction reagent. Commun. Soil Sci. Plant Anal., 31: 1299-1396.

ICO, 2010. Coffee market report. Letter from the Executive Director.

Janvier, C., F. Villeneuve, C. Alabouvette, V. Edel-Hermann, T. Mateille and C. Steinberg, 2007. Soil health through soil disease suppression: Which strategy from descriptors to indicators? Soil Biol. Biochem., 39: 1-23.

Jones, J.B., 2007. Tomato Plant Culture: In the Field, Greenhouse and Home Garden. 2nd Edn., CRC Press, New York.

Labouisse, J.P., B. Bellachew, S. Kotecha and B. Bertrand, 2008. Current status of coffee (*Coffea arabica* L.) genetic resources in Ethiopia: Implication for conservation. Genet. Resour. Crop Evol., 55: 1079-1093.

Lazcano, C., J. Arnold, A. Tato, J.G. Zaller and J. Dominguez, 2009. Compost and vermicompost as nursery pot components: Effects on tomato plant growth and morphology. Spanish J. Agric. Res., 7: 944-951.

Mburu, J.K. and P. Mwaura, 2006. Opportunities and constraints of coffee by-product utilization. Kenya Coffee (Kenya), 61: 2237-2245.

Montgomery, D.C., 2008. Design and Analysis of Experiments. 7th Edn., John Wiley and Sons, New York, USA.

Ostos, J.C., R. Lopez-Garrido, J.M. Murillo and R. Lopez, 2008. Substitution of peat for municipal solid waste- and sewage sludge-based composts in nursery growing media: Effects on growth and nutrition of the native shrub *Pistacia lentiscus* L. Bioresour. Technol., 99: 1793-1800.

Petit, N., 2007. Ethiopias coffee sector: A bitter or a better future. J. Agrarian Change, 7: 225-263.

Sterrett, S.B., 2001. Compost as Horticultural Substrates for Vegetable Transplant Production. In: Compost Utilization in Horticultural Crooping Systems, StoVella, P.J. and B.A. Kahn (Eds.). Lewis Publication, Boca Raton, FL, pp: 227–240.

Veeken, A.H.M., W.J. Blok, F. Curci, G.C.M. Coenen, A.J. Termorshuizen and H.V.M. Hamelers, 2005. Improving quality of composted biowaste to enhance disease suppressiveness of compost-amended, peat-based potting mixes. Soil Biol. Biochem., 37: 2131-2140.

Vega, F.E., 2008. The rise of coffee. Am. Sci., 96: 138-145.

Venugopal, C., T. Jayachandra and K.A. Anu Appaiah, 2007. Effect of aeration on the production of endo-pectinase from coffee pulp by a novel thermophilic fungi *Mycotypha* sp. strain No. AKM 1801. Biotechnology, 6: 245-250.

Yadessa, G.B., A.H.C. van Bruggen and F.L. Ocho, 2010. Effect of different soil amendments on bacterial wilt caused by *Ralstonia solanacearum* and on the yield of tomato. J. Plant Pathol., 92: 429-440.