World Journal of Agriculture & Soil Science WJASS

ISSN: 2641-6379

World Journal of Agriculture and Soil Science

DOI: 10.33552/WJASS.2022.08.000678

Iris Publishers

Research Article

Effects of Pot Sizes and Biochar Base Media Composition on Nutrient Uptake of Coffee (*Coffea arabica L.*) Seedlings in South Ethiopia

Leta Ajema[1]*, Gezahegn Berecha[2] and Taye Kufa[3]

[1]*Ethiopia Institute of Agricultural Awada Agriculture Research Sub-Center Yirgalem, Ethiopia*

[2]*Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia*

[3]*Ethiopia Institute of Agricultural Jimma Agriculture Research Center Jimma, Ethiopia*

***Corresponding author:** Leta Ajema, Ethiopia Institute of Agricultural Awada Agriculture Research Sub-Center Yirgalem, Ethiopia.

Received Date: June 07, 2022

Published Date: June 15, 2022

Abstract

Modern coffee farming is essentially based on the production of quality seedlings with the desirable shoot and root growth mainly determined by nutrient uptake of the seedlings. Therefore, this study was conducted to evaluate the effects of pot size and biochar-based media composition on the nutrient uptake of coffee seedlings. The experiment was laid out in a factorial experiment arranged in RCBD with three replications. The treatment combination included four levels of pot size (P1=7x13cm, P2=10x16cm, P3=13x19cm and P4=16x22cm) and five biochar to topsoil ratios (0:1, 1:1, 1:2, 1:3, and 1:4 v/v). All soil and seedling leaf tissue laboratory results were computed using SAS software and treatment means separation was compared using LSD at 5%. The results revealed significant variation in seedling nutrient uptake due to treatments and their interaction effects. Nitrogen uptake of the seedlings treated by 13x19cm pot size and one to three ratios of biochar to topsoil was increased by 58.00% over the farmers practice representing treatment. Phosphorus uptake of the seedling raised in 16x22cm pot size with 2g DAP/pot and one to three biochar to topsoil ratio were increased by 46% and 43% over the local control, respectively. Potassium uptake of the seedling raised in 16x22cm pot size with one to three biochar to topsoil ratio was increased by 180.00%, over the local control, respectively. Therefore, nutrient uptake of the seedling through the use of biochar as a fertilizer at a lower rate provides alternative enhancement media options to coffee seedling growth.

Keywords: Biochar-ratio; Coffee seedling; Interaction effects; NPK; Pot size

Introduction

The imperative aspect of coffee cultivation begins with the production of coffee seedlings with desirable characteristics under the recommended nursery management practices. Coffee seedling production could be bare rooted and/or in a pot with the subsequent advantages of growing seedlings as the seedlings grow faster, field establishment is also faster and survival rate is higher than that of the bare root. Therefore, pot size (16cm x 22cm) with forest soil was recommended as a practical guide. The growth medium like forest soil was extremely important that, play a great role in terms of seedling growth and quality while a widespread soil quality decline caused by increasing population based on natural resources, and climate changes [1] are the major challenge to get the forest soil appropriate to growth media. Biochar is considered as a soil conditioner and a carrier for nutrients, [2] that its applications can increase the contents of ammonium (NH_4^+), and nitrate (NO_3^-), and enhanced the soil microorganism and enzymatic activities [3]. Application of biochar has also been reported as it can increase crop yield, soil microbial biomass, plant tissue potassium (K) concentration, soil P and K, total soil C and N [4].

Nitrogen is important for plant growth and development. The shoot and root extension seedling growth and its destructive parameters were significantly increased with the addition of P and rate as compared to no application of P for coffee seedlings [5]. It promotes both shoot and root growth and their respective fresh and dry weight of coffee seedlings [6]. It is important in the rooting of young coffee seedlings and a sufficient quantity of phosphorus is required for optimum growth of coffee seedlings [7]. Coffee plants also need potassium nutrients for their growth [8] that which has an irreplaceable part to play in the activation of enzymes, which are fundamental to metabolic processes especially the production of proteins and sugars. Currently, coffee seedling production is eagerly expanding due to the growing local and international coffee market. The seedling growers are using three to one (3:1) blends of topsoil to compost while the seedling growth is still stunted growth (thin internode length, and narrow-leaved seedlings, poor performance). Coffee seedling producers were not able to transport a large number of seedlings to the market and field, as it needs to transport 2.5kg of soil per seedling, and farmers are forced to transact on-farm, which in turn can limit the number of buyers by distance, location accessibility and total benefit of producers [9]. Others are using the smaller sizes not yet tested to minimize time and labor demand and cost of transport. Therefore, this study was conducted to assess the effects of pot size and biochar-based media composition on the nutrient uptake of coffee seedlings before transplanting at the Awada Research sub-center nursery site.

Materials and Methods

Description of the Study Area

The study was conducted at Awada Agricultural Research Sub-Center. The area has a semi-bimodal rainfall distribution with an average precipitation of 1354 mm per annum, while the annual average minimum and maximum air temperatures are 6^0C and 28.8^0C, respectively. The major soil type of the center is nitisol [10].

Biochar, Topsoil, and compost preparation

Biochar was prepared from coffee husk at AARSC. The dried husk was filled into the smaller barrel. The barrel filled with husk was inverted in the large barrel to minimize the oxygen and facilitate the pyrolysis process. The resulting biochar material was grounded and sieved through a 2mm square-mesh sieve to have the same particle sizes as the topsoil used for the experiment. Topsoil was collected from the surface of cultivable lands at 0-15cm depth, dried and crushed by pestle and mortar, and sieved with a two mm square-mesh sieve to have a smaller particle size. Compost was also prepared from locally available materials such as maize straw, ash, and farmyard manure, following the conventional compost preparation method. The nursery media adopted by farmers in the study area was prepared by mixing topsoil and compost in a three to one (3:1) ratio [11]. The media was thoroughly mixed with biochar following the adjusted ratio for each treatment.

Experimental design and treatment combinations

The experiment was conducted with a factorial experiment arranged in RCBD with three replications to provide estimates of the effects of treatment. Twenty four (24) treatment combinations with four levels of pot size (width by height) (P1 = 7cm x13cm, P2 = 10cm x 16cm, P3 = 13x19 cm and P4 = 16 x 22cm) and five levels of biochar to topsoil (0:1, 1:1, 1:2, 1:3, 1:4) by (v/v) ratios were used for the treatment. The conventional pot (16x22 cm) filled with topsoil with 2gDAP was used as a standard control, while topsoil alone in the same size (16x22cm) was used as local control.

Data collection

Physico-Chemical properties of soil and biochar: Topsoil and biochar samples were separately subjected to physical and chemical analysis. The pH of each treatment sample was measured by using a 1:2.5 ratio of water suspension method with a pH meter and Soil Organic Matter (SOM) was analyzed by wet digestion method [12], and the percent of organic carbon was obtained by dividing percent soil OM by a factor of 1.724, following the assumption that SOM is composed of 58% carbon [13]. Total nitrogen was analyzed using the Kjeldahl method [14]. Potassium was analyzed by using the Ammonium acetate extraction method and available phosphorus was determined by the Olsen methods [15].

Leaf tissue analysis: The leaf analysis was done when the seedling attained the normal transplanting stage. The central coffee seedlings in each plot were used to collect healthy leaves and prepare to determine the major plant nutrients (N, P, and K). The fourth pair of leaves were collected from sample seedlings from each plot. The collected leaf samples were packed and placed between two sheets of blotting paper. The leaves were oven-dried at 700C until the constant weight was attained. Then the leaf was ground with a stainless-steel mill to pass through a 1.5 mm sieve. Sulfuric acid and 30% hydrogen peroxide were used for analysis. The total nitrogen was analyzed by using the Kjeldahl method [13]. The Kjeldahl procedure is based on the principle that treating plant material with concentrated oxidized sulfuric acid and nitrogen in the plant material is being converted into ammonium sulfate during oxidation. The ammonia liberated in the distillation process with NaOH is trapped by the acid. The ammonia is adsorbed in the form of NH_4^+ ion in boric acid and back titrated with standard H_2SO_4.

Available phosphorus was determined by the Olsen method used for both acid and non-acid soils [15]. Determination of phosphorus is carried out on the digest a liquor obtained through calibration or wet digestion. Phosphorus in the solution is determined calorimetrically by using molybdate and metavanadate for color development. The potassium content of the soil and seedling leaves were (cmolkg^{-1}) assessed by the ammonium acetate method using flame photometer [13]. The K in the sample digest wet digestion was determined by flame photometer. The sample is neutralized into the flame where it is vaporized; potassium and sodium compounds are atomized and the potassium and sodium atoms thus formed are measured at wavelengths of 766.50 and 589.0nm, respectively. The nutrient uptakes were calculated as the product of the nutrient concentration and dry matter yield of the coffee seedlings as described by [16]. Accordingly, the leaf N, P, and K uptakes were obtained by multiplying the nutrient concentration of the leaf dry matter.

Results and Discussion

Physico-Chemical properties of topsoil and biochar

Table 1: Selected physicochemical properties of experimental topsoil and biochar.

S.N	Parameter	Topsoil	Biochar
1	Sand (%)	63	-
2	Clay (%)	26	-
3	Silt (%)	11	-
4	pH (H_2O)	4.82	11.26
5	Organic carbon (%)	2.81	5.24
6	Organic matter (%)	4.84	9.04
7	Total Nitrogen (%)	0.31	0.35
8	Available phosphorus (ppm)	19.03	353.3
9	C:N ratio	9.1	14.77

The initial soil characterizations result showed that the sand, clay and silt content of the soil were 63%, 26% and 11%, respectively (Table 1). The soil has a pH of 4.82 while biochar has a pH of 11.26 thus, the soil reactions fall under strongly acidic and biochar considered as moderately alkaline [17]. Therefore, under very acidic conditions, the soil solution might be occupied by aluminum and hydrogen ions which has a direct effect on plant growth by suppressing the root development and reducing the availability of macronutrients to plants especially phosphorus, which is readily available under medium pH range [18]. The results of present study were almost in line with the findings of [19], who reported a pH of 4.90 acidity status of Awada research sub-center. Total nitrogen, organic carbon, and available phosphorus contents of the topsoil were 0.31%, 2.81%, and 19.03ppm, respectively. Total nitrogen, organic carbon, and available phosphorus of biochar were 0.35%, 5.24%, and 353.30 ppm, respectively. The C:N ratios of topsoil and biochar were also 9.09 and 14.77, respectively (Table 1).

Chemical properties of potting media

At the end of the experiments, the result of soil laboratory analysis indicated that amendment of topsoil with biochar was found to increase the pH of the soil from 4.74 to 7.42, which was from strongly acidic to alkaline condition with the higher (one to one) ratio of biochar to topsoil (Table 2). The pH range of 5.3-6.5, 4.5-5.2/6.6-7.0, and 4.2-4.44/7-7.5 has been classified as highly, moderately, and marginally suitable in coffee production, respectively [20]. Therefore, the suitability status of the potting media ranged from highly to moderately suitable conditions. Application of 2gDAP/seedlings (used as the standard control) increased phosphorus contents of the media with increasing biochar application ratios (Table 2). The percentage of total nitrogen and potassium content of the potting media increased with the application of biochar to topsoil (Table 2). The nitrogen content of the media increased from 0.33% for topsoil alone to 0.49% for a higher (one-to-one) ratio of biochar to topsoil. The potassium content of the soil also increased from 0.45 $Kgcmolk^{-1}$ for the topsoil to 1.150 $Kgcmolk^{-1}$ due to applications of biochar to topsoil at a 1:1(v/v) ratio (Table 2). This could probably be due to the increased nitrogen and potassium contents added with biochar and a decrease in the rate of nitrogen leaching from the soil during watering due to the nutrient retention capacity of biochar. This result is in line with the study of [21] which indicates biochar increased the soil nitrogen content. [22], stated that biochar addition to topsoil leads to a decrease in nitrogen leaching from the soil profile at a higher rate. It has also been reported that biochar has an indirect influence on soil nitrogen concentration, through a change in microbial communities. The soil microorganisms play a leading role in the ammonification process of nitrate (NO_3^-) to ammonium (NH^4_+) reducing nitrogen losses by leaching or gaseous fluxes [22] and the application of biochar increased the availability of N, P, K, Ca, and Na in the soil. Authors have also observed that, the cation exchange capacity (CEC) of soil, which is a measure of how well some nutrients (cations) are bound to the soil, and available for plants uptake and prevented from leaching to ground and surface waters, increased with biochar ratio.

Table 2: Selected physicochemical properties of experimental topsoil and biochar.

Treatments	pH	%N	Pppm	Kcmol/kg	Treatments	pH	%N	P ppm	Kcmol/kg
P_1B_0Ts	5	0.39	17.88	0.8	P_3B_0Ts	5.1	0.33	14.15	0.83
P_1BT_{s1}	7.24	0.48	33.86	1.05	P_3BT_{s1}	7.3	0.47	33	0.99
P_1BT_{s2}	7.1	0.45	31.25	1.01	P_3BT_{s2}	7.07	0.46	28.52	1.14
P_1BT_{s3}	5.83	0.42	22	0.96	P_3BT_{s3}	6. 20	0.44	29.37	1.03
P_1BT_{s4}	6.14	0.44	22	0.96	P_3BT_{s4}	5.65	0.46	28.36	1.06
P_1BT_{s5}	4.74	0.38	71.09	0.45	P_3BT_{s5}	4.86	0.36	52.89	0.69
P_2B_0Ts	4.95	0.38	12.03	0.64	P_4B_0Ts	4.9	0.37	18	0.79

P_2BT_{s1}	7.41	0.49	35	1.05	P_4BT_{s1}	7.42	0.48	36	1.15
P_2BT_{s2}	7.05	0.39	18.57	0.83	P_4BT_{s2}	7.19	0.45	33.41	1.04
P_2BT_{s3}	6.14	0.44	24	1.03	P_4BT_{s3}	6.4	0.41	22.67	0.86
P_2BT_{s4}	7.05	0.47	34.26	0.98	P_4BT_{s4}	6.96	0.44	23	0.7
P_2BT_{s5}	5.02	0.42	68.74	0.48	P_4BT_{s5}	4.73	0.36	71.25	0.63

P_1, P_2, P_3, P_4=Pot size (7x13, 10x16, 13x19, 16x22) cm in width to height, respectively. B_0TS = No biochar or Topsoil only, BT_{s1} = one to one biochar to topsoil ratio BT_{s2} = one to two biochar to topsoil ratio, BT_{s3} = one to three biochar to topsoil ratio, BT_{s4} = one to four biochar to topsoil ratio, BT_{S5} = Topsoil plus 2g DAP per pot.

Nutrient uptake of coffee seedlings

Nitrogen uptake: Nitrogen uptake of the seedling was significantly (P=0.044) affected by the interaction of pot size and biochar to topsoil ratio. The highest nitrogen uptake (12.11mg plant^{-1}) was obtained from the largest 16x22 cm pot size with a one to three biochar to topsoil ratio. Similarly, those plots treated with 16x22cm, 13x19cm, and 10x16cm and interacted with one to three and one to four biochar to topsoil ratio and 2g DAP/pot were able to produce significantly higher and statically similar with the largest value (Table 3). The lowest nitrogen (4.58mg plant^{-1}) uptake was obtained from the interaction effects of 7x13cm pot size and the one-to-one ratio of biochar to topsoil (Table 3). Nitrogen uptake of the seedlings treated by 13x19cm pot size and one to three ratios of biochar to topsoil was increased by 58.00% over the farmer's practice representing treatment (Table 3). The result showed that biochar applied as a fertilizer, at a lower ratio was enhanced the nitrogen use efficiency of coffee (*Coffea arabica L.*) seedling. In line with this, it has been reported that biochar is an opportunity to improve soil fertility and nutrient use efficiency [23]. Biochar plays a leading role in the ammonification of nitrate (NO_3^-) to ammonium (NH_4^+), reducing nitrogen losses [24]. Although the soil analysis result indicated that the nitrogen content increased with increased biochar to topsoil ratio (Table 2), the carbon contents of the media were also increased. At the optimum (one to three) supply of biochar as a fertilizer, nitrogen in the substrate might be easily available for coffee (*Coffea Arabica L.*) seedlings and thereby, promoting nitrogen uptake and growth of leaf that enhancing the total plant growth. As biochar addition increased, total nitrogen increased from 0.33% to 0.49%. However, the nitrogen immobilization might occur with increasing biochar ratios due to the increased C: N. The findings have shown an increase in the soil's total carbon from 2.27% to 2.78% and total nitrogen from 0.24% to 0.25% with biochar addition. However, the microbial nitrogen immobilization with a C: N ratio of biochar occurs above 8:1 [24]. Furthermore, an increase in the soil total nitrogen added from the coffee husk biochar might not indicate nitrogen availability to plants. Hence, the increase in the C: N ratio with increasing ratios of biochar could possibly be high enough to immobilize nitrogen thereby limiting nitrogen availability to coffee seedlings. Other research shows that biochar addition improves the retention capacity of ammonium (NH_4^+) nitrogen through enhanced CEC [25]. However, the adsorption of inorganic nitrogen onto biochar surfaces could decrease ammonia and nitrate losses from the soil but could as well potentially lead to the slow release of these nutrients to plants [26]. This trend of biochar can be used fully for perennial crops like coffee plantations.

Table 3: Leaf nitrogen (mg) uptake of coffee seedling as affected by biochar ratio and pot size.

Biochar to Topsoil Ratio	Pot Size (cm)			
	7x13	10x16	13x19	16x22
Topsoil	6.32^{f}	6.32^{f}	7.50^{ed}	7.66^{ed}
1BC:1TS	4.58^{g}	5.16^{g}	6.32^{f}	7.37^{ef}
1BC : 2TS	7.37^{ef}	7.36^{ef}	8.50^{cd}	9.66^{b}
1BC:3TS	9.33^{bc}	11.47^{a}	12.10^{a}	12.11^{a}
1BC : 4TS	9.23^{bc}	9.66^{b}	11.48^{a}	11.56^{a}
Ts+2gDAP	9.50^{bc}	11.45^{a}	11.63^{a}	12.10^{a}
CV (%)		7.8		
LSD (0.05)		1.06		

Mean values followed by the same letter(s) in a row or column are not significantly different at P≤0.05.

Phosphorus uptake: The combined effect of both pot size and biochar to topsoil ratio was highly significant (P = 0.006) for leaf phosphorus uptakes of coffee seedlings (Table 4). Accordingly, the highest phosphorus uptake (4.00 mg plant^{-1}) was obtained from the largest 16x22cm pot size filled with topsoil plus 2gDAP/pot followed by (3.86mg plant^{-1}) recorded for 16x22cm pot size interacted with one to three ratios of biochar to topsoil. These plots treated with 16x22cm, and 13x19cm, and interacted with one to three biochar to topsoil ratio and 2g DAP/pot were able to produce significantly higher and statically similar to the largest value. The phosphorus uptake of the seedling raised in 16x22cm pot size and treated with 2g DAP/pot and one to three biochar to topsoil ratio was increased by 46% and 43% over the local control, respectively. On the other hand, the lowest value (1.21 mg plant^{-1}) was obtained from the interaction effects of a 7x13 cm pot size treated without biochar amendment (Table 4). Phosphorus promotes both shoot and root growth and the fresh and dry weight of coffee seedlings [6]. The highest positive responses of leaf phosphorus contents treated with 2g DAP/pot might be due to the easily of organic phosphorus available to the seedling. This study also showed that biochar applied as a fertilizer, (at optimum ratio) was able to enhance the phosphorus use efficiency of coffee (*Coffea arabica L.*) seedling. The cation exchange capacity (CEC) of biochar which enhances the retention of basic nutrients [27] might have increased the uptake of phosphorus and its availability in the soil. Similarly, the liming effects of biochar [28], could be the cases of the increased leaf nutrient concentration at the one to three application ratios of biochar to topsoil. The pH range of 5.3-6.5, 4.5-5.2/6.6-7.0, and 4.2-4.44/7-7.5 has been classified for coffee production as highly, moderately, and marginally suitable for coffee production, respectively [20]. The soil Physico-chemical investigation results indicate that the pH of the soil sample was ranged from 4.73 which is very strongly acidic found in the range of (pH=4.5-5.0) to (7.42) which was slightly alkaline (pH = 7.4-7.8) [29]. Phosphorus content of the soil samples also increased from 12.03 to 36.00 (ppm) which could be attributed to the increased phosphorus uptake of the leaf. In the topsoil without biochar amendments, as the media used for the experiment were highly acidic, the phosphorus availability to the seedling might be too low due to the complex interaction of phosphorus with metals (Al_3^+, Fe_3^+, and Ca_2^+), which is important for determining phosphorus availability by absorption and desorption reactions in soils [30]. The sorption of metal ions like Al_3^+, and Fe_3^+ on biochar surface increase phosphorus availability because the sorption might reduce the presence of freely Al_3^+ and Fe_3^+ ions in soil solution [31]. On the other hand, higher biochar application rates can significantly increase the absorption of phosphorus and decreased the availability of phosphorus to the plant [32].

Table 4: Leaf phosphorus (mg/plant) contents of coffee seedlings.

Biochar to Topsoil Ratio	Pot Size (cm)			
	7x13	10x16	13x19	16x22
Topsoil	1.21^{j}	1.21^{j}	2.15^{i}	2.16^{i}
1BC:1TS	1.44^{j}	2.08^{i}	2.27^{ih}	2.12^{i}
1BC:2TS	2.37^{ghi}	2.70e^{-h}	2.75^{efg}	2.74^{efg}
1BC:3TS	2.90^{ef}	2.74^{efg}	3.66^{abc}	3.86^{ab}
1BC:4TS	2.90^{ef}	3.06^{de}	3.43^{bcd}	3.40^{cd}
Ts+2gDAP	2.60f^{gh}	3.00^{def}	3.60^{abc}	4.00^{a}
CV (%)		10		
LSD (0.05)		0.44		

Means followed by the same letter(s) within a row or column are not significantly different at P≤0.05.

Potassium uptakes: The combined effect of pot size and biochar to topsoil ratio was very highly significantly (P=0.0001) different for leaf potassium contents of coffee seedlings. Accordingly, the highest potassium uptake 7.00 mg plant^{-1} was obtained for the largest 16x22cm pot size with a one to three biochar to topsoil ratio. The plot treated with 16x22cm pot size interacted with one to two, and one to three biochar to topsoil ratio and 13x19cm treated with one to three and one to four biochar to topsoil ratio was able to respond statically equal values with the highest response (Table 5). The potassium uptake of the seedling raised in 16x22cm pot size and treated with one to one, one to two, one to three, and one to four biochar to topsoil ratio was increased by 144.00%, 148.40%, 180.00%, and 166.40% over the local control, respectively. The addition of biochar as the substrate into the soil at a lower dose significantly increased the potassium content of the seedlings. In line with this, it has been reported that biochar, or biomass ash, or their mixtures in the soil alters the concentration of, potassium in above-ground parts of the plants [33]. Biochar application increased the availability of nutrients by 61-70% for Ca++, 39-53% for total N, 179-208% for P, and 14-184% for K [34]. Potassium content in stems leaves and roots of green in spring spinach (72%), mustard (16%), and autumn spinach (36%) were increased due to biochar application [35]. Similarly, in acidic soils, suppressed and abnormal root morphology were reported due to Al toxicity [33] which directly hinders nutrient uptake, as well as water absorption, which might be responsible for the lower potassium contents of the seedling leaf in the smaller sizes without amendment. K uptake in the leaves increased by 128% was obtained from biochar at the lower rate of 50 tone ha^{-1} [34].

Table 5: Leaf Potassium (gm/plant) content affected by pot size and biochar to topsoil ratio.

Biochar to Topsoil Ratio	Pot Size (cm)			
	7x13	10x16	13x19	16x22
Topsoil	2.00[i]	2.03[i]	2.50[i]	2.50[i]
1BC:1TS	3.50[h]	5.77[cde]	5.77[cde]	6.10[bcd]
1BC : 2TS	5.33[de]	5.98[bcd]	5.98[bcd]	6.21[abc]
1BC:3TS	5.77[cde]	6.00[bcd]	6.66[ab]	7.00[a]
1BC : 4TS	5.98[bcd]	6.00[bcd]	6.21[abc]	6.66[ab]
Ts+2gDAP	4.16[gh]	3.87[gh]	4.51[fg]	4.53[fg]
CV (%)		10.81		
LSD (0.05)		0.82		

Mean values followed by the same letter(s) within a row or column are not significantly different at P≤0.05.

Summary and Conclusions

The leaf tissue analysis result indicates that, the macronutrients uptake of the seedling was significantly affected by the interaction effects of both pot size and biochar to topsoil application ratio. The seedling leaf NPK contents in the control plots was distinctly improved from 7.66, 2.16, and 2.50 to 12.10, 3.66 and 6.66 mg/plant, respectively due to the interaction effects of 13x19cm pot size with one to three biochar to topsoil ratio. Nitrogen and potassium uptake of the seedling were increased by 58.00% and 180.00%, over the farmers practice treatment and the phosphorus uptake of the seedling raised in 16x22cm pot size and treated with 2g DAP/pot and one to three ratio of biochar to topsoil were increased by 46% and 43%, as compared to the farmers practice respectively. The improved nutrient uptake through the use of biochar as a fertilizer provides alternative fertilizer and/or enhancement options to promote coffee seedling growth. This study showed the, promising potential of even the smallest pot size to produce good quality seedling when the topsoil amended with biochar as a fertilizer for the nursery media at the lower rate of applications. Using biochar from locally available biomass such as coffee husk would also reduce the dependence on the external production cost like fertilizer.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

Refrences

1. Ethiopian Institutes of Agricultural research (2016) Integrated Soil Fertility and Health Management Research Department Strategy.
2. Kathleen D (2018) The Potential for Biochar to Improve Sustainability in Coffee Cultivation.
3. Jin Z, Chen C (2018) The crucial factors of soil fertility and rapeseed yield-A five-year field trial China. Science of the Total Environment 221: 215-241.
4. Glaser B, Lehmann J, Zech W (2002) Ameliorating Physical and Chemical Properties of Highly Weathered Soil in the Tropics with Charcoal. Biology, and Fertility of Soil 35: 219-230.
5. Ewnetu T, Taye K, Alemayehu R (2019) Effects of Lime and Phosphorus Rates on Growth of Hybrid Arabica Coffee Seedlings at Jimma, Southwest Ethiopia. Journal of Biology, Agriculture and Healthcare 9(15): 37-46.
6. Taye K, Mesfen A, Paulos D (1999) Effect of nitrogen and phosphorus and organic fertilizer on growth and development of coffee (Coffea arabica L.) seedlings. In: African Crop Science Conference Proceedings, Moroco.
7. Ali M (1999) Coffee Management production A teaching material, Jimma University, College of Agriculture and Veterinary Medicine 165: 80-83.
8. Abayneh M, Fisseha I (2015) Nutritional requirement and management of Arabica coffee (Coffea arabica L.) in Ethiopia: national and global perspectives. American Journal of Experimental Agriculture 5(5): 418.
9. Walelign G (2008) Determinants and role of farmers' seed and seedling multiplication in the SNNP Region seed system (Doctoral dissertation, haramighta University). 115p.
10. Mesfin K, Bayetta B (2008) Phenotypic diversity in the Harerge coffee (Coffee arabica L.) germplasm for quantitative traits. East African Journal of Sciences 2: 13-18.
11. Anteneh N, Taye K, Tesfaye S (2015) Review of Arabica Coffee Management Research in Ethiopia. Journal of Biology Agriculture and Healthcare 5(13): 2225-093.
12. Walkley A, Black IA (1934) An examination method for determining soil organic matter, and a proposed modification of chromic acid titration method. Soil science 37(1): 29-38.
13. Jackson ML (1958) Soil Chemical Analysis. Englewood Prentice Hall 3(6): 498-512.
14. Jones DL, Rousk J, Edwards-Jones G, Murphy DV (2012) Biochar-mediated changes in soil quality and plant growth in a three-year field trial. Biochem 45: 113-124.
15. Olsen SR, CV Cole, FS Watanab, LA Dean (1954) Estimation of available phosphorus in soils by extraction with Sodium Bicarbonate. U. S. D. A. Circ. 939 p.
16. Ibiremo OS, Akanbi O (2013) Evaluation of NPK fertilizer formulations on the growth and dry matter yield of coffee seedlings. Nigerian Journal of Soil Science 23(1): 22-26.
17. Karltun E, Tekalign M, Taye B, Sam G, Selamyihun K (2013) Towards improved fertilizer recommendations in Ethiopia nutrient indices for categorization of fertilizer blends from EthioSISworeda soil inventory data. Addis Ababa, Ethiopia.

18. Robarge WP (2008) Acidity. In: Encyclopedia of Soil Science, Encyclopedia of Earth Sciences Series (Ed.: Ward Chesworth). 860pp.
19. Hailemichael MS (2009) Influence of genotype, location and processing methods on the quality of coffee (Coffea arabica L.). MSc thesis (Horticulture). Hawassa University, 105p.
20. Paulos D (1994) Ecology and soils of major coffee growing regions of Ethiopia. In Mineral Fertilization of Coffee in Ethiopia (Paulos Dubale, ed.). (IAR), Addis Ababa, Ethiopia.
21. Zhang R, Zhang Y, Wu J (2017) Biochar enhances nut quality of Torreya grandis and soil fertility under simulated nitrogen deposition. For Ecol Manag 391: 321-329.
22. Ullah MR, Dijkstra F, Dilb A (2019) Fungicide and Bactericide Effects on Carbon and Nitrogen Cycling in Soils: A Meta-Analysis. Soil Systems 3(2): 23.
23. Lehmann J, Rondon M (2006) Bio-char soil management on highly weathered soils in the humid tropics. Biological approaches to soil systems. Press, Raton, FL 7: 517-530.
24. Biederman LA, Harpole WS (2013) Biochar and its effects on plant productivity and nutrient cycling: a meta-analysis. GCB bioenergy 5(2): 202-214.
25. Clough T, Condron LM, Kammann C, Muller C (2013) A Review of Biochar and Soil Nitrogen Dynamics. Agronomy 3: 275-293.
26. Helmi H (2014) The Effect of Type Biochar and Agrodyke Fertilizer Concentration on the Growth of Seedling of Mahoni). Jurnal Biologi Edukasi 6(2): 71-77.
27. Van Zwieten L, Kimber S (2010) Effects of biochar from slow pyrolysis of papermill waste on agronomic performance and soil fertility. Plant Soil 327: 235-246.
28. Woldetsadik DD (2018) Effect of biochar derived from faecal matter on yield and nutrient content of lettuce in two contrasting soils. Environ Syst Res 6(27): 205-212.
29. Elias S, Worku A, Mathewos N (2017) Technical efficiency of smallholder coffee farmers in Gedeo Zone, Southern Ethiopia: Agricultural Science Research Journal 7(4): 147-153.
30. Wang T, Camps-Arbestain M, Hedley M, Singh BP, Calvelo-Pereira R, et al. (2014) Determination of carbonate-C in biochars. Soil research 52(5): 495-504.
31. Hong C, Lu S (2018) Does biochar affect the availability and chemical fractionation of phosphate in soils? Environmental Science and Pollution Research 25: 8725-8734.
32. Bayu D, Dejene A, Gezahegn B (2017) Effects of Biochar on Phosphorus Sorption and Desorption in Acidic and Calcareous Soils. Environmental Research 9(5): 2224-5790.
33. Bogdan S, Marcin B, Grzegorz Z (2016) Influence of biochar and biomass ash applied as soil amendment on germination rate of Virginia mallow seedsm. An international quarterly journal 5(3): 71-76.
34. Widowati, Asnah (2014) Biochar Can Enhance Potassium Fertilization Efficiency and Economic Feasibility of Maize Cultivation. Journal of Agri. Science 6(2): 9752-9752.
35. Rangaswami MN (2018) Effect of biochar on phosphorus transformation in an acid soil and its nutrition in wheat. Soil Science and Agricultural Chemistry, 97p.

Citation: Leta Ajema, Gezahegn Berecha, Taye Kufa. Effects of Pot Sizes and Biochar Base Media Composition on Nutrient Uptake of Coffee (*Coffea arabica L.*) Seedlings in South Ethiopia. World J Agri & Soil Sci. 8(1): 2022. WJASS.MS.ID.000678.
DOI: 10.33552/WJASS.2022.08.000678