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Research Article

Effect of Spent Coffee Ground on Growth, Yield and Yield Components of Two Green Bean (*Phaseolus vulgaris L.*) Varieties at Jimma, South West Ethiopia

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Abstract

This experiment was conducted at Jimma with the objective of evaluating the effect of spent coffee ground on growth, yield and yield component of two green bean varieties. The treatments consisted of two green bean varieties namely, BC4.4 and Plati with eight amendments, six levels of spent coffee ground (2.5%, 5%, 7.5%, 10%, 12.5% and 0%), recommended rate of NPS and NPSB as a control). The experiment was laid out as a randomized complete block design with three replications. The results revealed that the difference between the two varieties was significant (P<0.05) for plant height, number of leaf, number of pod, pod length and total pod yield. Variety Plati gave maximum result for all listed parameters. Application of spent coffee ground had a significantly decreasing effect on all studied parameters compared to the control except number of nodule. The control treatment had statistically the largest plant height, number of leaves, number of pods, root volume, total pod yield and pod length. The interaction effects between variety Plati and control (NPSB) gave the highest total leaf area, root fresh weight, shoot and root dry weight and dry weight of pod whereas higher pod diameter was obtained from the interaction of variety BC4.4 and control (NPSB). The results revealed that application of recommended rate of NPSB fertilizer with Plati improved growth and yield component. It could also be added that growth, yield and yield components of green bean could not be increased by application of spent coffee ground.

Keywords

Spent Coffee Ground, Green Beans, Green Bean Yield

1. Introduction

The green bean *(Phaseolus vulgaris L.),* belongs to the family Leguminaceae and subfamily Papilionaceae [27]. It is originated in Central and South America. Africa is considered to be the secondary center of diversity [4]. There is a speculation that green bean was introduced to Ethiopia in the 16th century by the Portuguese [16]. It is known by many common names, including French beans, string beans, and snap beans [34]. In Ethiopia the production obtained from green bean was 6,486 tones with the average productivity of 4.12 ton ha^{-1} which is very low compared to world average productivity of 14.22 ton ha^{-1} [15].

According to [3] production of green bean in Ethiopia relies

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on a few introduced cultivars from Europe and America. The agronomic practices of the introduced cultivars are usually based on the package developed by the seed companies in the respective countries. These agronomic practices are usually difficult to apply in the Ethiopian context, especially by small-scale farmers due to limited resources. For instance, commercial green bean production depends heavily on application of nitrogen fertilizer. Relatively high rates of N fertilizer (82 kg N ha^{-1}) are applied regardless of the cultivars and other factors such as residual soil nitrogen [25]. The majority of Ethiopian farmers, however, are unable to afford the high mineral fertilizer cost [9].

Furthermore, green bean production in Ethiopia is constrained by a lack of suitable improved high yielding with better quality and disease resistance cultivars for the different agro-ecological zones, a lack of infrastructure and transportation facilities, the absence of local markets and a poor knowledge of the nutritional value of the crop. Research and extension in Ethiopia has traditionally focused on staple cereals, coffee, and livestock sectors, giving limited support to the horticultural sectors, including green bean production [3].

There is an increase of coffee beverages consumption all over the world [17]. As a consequence of this big market, the coffee industry generating large quantities of residues; among which spent coffee grounds (SCG) is the most significantly generated. Almost 50% of the worldwide coffee production is processed for soluble coffee preparation, which generates around 6 million tons of SCG per year [28].

The chemical composition of SCG indicates several applications of this residue. For instance, the presence of nitrogen (about 1.2 - 2.3%), phosphorus (0.02 - 0.5%) and potassium (0.35%) contents suggest its utilization on agriculture as fertilizer or soil improver [10].

Despite the presence of huge amount of spent coffee ground in Ethiopia, no research has been done to evaluate its potential role as fertilizer for crop production in Ethiopia. Therefore, the current study was proposed to partly address this issue as a means of SCG management by utilization for crop production. It is hypothesized that growth, yield and yield component of green bean can be increased by addition of spent coffee ground. Thus, objective of this study was to investigate the effect of spent coffee ground on growth, yield and yield component of two green bean varieties.

2. Materials and Methods

2.1. Description of the Experimental Site

The study was conducted at Jimma University College of Agricultural and veterinary medicine during 2018/2019 under Lath house using irrigation. The dominant soil of the area is nitosoil. The research site is geographically located at 7°42` N latitude and 36°50`E longitude with an altitude of 1710 m above sea level. The area has an average maximum and minimum temperature of 26.2°C and 11.3°C, respectively and average maximum and minimum relative humidity of 91.40% and 37.92%, respectively [5].

The Initial physio-chemical soil analysis showed that the experimental soil had a pH of 6.13 (slightlyacidic). [22] reported that the preferable pH ranges for green bean is 6.0 and 6.5. Thus, the pH of the experimental soil is within this range of suitable for green bean cultivation. Textural class of the soil is clay loam having compositions of 35% clay, 48% silt and 17% sand, which is suitable for green bean as well as for other agricultural crops according [36]. Total nitrogen of the experimental site is 0.21%. Sulfur is 8.61 Cmol/kg. Boron is 0.46 mg kg-1. According to [7], the nitrogen in the soils is medium. Available phosphorus of the soils is 3.46 ppm and according to [20], the experimental soil is found to be very low and deficient in phosphorus as the area receives heavy rainfall, phosphorus is probably fixed by high concentrations of iron and aluminum. The nitrogen, phosphorous and boron content of spent coffee ground is 1.2%, 16.7 ppm and 9.57 mg/kg repectively. In general, the experimental soil was found to be conducive for green bean cultivation.

2.2. Treatments and Experimental Designs

The lath house experiment consisted of factorial combinations of two Green beans varieties (Plati and BC4.4) and eight levels of amendments (six levels of spent coffee ground (SCG) (0%SCG, 2.5% SCG with top soil, 5.0% SCG with top soil, 7.5% SCG with top soil, 10% SCG with top soil, and 12.5% with top soil) recommended rate of NPS and NPSB as a control). The experiment was laid out as a randomized complete block design (RCBD) in a factorial arrangement and replicated three times. One hundred forty-four pots were used for this study. Three pots per treatment per replication were maintained.

2.3. Experimental Procedures

Prior to planting, the top soil used in this study was collected from field of Jimma university college of agriculture and veterinary medicine at depth of 0 to 20 cm. Fresh spent coffee ground was also collected from several coffee houses existing in Jimma town. The collected spent coffee ground and top soil were air dried and crushed to finely size before filled into the pot. Then top soil and SCG were mixed together depending on volume proportion (2.5%SCG+top soil, 5% SCG+ top soil, 7.5%SCG+ top soil, 10%SCG+ top soil, 12.5% SCG+ top soil) and in addition to this, the soil alone and the soil with applied recommended rate of NPS and NPSB was applied in to the pot which has 18 cm width and 18 cm height. The rate of NPS and NPSB for pot was calculated by converting recommended rate of NPS and NPSB (100 kg/ ha^{-1}) into the area of pot (0.0254 m^2). Further, the rate of spent coffee ground was calculated by multiplying volume of soil with above listed percentage. Then, the result obtained was multiplied with bulk density of spent coffee ground to get dry mass of spent coffee ground. Finally, applied spent coffee ground was obtained by adding moisture content lost (in oven dry) to dry mass of spent coffee ground. Then four seeds of each green bean varieties (Plait and BC4.4) were sown in each pot and latter thinned to two plants per pot. Every routine management practices (weeding, watering etc.) were performed to all experimental units.

2.4. Soil Sampling and Analysis

A composite soil sample was taken randomly from the experimental unit. The soil was broken in to small crumbs and thoroughly mixed. From this mixture, a sample weighing one kg was filled in to a plastic bag and prepared for analysis. The soil was air dried and sieved through a 2 mm sieve. The soil samples were analyzed for soil pH, textural class, total nitrogen, available phosphorous, sulfur and boron. Analysis of spent coffee ground was following the same procedure with soil analysis.

A. Soil pH: The composite soil sample was analyzed for soil pH and determined potentiometrically in 1: 2.5 ratio soil water mixtures using a glass electrode attached to a digital pH -meter as described by [37].

B. Soil particle size distribution (texture): Soil texture was analyzed by Bouyoucos hydrometric method following the procedure described by [11].

C. Total Nitrogen content of the soil (%): It was determined using Micro Kjeldahl method by oxidizing the Organic Matter (OM) with sulfuric acid (through sulfuric acid digestion and distillation) and converting the Nitrogen into NH_4^+ as ammonium sulfate as modified by [32].

D. Soil organic matter content (%): It was estimated from soil organic carbon (OC) using wet oxidation method where the carbon was oxidized under standard conditions with potassium dichromate ($K_2Cr_2O_5$) in sulfuric acid solution. Finally, the organic matter (OM) content of the soil was calculated by multiplying the percent organic carbon (% OC) by 1.724 standard procedures outlined by [32].

E. Soil available P (mg/kg soil): Available phosphorus was estimated by using Bray II method of extraction as described by [6].

F. Cation exchange capacity (Cmol kg-1 soil): The CEC was determined titrimetrically by distillation of ammonia that was displaced by Na [32].

G. Available sulfur (meq/l SO_4^{-2}): It was determined by monocalcium phosphate extraction method or turbidimetric estimation [23].

H. Available Boron: It was determined using hot water method [18].

2.5. Data Collection and Measurements

Days to emergency: The number of days required for emergence was recorded when 50% of the seedlings emerged from the soil in each experimental unit. Days to emergence were determined by counting.

Days to flowering: This refers to the actual number of days required by the plants from emergence to a stage when 50% of the plants in the plot produced flowers. This was determined by counting.

Plant height (cm): Plant height was measured from the ground level to the tip point of the stem at the harvest stage from three randomly selected plants per experimental unit.

Number of leaf per plant: Numbers of leaves per plant were determined by counting the leaves on a single plant at flowering stage. Three plants in each plot were randomly selected to determine number of leaves per plant at harvesting stage.

Total leaf area (cm^2/plant): Leaf area was measured on graph paper that has one centimeter square grid lines, and the number of grid squares that are inside of the leaf on the paper was the area of the leaf. Accordingly, nine leaves were taken randomly from three plants at flowering stage and data were recorded as the average leaf area per plant.

Number of primary branches per plant: The number of primary branches per plant was recorded from three randomly selected plants per experimental unit by counting the number of branches arising from the base of the stem at harvesting stage.

Shoot and root dry weight (g/plant): Three sample plants were taken for determination of fresh weight and dry weight of shoot and root at harvesting stage. After taking the fresh weight of shoot and roots, the samples were dried in an oven at 70°C at a constant weight and their weights were determined.

Root volume (ml/plant): Root volume of three randomly selected plants per experimental unit was measured at the harvestable stage by using water displacement method. The measuring cylinder was filled with water and the initial reading value was taken.

Root fresh weight (g/plant): Root fresh weight of three randomly selected plants was measured using a sensitive balance at harvesting stage.

Number of nodule per Plant: Two sample plants were taken for determination of number of nodule per plant. Roots were carefully washed under gently flowing tap water on a screen and nodules were separated and counted at flowering stage.

Number of Pods per Plant: Number of pods per plant was recorded from the mean of number of pods per plants from the three plants at harvesting stage.

Pod length (cm): The average length of randomly selected fifteen fresh pods was taken randomly from three plants per experimental unit. It was measured by using ruler.

Pod diameter (cm): The average pod diameter was measured at the point of maximum diameter from fifteen randomly selected fresh pods per plot by using a caliper.

Dry weight of pods per plant (g/plant): Dry weight of pods was recorded by taking 10 pods per experimental unit from total production randomly and put in the oven at 70°C to dry to a constant weight and finally it was converted to average dry weight of pods per plant. Finally, the mean dry weight of pod was multiplied by number of pod per plant.

Total Pod Yield (g/plant): Total weight of pods was determined from all the pots per treatment per replication at harvesting stage.

2.6. Data Analysis

All data collected on different growth, yield and yield component parameters were first checked for normality test using Minitab software. The data were subjected to analysis of variance (ANOVA) using SAS version 9.3. Significance differences between treatment means were delineated by LSD (Least Significance Difference) test at 5% level of significance.

3. Results and Discussion

3.1. Phenological Parameters

3.1.1. Days to Emergency

The number of days required for emergency was highly significantly influenced by the main effect of spent coffee ground rates. However, the main effect of the varieties and the interaction effect of the two factors did not show a significant effect (P>0.05) on days to emergency. This implies that only spent coffee ground amendment acted independently to affect days to emergency of green bean in this experiment. The maximum days to emergency was recorded at 12.5% SCG while the minimum days were recorded from 0% SCG which was statistically similar with pots amended with NPSB, NPS and 2.5% SCG (Table 1). This might be due to the water leaching effect of spent coffee ground [33]. This finding is in agreement with [30] who reported that emergency of tomato was delayed by application of spent coffee ground compared with the control treatment. Similarly, [33] reported that spent coffee ground could inhibit the germination of alfalfa, white and red clovers.

3.1.2. Days to Flowering

The analysis of variance revealed that the main effect of spent coffee ground rate showed a highly significant effect (P<0.01) on days to flowering. However, the main effect of the varieties and the interaction effect of the two factors did not show a significant effect (P>0.05) on days to flowering (Table 1). This may be attributed to only spent coffee ground amendments that acted independently to affect days to flowering of green bean in this finding.

High rate of spent coffee ground resulted in significantly delayed flowering of green bean. Hence the prolonged days to flowering was recorded at 12.5%SCG while the shortest day to flowering was recorded from control (top soil +0%SCG. This might be due to the phytotoxic effect of spent coffee ground which contains chlorogenic acid that inhibits plant growth [24]. This finding is in agreement with [29] who reported the inhibitory effect of spent coffee ground on growth of alfalfa, crotalaria, guinea grass, hairy vetch, sorghum and sunflower, buckwheat and bitter buckwheat, barley, rye grass, oat and rye.

3.2. Growth Parameters

3.2.1. Plant Height (cm)

The main effect of spent coffee ground rate and varieties had a significant effect on plant height. However, the interaction effect of the two factors did not show a significant effect (P>0.05) on plant height. This indicated that spent coffee ground rate and varieties acted independently to affect plant height of green bean in this finding.

The result of this experiment indicated that the tallest plant was observed from Plati while the shortest plant was observed from BC4.4 (Table 1). The differences in plant height between varieties were likely due to the differences in genetic constitutions. This is in agreement with the findings of [1] who reported that plant height was significantly different among green bean varieties and similar result was also reported on three cluster bean varieties [2].

The tallest plant was recorded on pots amended with recommended rate of NPSB which was statistically similar with recommended rate of NPS. The shortest plant height was gained from 12.5% SCG. The application of recommended rate of NPSB and NPS increased plant height by 54.11% and 52.70% as compared to 12.5%SCG respectively. This might be due to highest amount of nitrogen existed in the two blended fertilizers (NPS and NPSB) than SCG. The highest nitrogen existed in NPS and NPSB may enhance vegetative growth through increasing cell division and elongation [19]. In addition to this, the phytotoxic effect of spent coffee ground which contains chlorogenic acid inhibited vegetative parts of the crop. This is in line with the finding of [30] who reported that maximum plant height was recorded in control compared to spent coffee ground in tomato.

3.2.2. Number of Leaf per Plant

Number of leaf per plant was significantly affected (P<0.01) by the main effect of spent coffee ground rate and varieties. However, the interaction effect of the two factors had not a significant effect (P>0.05) on number of leaf per plant. As it can be observed from the displayed result, the main effect of spent coffee ground rate and varieties acted independently to affect number of leaf per plant of green bean in this finding.

The analysis of variance showed that maximum number of leaf per plant was observed from Plati while the minimum number of leaf per plant was recorded from BC4.4. This is in agreement with the findings of [1] who reported that number of leaves showed variations among green bean varieties. The possible reason for the variation on number of leaf per plant among varieties could be due to the genetic factor. The highest number of leaf per plant was registered from pots amended with recommended rate of NPSB application which was statistically similar with recommended rate of NPS while the lowest number of leaf per plant was recorded from pots amended with 12.5% SCG (Table 1). These results further indicate that number of leaf per plant was favored due to the application of recommended rate of NPSB. This might be due to more nitrogen available in NPSB and NPS which helps to increase the vegetative growth and number of leaf per plants of green bean [21]. The minimum number of leaf obtained from 12.5% SCG was probably because of the limited vegetative growth of plants due to inhibitory effect of spent coffee ground. This finding is in line with [32] who reported that control treatments had the largest mean number of leaves of tomato than applied spent coffee ground.

Table 1. Effects of spent coffee ground rates and varieties on phenological, growth and yield parameters.

Treatment Variety	DTE	DTF	PH (cm)	NNP	NLP	RVP (ml/plant)
BC4.4	8.45[a]	44.91[a]	32.08[b]	208.08[a]	30.56[b]	4.91[a]
Plati	8.37[a]	44.62[a]	35.26[a]	207.79[a]	31.91[a]	4.98[a]
LSD (5%)	0.32	0.6	1.5	5.14	0.64	0.28
Amendments						
NPS	7.33[d]	42.33[d]	40.30[a]	180.08[e]	35.88[a]	7.03[a]
NPSB	7.33[d]	43.66[dc]	40.67[a]	180.41[e]	36.47[a]	7.21[a]
0%SCG	7.17[d]	41.33[e]	35.61[b]	85.16[g]	33.05[b]	4.00[d]
2.5%SCG	7.33[d]	43.83[dc]	34.79[b]	376.55[a]	32.22[b]	4.91[b]
5%SCG	8.67[c]	44.33[c]	33.39[b]	310.58[b]	30.83[c]	4.80[bc]
7.5%SCG	9.17[cb]	45.66[b]	30.24[c]	260.76[c]	28.75[d]	4.45[c]
10%SCG	9.67[b]	46.33[b]	27.99[cd]	209.08[d]	27.68[e]	3.95[d]
12.5 SCG	10.67[a]	50.66[a]	26.39[d]	135.21[f]	24.98[f]	3.25[e]
LSD (5%)	0.64	1.21	3.13	10.29	1.28	0.41
CV (%)	6.5	2.2	7.9	4.01	3.49	7

Means followed by the same letter within a column in a treatment are not significantly different at 5% P level. Where DTE=date of emergency, DTF=date of flowering, PH=plant height, NNP=number of nodule per plant, RVP=root volume per plant and NLP=number of leaf per plant per plant.

3.3. Yield and Yield Components Traits

3.3.1. Number of Nodule per Plant

The main effect of spent coffee ground rate had a highly significant (P<0.01) effect on number of nodule per plant. However, the main effect of the varieties and the interaction effect of the two factors did not show a significant effect (P>0.05) on number of nodule per plant (Table 1). This could be indication of spent coffee ground which acted independently to affect number of nodule per plant of green bean.

The maximum number of nodules per plant was recorded from pots amended with 2.5%SCG while the minimum number of nodule per plant was recorded from control (top soil + 0% SCG) (Table 1). The main reason might be due to spent coffee ground which can reduce the amount of available nitrogen, like nitrate and ammonium in the soil, thus increasing the dependence for nitrogen fixation to convert atmospheric nitrogen to available nitrogen. A similar result was reported by [8] on number of nodule which showed a significantly difference in soya bean where SCG applied samples had greater number of nodules than without SCG. Moreover, the amount of nitrogen existed in NPS and NPSB is greater than spent coffee ground. Nodule number is lower in former because nitrogen has inverted relationship to nodule formation. If there is high amount of nitrogen in the soil for the plants to use, nitrogen fixation doesn't take place. This in turn results in reduction of nodule formation. This is in line with [9] and [35] who reported that high rate of nitrogen resulted in reduction of nodule number in soya bean.

3.3.2. Root Volume (ml)

Though root volume was highly significantly (P<0.01) influenced by the main effect of spent coffee ground rate. The main effect of the variety and the interaction effect of the two factors did not show a significant effect (P >0.05) on root volume (Table 1).

The highest root volume was recorded in pots amended with recommended rate of NPSB which was statistically similar with the recommended rate of NPS (Table 1). These results further indicate that root volume was favored due to the application of NPSB and NPS owing to more available nitrogen in the root zone which upon uptake increased the growth of the root. Nitrogen is used to increase root volume [26]. The minimum root volume per plant was obtained from the 12.5% SCG. This could be due to the inhibitory effect of SCG on growth of plants [38].

3.3.3. Total Leaf Area per Plant (cm^2/plant)

For total leaf area per plant, the interaction effect of variety and rate of spent coffee ground were significant (P< 0.05). However, the analysis of variance evidenced that the main effect of spent coffee ground application as well as varieties did not show a significant effect (P>0.05) on total leaf area per plant independently. The maximum total leaf area per plant was observed from Plati variety interacted with amended recommended rate of NPSB while the minimum total leaf area per plant was observed from the combination of Plati variety with 12.5%SCGwhichwas statistically similar with the combination of BC4.4 with 12.5% SCG.

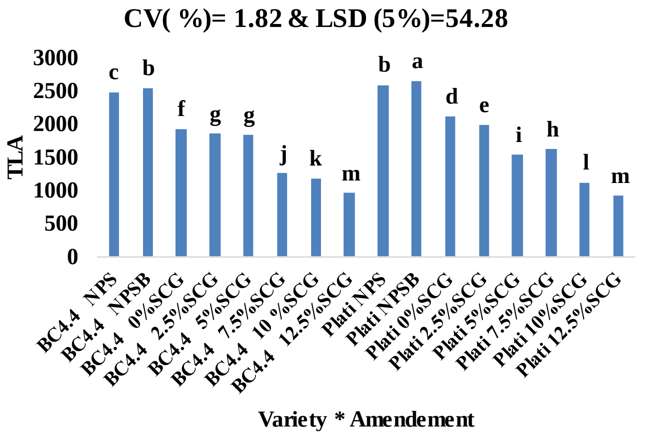

Figure 1. *Interaction effect of spent coffee ground and variety on total leaf area per plant (TLA= cm^2/ plant).*

3.3.4. Number of Primary Branches per Plant

The main effect of spent coffee ground rate showed a highly significant effect (P<0.01) on number of primary branch per plant. In contrast, the main effect of variety and the interaction effect of the two factors did not show a significant effect (P >0.05) on number of primary branch per plant (Table 1). This implies that only rate of spent coffee ground acted independently to affect number of primary branch of green bean. The maximum number of primary branches was recorded from pots amended with recommended rate of NPSB which was statistically similar with recommended rate of NPS while the minimum number of primary branches was obtained from 12.5% SCG amended pots. These results further indicate that number of primary branches was favored due to the application of NPSB and NPS.

This is probably due to more available nitrogen existed in NPSB and NPS than the amended spent coffee ground which helps to increase vegetative growth. This finding is in agreement with [14] who reported that number of primary branches per plant showed a significant increment with successive application of N. In addition to this the minimum number of primary branch was recorded due to inhibitory effect of spent coffee grounds.

3.3.5. Root Fresh Weight per Plant (g/plant)

Root fresh weight per plant was highly significantly (P<0.01) influenced by the interaction effect of spent coffee ground rate and varieties (Table 2). The maximum root fresh weight was recorded from combination of Plati with recommended rate of NPS which was statistically similar with the root fresh weight registered due to the combined application of BC4.4 with recommended rate of NPSB while the minimum root fresh weight was observed from the interaction effect of BC4.4 with the amended 12.5%SCG (Table 2).

3.3.6. Shoot and Root Dry Weight (g/plant)

The analysis of variance revealed that the main effect of spent coffee ground application and varieties did not show a significant effect (P>0.05) on shoot and root dry weight independently. However, the interaction effect of the two factors showed a highly significant effect (P<0.001) on shoot and root dry weight per plant (Table 2).

The result showed that maximum shoots and root dry weight was obtained from Plati variety with recommended rate of NPS which was statistically similar with Plati with recommended rate of NPSB (Table 5). On the other hand, the minimum shoot and root dry weight was observed from the combined effect of BC4.4 variety and 12.5%SCG. This finding is in line with [8] who reported that aboveground plant biomass showed lower weight than control when treated with 2.5% SCG, 10%SCG, and 20% SCG. Similarly [30] also reported that the control had the largest stems, leaves, and roots dry mass than applied spent coffee ground in tomato.

3.3.7. Number of Pod per Plant

The analysis of variance revealed that the main effect of spent coffee ground and varieties showed a highly significant effect (P<0.01) on number of pod per plant. However, the interaction effect of the two factors did not show a significant effect (P >0.05) on number of pod per plant. This implies that the main effect of spent coffee ground rate and varieties acted independently to affect number of pod per plant of green bean in this finding (Table 3).

The result of this experiment indicated that maximum number of pod per plant was observed from Plati while the minimum number of pod per plant was recorded from BC4.4 (Table 3). This is in agreement with the findings of [2] who reported that number of pod per plant was significantly different among three cluster bean varieties. Similarly, [12] also reported that the same result on faba been varieties. The possible reason for the variation on plant height among varieties could be due to the genetic factor.

Total number of pod per plant was highly significantly (P< 0.001) affected by application of spent coffee ground. The maximum total number of pod was recorded from the application of recommended rate of NPSB which was statistically similar with recommended rate of NPS while the minimum pod number was recorded from 12.5%SCG. Application of recommended rate of NPSB and NPS increased the number of pod per plant by 73.3% and 67.8% respectively as compared to 12.5%SCG. This is in line with the finding of [8] who reported that the control treatment contained more seed pods than the amended spent coffee ground.

3.3.8. Pod Length (cm)

The analysis of variance showed that the main effect of spent coffee ground and varieties showed a highly significant effect (P<0.01) on pod length. However, the interaction effect of the two factors did not show a significant effect (P>0.05) on pod length (Table 3).

The result of this experiment indicated that the longer pod length was observed from Plati variety while the shorter pod length was obtained from BC4.4 (Table 3). This finding is in agreement with [12] who reported that pod length was significantly different among faba bean varieties and the same result was also reported on three cluster bean varieties by [2]. The possible reason for the variation on pod length among varieties could be due to the genetic factor.

Pod length was highly significantly (P< 0.001) affected by rate of spent coffee ground. The longest pod length was recorded from the application of the recommended rate of NBSB which was statistically similar with NPS while the shortest pod length was registered from 12.5% SCG (Table 3). The shortest pod length obtained from the treatment 12.5% SCG might be due to the presence of chlorogenic acid in spent coffee grounds that inhibits plant growth [29].

3.3.9. Total Pod Yield per Plant (g/plant)

The main effect of spent coffee ground rate and varieties showed a highly significant effect (P<0.01) on total pod yield per plant. However, the interaction effect of the two factors did not show a significant effect (P>0.05) on total pod yield per plant.

The result of this experiment indicated that maximum total pod yield per plant was observed from Plati while the minimum was recorded from BC4.4 (Table 3). This finding is in agreement with [1] and [25] who reported that significant variations on total pod yield was shown among green bean varieties. Variation in total pod yield among varieties could be associated with differences in genetic make-up.

The maximum total pod yield was observed from pots amended with recommended rate of NPSB which was statistically similar with NPS while the minimum total pod yield per plant was recorded from pots amended with 12.5% SCG (Table 3). It is probably due to the availability of more essential nutrient in NPS and NPSB which help to increase more yield. This study is in line with [31] who reported that the maximum value of pod yield was high at high phosphorus and [13] reported significant increase in yield of French bean with an increase in the rate of N. This is in line with the finding of [8] who reported that the control treatment contained more seed pods than the amended spent coffee ground which helps to increase total pod yield in the control.

Table 2. *Effects of variety and spent coffee ground interaction on root fresh weight and shoot and root dry weight.*

Treatment	**RFW**	**SRDW**
Varity *Amendments		
BC4.4 NPS	38.12[ab]	28.8967[b]
BC4.4 NPSB	40.03[a]	29.7333[b]
BC4.4 0%SCG	32.36[cde]	27.2675[c]
BC4.4 2.5%SCG	33.18[cd]	18.4706[f]
BC4.4 5%SCG	30.61[def]	22.2[e]
BC4.4 7.5%SCG	28.9[efg]	24.74[d]
BC4.4 10%SCG	30.62[def]	18.1[f]
BC4.4 12.5%SCG	21.16[i]	13.07[g]
Plati NPS	41.61[a]	31.79[a]
Plati NPSB	35.38[bc]	31.64[a]
Plati 0%SCG	33.3[cd]	27.38[c]
Plati 2.5%SCG	32.6[cde]	20.88[e]
Plati 5%SCG	27.86[fg]	23.67[d]
Plati 7.5%SCG	26.67[fgh]	21.25[e]
Plati 10%SCG	24.84[gh]	19.09[f]
Plati 12.5%SCG	22.86[ih]	13.88[g]
LSD	4.16	1.4
CV%	7.98	3.79

Means followed by the same letter within a column in a treatment are not significantly different at 5% P level. Where, RFW=root fresh weight and SRDW=shoot and root dry weight.

Table 3. Effect of spent coffee ground and variety on yield component of green bean.

Treatment	NPP	PL (cm)	TPY (g/plant)
Variety			
BC4.4	12.42^{b}	11.36^{b}	45.32^{b}
Plati	13.04^{a}	12.03^{a}	49.06^{a}
LSD	0.28	0.33	1.18
Amendments			
NPS	15.71^{a}	12.13^{ab}	52.95^{a}
NPSB	16.23^{a}	12.43^{a}	53.4^{a}
0%SCG	12.85^{b}	12.06^{ab}	47.86^{bc}
2.5%SCG	10.45^{b}	11.54^{ab}	45.93^{cd}
5%SCG	12.46^{b}	11.56^{b}	49.49^{b}
7.5%SCG	12.68^{bc}	12.06^{b}	47.06^{c}
10%SCCG	12.10^{c}	11.73^{b}	44.6^{d}
12.5%SCG	9.36^{d}	10.05^{c}	36.19^{e}
LSD	0.57	0.66	2.35
CV%	3.7	4.8	4.23

Means followed by the same letter within a column in a treatment are not significantly different at 5% P level. NPP=Number of pod per plant, PL=pod length and TPY=total pod yield

Table 4. Effects of spent coffee ground and variety interaction on dry weight of pod per plant and pod diameter of green bean.

Treatment	DWPP (g/plant)	PD (cm)
Variety*Amendments		
BC4.4 NPS	5.38^{bc}	1.05^{a}
BC4.4 NPSB	5.27^{c}	0.96^{b}
BC4.4 0%SCG	3.44^{ef}	0.77^{cd}
BC4.4 2.5%SCG	2.37^{h}	0.82^{c}
BC4.4 5%SCG	3.11^{gf}	0.78^{cd}
BC4.4 7.5%SCG	2.60^{h}	0.76^{cd}
BC4.4 10%SCG	2.59^{h}	0.71^{de}
BC4.4 12.5%	2.39^{h}	0.60^{f}
Plati NPSB	5.72^{ab}	0.78^{cd}
Plati NPS	5.85^{a}	0.81^{c}
Plati 0%SCG	3.81^{d}	0.73^{de}
Plati 2.5%SCG	2.55^{h}	0.75^{cd}
Plati 5%SCG	2.95^{g}	0.70^{de}
Plati 7.5%SCG	3.79^{d}	0.72^{de}
Plati 10%SCG	3.60^{de}	0.67^{ef}
Plati 12.5%SCG	2.02^{i}	0.60^{f}
LSD (5%)	0.34	0.0782
CV%	5.6	6.12

Means followed by the same letter within a column are not significantly different at 5% P level. Where, DWPP=dry weight of pod per plant and PD=pod diameter.

3.3.10. Dry Weight of Pods (g/plant)

For dry weight pod per plant, the interaction effect of variety and spent coffee ground rate were significant ($P<0.05$) (Table 4). In the present study, the highest dry weight of pod was observed from Plati variety combined with recommended rate of NPS which was statistically similar with plati with recommended rate of NPSB while the lowest dry weight of pods was observed from Plati with the application of 12.5% SCG (Table 4). The difference in dry weight of pod among the varieties could be attributed to their genetic makeup. In addition to this, this finding is in line with [8] who reported that aboveground plant biomass of soya bean reduced with application of the SCG compared with untreated control.

3.3.11. Pod Diameter

The main effect of spent coffee ground and varieties did not show significant effect ($P>0.05$) on pod diameter independently (Table 4). However, pod diameter was significantly ($P<0.05$) influenced by the interaction effects of variety and amendments. The maximum pod diameter was obtained as a result of BC4.4 variety with the application of recommended rate of NPS. The minimum pod diameter was recorded from Plati with 12.5%SCG which was statistically similar with the pod diameter registered due to the combined effect of Plati with 10%SCG and BC4.4 with 12.5% SCG (Table 4). This finding was in agreement with the results obtained by [1] who reported that green bean varieties have shown highly significant variations on pod diameter.

The possible reasons for the maximum pod diameter obtained from the highest N application could be due to the increased supply of N fertilizer that may result in more foliage, leaf area and higher supply of photosynthates which may have induced formation for higher pod diameter. In addition to this the minimum pod diameter obtained from the treatment

12.5%SCG might be due to the presence of chlorogenic acid in spent coffee grounds that inhibits plant growth [29].

4. Conclusions

It was found that varieties and amendment of spent coffee ground significantly influenced green bean growth attributes, yield and yield components. Variety Plati produced higher value for plant height, number of leaves, and total pod yield per plant, number of pod per plant and pod length while higher value of pod diameter was recorded from BC4.4.

Pots amended with 2.5% SCG resulted into maximum value for number of nodule. The prolonged days of emergency and flowering was recorded with application of 12.5%SCG. Generally, it can be concluded that spent coffee ground performed less compared with recommended rate of blended fertilizers in other tested response variables. Thus, contrary to our expectation, the highest value for plant height, shoot and root dry weight, fresh weight of root, root volume, number of leaves per plant, number of primary branch, total pod yield, pod length, pod diameter, number of pods and dry weight of pod were observed from the main effect of varieties tested and application of the recommended rate of NPSB and NPS and their interaction effect.

Abbreviations

FAOSTAT	Food and Agricultural Organization Statistical Database
NPSB	Nitrogen Phosphorous Sulfur and Boron
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis Software
SCG	Spent Coffee Ground

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Author Contributions

Felka Mulat: Project administration, coordination, Supervision, Methodology, Data collection, Data analyses and writing orginal-document

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Conflicts of Interest

The authors declare no conflicts of interest.

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