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Growth and phenological responses of selected improved coffee varieties (*Coffea arabica* L.) to Vermicast application

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Abstract

Organic soil amendment is important for sustainable coffee production; however, efforts to establish its scientific basis have been insufficient. This study evaluated the phenological and growth responses of selected CBD-resistant coffee varieties to different vermicast application rates at Wonago, Gedeo, during 2022–2023 under irrigation. A 4 × 6 pot experiment was arranged in a randomized complete block design with three replications. Treatments consisted of four coffee varieties (74112, 74110, Kotti, and Fayate) and six levels of cow dung vermicast (4.5, 6.3, 8.1, 9.9, and 11.7t ha^{-1}, plus a control) were considered as treatments. ANOVA showed that both variety and vermicast significantly affected seedling girth, number of primary branches, leaf number, leaf chlorophyll content, leaf area, specific leaf area, primary branch length, biomass, and dry weight of seven-month-old coffee seedlings. In addition, node number, seedling height, and days to 50% emergence were significantly influenced by the interaction between variety and vermicast. Variety Kotti exhibited the highest biomass, seedling girth, leaf chlorophyll content, leaf area, and specific leaf area, possibly in relation to this variety is native to the study area, while variety 74112 produced the highest number of primary branches, primary branch length, leaf number, and seedling dry weight. Application of 9.9 and 11.7t ha^{-1} vermicast shortened the number of days to first emergence and 50% emergence. As the vermicast rate increased up to 9.9t ha^{-1}, seedling growth improved for most parameters; however, when the rate exceeded 9.9t ha^{-1}, a slight decline was observed, possibly because some growth regulators in the vermicast became dominant in the growth process. Further studies are suggested to determine the levels and types of growth hormones present in cow dung vermicast.

Keywords/Phrases: Growth, Phenology, Varieties, Vermicast

1 Introduction

In Ethiopia, more than 22 million people depend directly or indirectly on coffee for their livelihoods (Sisay, 2018; Woyesa & Kumar, 2021). Approximately 95% of the country's coffee is produced by smallholder farmers, who often face shortages of production inputs and improved technologies required for efficient coffee production (Dida, 2022; Sarirahayu & Aprianingsih, 2018).

In addition, Ethiopian coffee production is constrained by multiple factors, including climate change, poor postharvest handling practices, settlement and resettlement activities, deforestation, low market returns, and inadequate nutrient management (Dida, 2022; Tadesse *et al*., 2020). Among these constraints, nutrient management is one of the most important determinants of coffee productivity and sustainability across different production systems (Wang *et al*., 2015).

Commercial coffee farms generally adopt better nutrient management practices than garden and semi-

forest coffee production systems. In forest coffee production, nutrient supply relies mainly on natural soil amendments such as humus and green manure. However, as in other agricultural lands, soil fertility in many Ethiopian coffee-growing areas has been declining at an alarming rate, requiring substantial intervention to maintain productivity (Maryo *et al.*, 2025; Netsere & Takala, 2021; Tadesse *et al.*, 2020). Deficiencies of essential micronutrients, including zinc (*Zn*), copper (*Cu*), boron (*B*), and molybdenum (*Mo*), have been reported in several coffee-growing regions of the country (Maryo *et al.*, 2025; Netsere & Takala, 2021).

Recently, vermicast has been reported as an excellent source of nutrients and has been shown to improve plant height, leaf number, stem circumference, and leaf area of Robusta coffee seedlings during the three- to six-month growth period (Adhikary, 2012). Beyond nutrient management, coffee variety is also an important factor influencing coffee growth and yield performance (Fufa *et al.*, 2020). Nevertheless, the individual and interactive effects of vermicast application and varietal differences on coffee growth and development have not been adequately examined. Therefore, the present study aims to evaluate the effects of vermicast, coffee varieties, and their interactions on the phenological and growth responses of coffee seedlings.

2 Materials and Methods

The study was conducted at Tumata Chirecha, Wonago, in the Gedeo Zone, on the coffee research farm of the College of Agriculture and Natural Resources, Dilla University. A 4×6 factorial pot experiment was laid out in a randomized complete block design (RCBD) and replicated three times. The treatments consisted of four coffee varieties (74112, 74110, Fayette, and Kotti) obtained from the Jimma Agricultural Research Center, and six rates of cow dung vermicast (4.5, 6.3, 8.1, 9.9, and 11.7$t\ ha^{-1}$) plus a control; these were the two factors studied.

Data were collected on days to first emergence, days to 50% emergence, stem/seedling height at transplanting (cm), number of leaves per plant, specific leaf area (SLA), total leaf area (LA), stem girth (cm), number of primary branches, main branch length, total chlorophyll content, tap root length, biomass yield (g), and total dry weight (g). The collected data were checked for normality using univariate analysis and then subjected to two-way analysis of variance using Statistical Analysis System (SAS) software version 9.4.

Soil Analysis: Soil samples were taken in composite form across the potting media by mixing soils that received the same vermicast rate. The analyses included percentage of organic carbon (OC), percentage of organic matter (OM), available phosphorus (Av. *P*), total nitrogen (TN), cation exchange capacity (CEC), soil pH, and textural class of the media. For all parameters, the procedures were followed according to the (SRD, 2014) soil analysis manual.

3 Results and Discussion

3.1 Effect of vermicast rates on number of days to emergency

Vermicast rate significantly ($P \leq 0.05$) affected the number of days to first emergence. The shortest time to emergence after sowing (44.26 days) was recorded at *R*5(11.7$t\ ha^{-1}$), followed by *R*4(9.9$t\ ha^{-1}$). In contrast, the longest time to emergence (52.99 days) was recorded in the control treatment (*R*6), representing increases of 19.7%, 13.4%, and 12.8% compared to *R*5, *R*4, and *R*3 (8.1$t\ ha^{-1}$), respectively (Figure 1). The shorter time to emergence observed in seedlings treated with the highest rate of cow dung vermicast may be attributed to enhanced seed germination (Nagavallemma *et al.*, 2004). This effect could be associated with increased soil temperature resulting from microbial activity stimulated by earthworm casts (Govindapillai *et al.*, 2018). In addition, improved physicochemical properties of the growing medium—such as increased concentrations and availability of ammonium and nitrate—may help break seed dormancy. Vermicast also improves the moisture-holding capacity of the growing medium (Arancon *et al.*, 2003; Hilhorst & Karssen, 2000).

The findings of the present study are consistent with those of previous research (Arancon *et al.*, 2005; Edwards *et al.*, 1988), which reported that vermicast application significantly improved the emergence of tomato, radish, and cabbage seedlings.

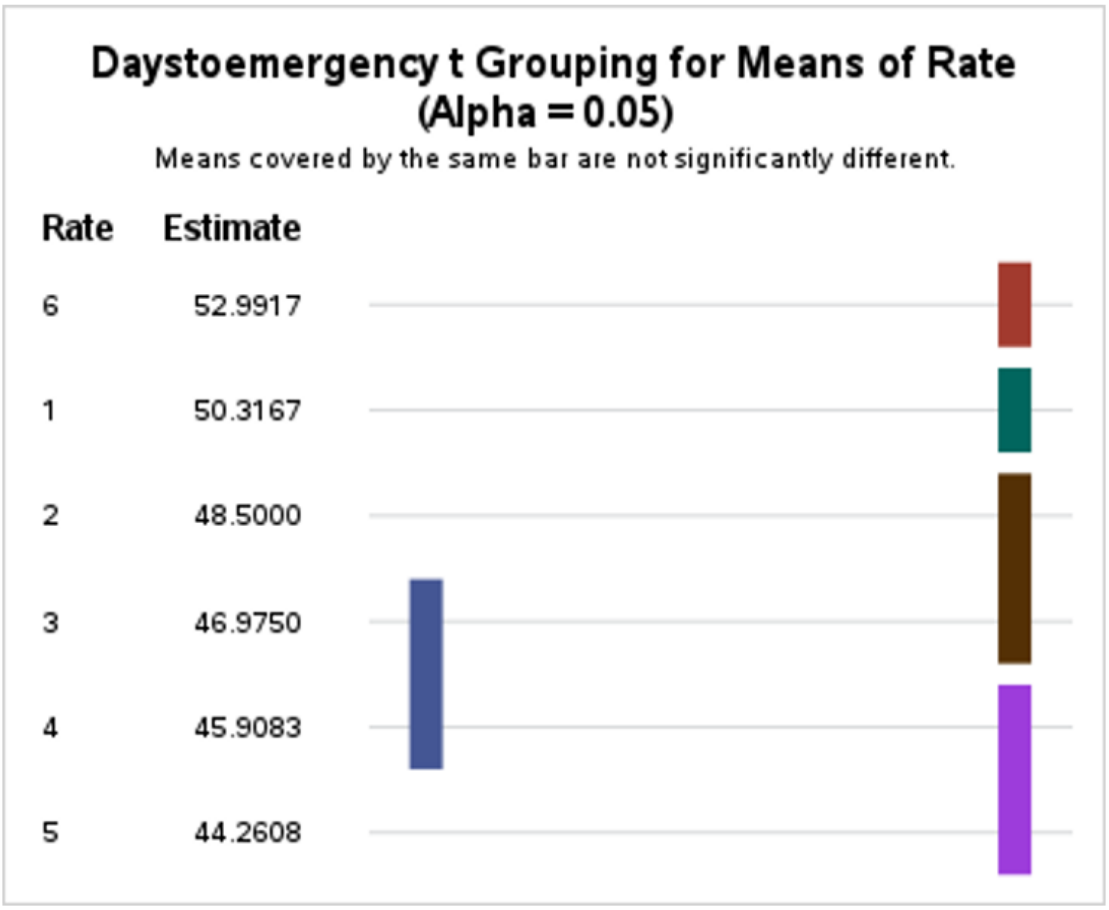


Figure 1. Effects of cow dung Vermicast rate on days to first emergency

3.2 Effect of coffee variety and vermicast rate on number of days to 50% emergency (D50E)

The interaction between coffee variety and vermicast rate significantly ($P \leq 0.05$) affected the number of days from sowing to 50% seedling emergence. The shortest time to 50% emergence (49 days after sowing [DAS]) was recorded from the combination of the Kotti variety and 11.7$t\ ha^{-1}$ ($R5$) vermicast, followed by 74110 $\times$ 11.7$t\ ha^{-1}$ (50.96 DAS), Kotti $\times$ 9.9$t\ ha^{-1}$ (51.00 DAS), and Fayyetae $\times$ 11.7$t\ ha^{-1}$ (51.50 DAS). In contrast, the longest time to 50% emergence was observed in the combinations of 74112 with $R6$ (control) and $R1$, respectively (Figure 2). Increasing the vermicast application rate by at least 15% reduced the number of days required to reach 50% emergence by up to 24%. This reduction may be attributed to enhanced soil temperature resulting from increased microbial activity stimulated by earthworm casts (Govindapillai *et al*., 2018), improved nutrient-use efficiency of the coffee varieties, and increased availability of ammonium and nitrate, which facilitate seed germination and early seedling establishment (Arancon *et al*., 2003; Hilhorst & Karssen, 2000). In addition, vermicast contains higher concentrations of humic substances. Humic acids are known to regulate plant growth by influencing hormonal signaling and physiological response pathways, thereby promoting seed germination and early seedling development (Aline *et al*., 2022; Keiji Jindo, 2020; Norman *et al*., 2006).

The results of the present study are consistent with those reported by Arancon *et al*. (2003) and R.M. Atiyeh *et al*. (2000), who found that vermicast application significantly improved seed germination and several early growth parameters through enhanced nutrient availability and improved soil conditions.

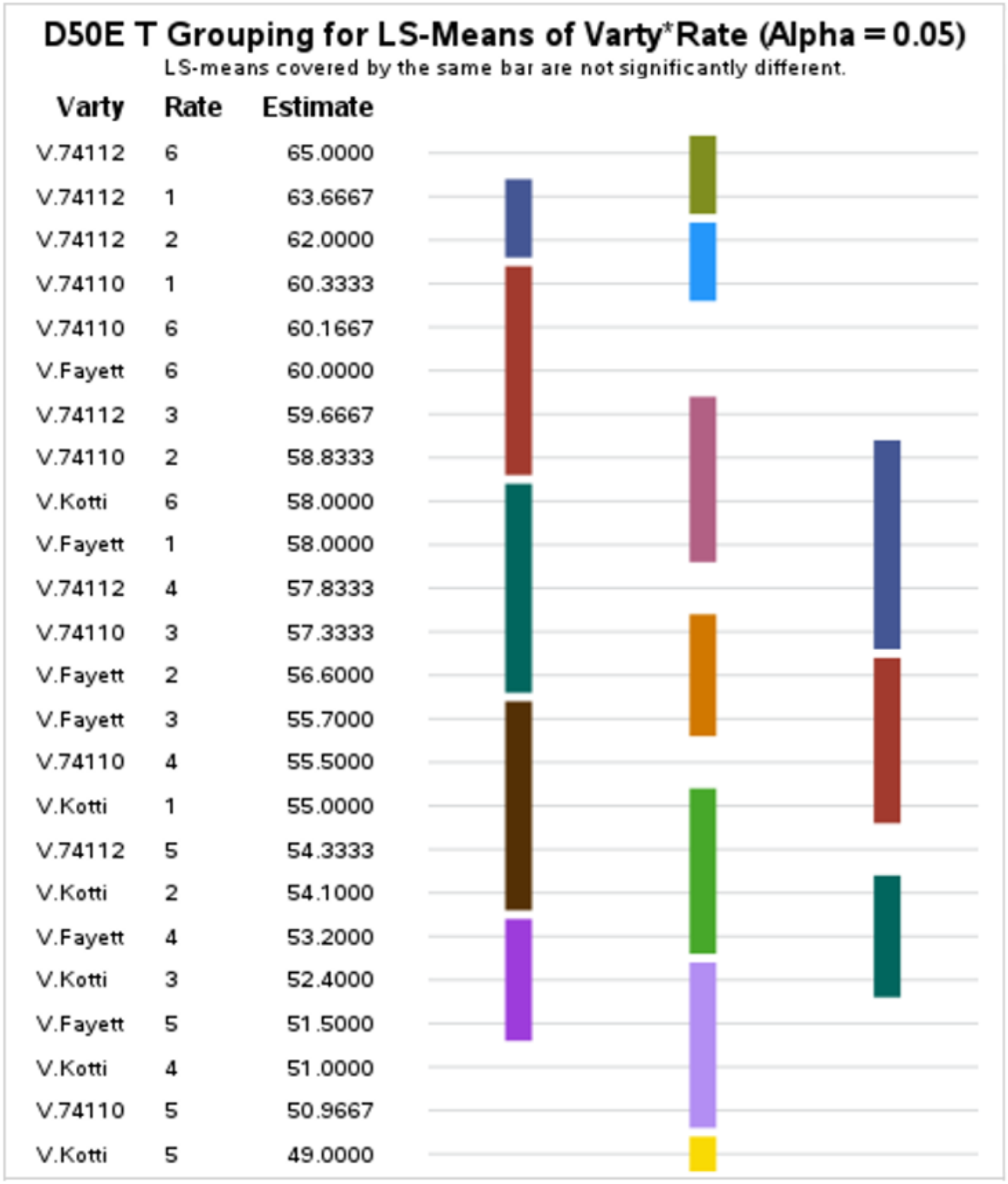


Figure 2. Interaction effect of variety and Vermicast on number of days to 50%

3.3 Effect of Coffee variety and Vermicast rate on the Number of nodes and Seedling height

The interaction between coffee variety and vermicast rate significantly ($P \leq 0.05$) affected the number of nodes (NN) and seedling height (SH). The highest number of nodes (8.0 and 7.9) and seedling heights (53.75 and 53.33*cm*) were recorded in the combinations of Fayette $\times$ *R*4 and 74112 $\times$ *R*5, respectively (Figure 3A and 3B).

Variety Kotti showed the highest response to the greatest vermicast rate for the variables NN and SH, compared with all varieties evaluated in the experiment, except variety 74112. This difference may be associated with the genetic potential of Kotti to utilize phytohormones that may be generated through interactions between microorganisms in the rhizosphere and earthworms in vermicast.

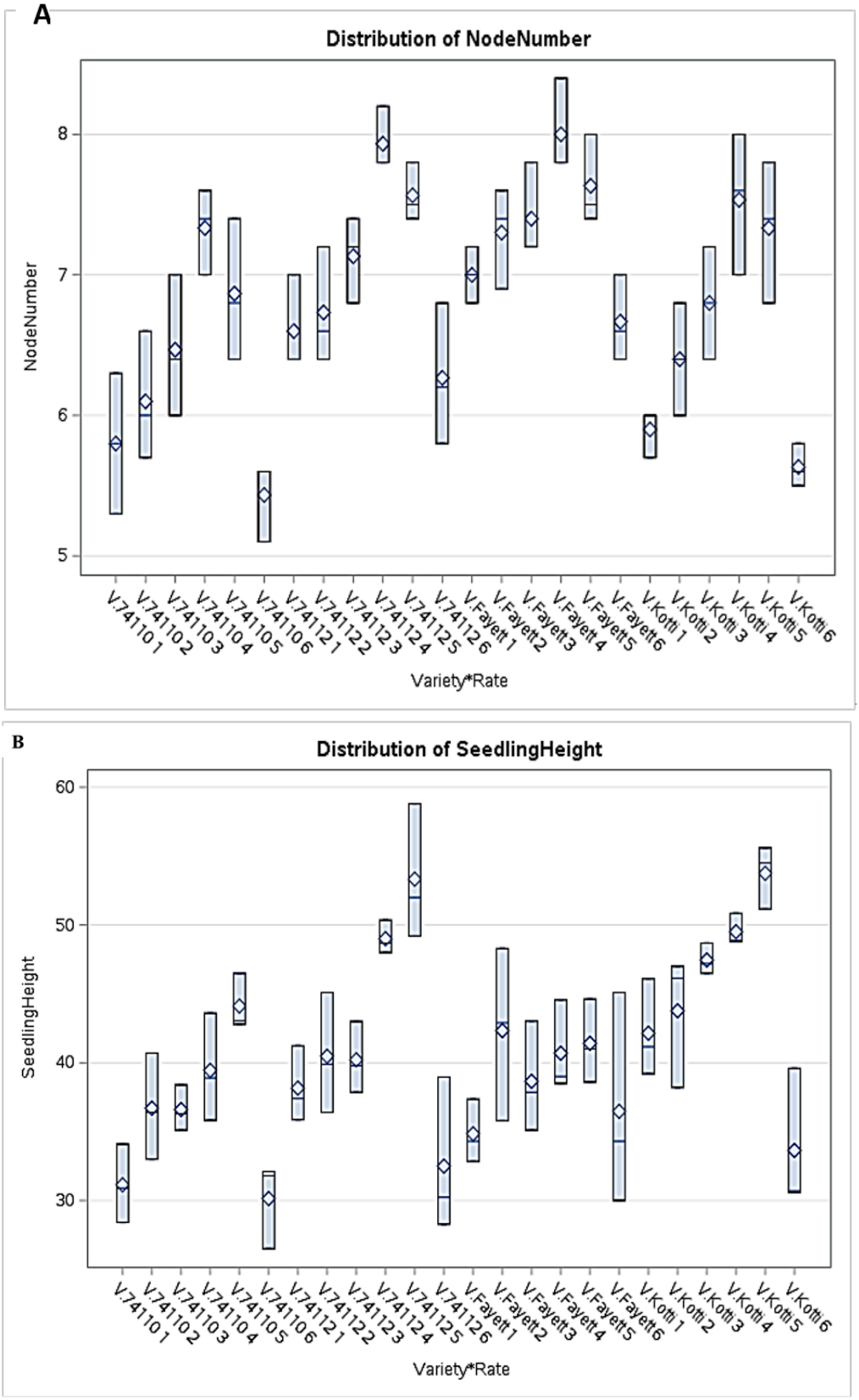


Figure 3. A: Interaction effect of coffee variety and Vermicast rate on Number of Node and height of 7 months aged coffee seedlings; **B:** Number of Node and height of 7 months aged coffee seedlings

Among the coffee varieties tested, Kotti also exhibited a greater response to the highest vermicast rate with respect to both number of nodes and seedling height, although its performance was comparable to that of 74112. The variation in response may be due to differences in the genetic capacity of coffee varieties to utilize growth-promoting substances present in vermicast. Vermicast is known to contain phytohormones and beneficial microorganisms that interact in the rhizosphere, thereby improving nutrient uptake and enhancing plant growth (Rehman *et al*., 2023).

The findings of the present study are in agreement with those reported by Atiyeh *et al*. (2002) and R.M. Atiyeh *et al*. (2000), as well as Govindapillai *et al*. (2018) and Norman *et al*. (2006), who found that vermicast significantly increased the number of nodes and plant height compared with farmyard manure, conventional compost, chemical fertilizer, and commercial synthetic plant growth hormones.

3.4 Effect of coffee variety and vermicast rate on Seedling Girth

Regarding the main effects, both factors significantly ($P \leq 0.01$) affected coffee seedling girth independently. For the variety factor, the thickest seedling girth (4.45cm) was recorded from variety Kotti, followed by 74112 (4.19cm) and Fayette (3.90cm). In contrast, the least seedling girth was obtained from variety 74110, which deviated by 20.2%, 15.3%, and 8.97% from varieties Kotti, 74112, and Fayette, respectively.

Concerning vermicast rate, the highest mean seedling girth (4.64cm)was observed in seedlings treated with $R5$, followed by $R4$, which was statistically comparable with $R3$. The lowest seedling girth was recorded in the control treatment (Table 1).

In living coffee plants, seedling girth is an important indicator of potential crop performance in terms of overall growth and yield. Therefore, only well-vegetatively grown coffee seedlings can achieve good transplanting quality and field establishment. The probable reason for the greater seedling girth observed in variety Kotti may be its genetic capacity to tolerate environmental conditions such as temperature, humidity, and radiation (Debela & Ayalew, 2018), as well as the effects of the vermicast rates applied (Arancon *et al*., 2003; Govindapillai *et al*., 2018).

The present findings are consistent with those reported by Atiyeh *et al*. (2002), R.M. Atiyeh *et al*. (2000), and Norman *et al*. (2006), who found that using vermicast as a nutrient source, either alone or combined with other organic or inorganic fertilizers, increased most growth parameters compared with other fertilizer sources. In addition, the presence of readily available nutrient forms in vermicast —such as NO_3, exchangeable phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) —may further explain the superior performance of vermicast-treated coffee seedlings (Arancon *et al*., 2005; Arora *et al*., 2011; Edwards *et al*., 1988).

3.5 Effect of coffee variety and vermicast rate on Primary Branch number

Seedling branch number is one of the most sensitive indicators of variation among varieties and environmental conditions (Atinafu & Mohammed, 2017). It also determines the crop's yield potential; therefore, differences in the number of primary branches (NPB) among varieties reflect differences in potential growth and yield.

The analysis of variance showed that variety had a highly significant effect ($P \leq 0.01$) on NPB. The observed mean NPB ranged from 1.41 to 2.54 (Table 1). The highest NPB was recorded for variety 74112, whereas the lowest NPB was observed in variety 74110.

Regarding vermicast rates, the highest mean NPB (3.26) was recorded in $R4$, followed by $R5$(2.53). The minimum NPB was obtained from the control treatment (Table 1). Overall, the mean NPB of all vermicast-treated 7-month-old seedlings increased by 54% compared with the control. This improvement may be attributed to enhanced nutrient availability —particularly nitrogen —and the presence of growth-regulating hormones involved in vegetative growth (Arora *et al*., 2011; Debela & Ayalew, 2018; Edwards *et al*., 1988; Govindapillai *et al*., 2018).

According to the review by Theunissen *et al*. (2010), nitrogen plays key roles in several physiological pro-

cesses, including photosynthesis, cell division and differentiation, growth and somatic embryogenesis, chlorophyll content, Rubisco activity, and electron transport rate.

3.6 Effect of coffee variety and vermicast rate on Number of Leaf

Leaf is a vegetative part of the plant where several physiological processes occur, including photosynthesis, respiration, transpiration, phototropism, and photophosphorylation (Faujiah *et al*., 2023). Therefore, increases or decreases in the number of leaves directly influence coffee growth and yield.

Results from the analysis of variance for the main effects indicated that variety had a highly significant effect ($P \leq 0.01$)on the number of leaves (NL). The mean NL among the varieties used ranged from 13.66 to 18.93 (Table 1). The findings of this study showed that variety 74112 had the highest NL, followed by Fayette (16.38). In contrast, variety 74110 produced the lowest mean NL, which differed by 27.8% from variety 74112.

The analysis of variance also showed that vermicast rate had a highly significant effect on NL. The highest mean NL (18.93) was recorded in seedlings treated with *R*4, followed by *R*5(17.55). The lowest NL (12.93) was obtained from seedlings treated with *R*6. The probable reason for the higher NL in the plants treated with larger vermicast rates may be related to the availability and concentration of growth-regulating substances, such as ethylene and cytokinin, which are involved in cell division and differentiation (Abdallah *et al*., 1986; Grapelli *et al*., 1985).

The findings of the present study are consistent with those reported by Indrakumar and Chauhan (2009), who found that vermicast-treated plants performed best compared with inorganic nutrient sources, farmyard manure, and mixtures of these. Similarly, Nijhawan and Kanwar (1951) reported that plants treated with vermicast produced higher mean values than other treatments. Govindapillai *et al*. (2018) also reported that 50% vermicast-treated *Capsicum annuum* (L.) plants showed the best mean leaf number compared with other plant growth enhancers.

3.7 Effect of coffee variety and vermicast rate on Leaf chlorophyll content

The energy of sunlight is first absorbed by plant pigments located in the chloroplasts of leaves. Chlorophyll is a typical pigments that absorb photon energy, consisting primarily of chlorophyll-*a* and an accessory pigment, chlorophyll-*b* (Ying *et al*., 2018). When electrons are excited from their ground state to an excited state through inductive resonance in relation to wavelength, photosynthesis begins (Heber *et al*., 1978). Therefore, biosynthesis and the distribution of substrates in plants are strongly influenced by leaf chlorophyll content (LCC). The analysis of variance (ANOVA) results of the current study show that variety had a highly significant effect ($P \leq 0.05$) on LCC. The observed extremes between the highest and lowest mean chlorophyll contents among the tested coffee varieties were 63.06 and 60.42μmol cm^{-2}, respectively. Variety Kotti was the highest, while the remaining tested varieties produced results that were statistically comparable to one another. In addition to environmental factors (light, temperature, CO_2, and humidity) (EUmRSON, 1929) that affect chlorophyll content, differences in chlorophyll content may also be attributed to genetic differences among the varieties (Ying *et al*., 2018).

Besides variety, vermicast rate also had a significant effect ($P \leq 0.05$) on the LCC of the tested coffee seedlings. The minimum and maximum mean values recorded in the study were 55.07 and 66.88μmol cm^{-2}, respectively. Rate *R*4 was the best, followed by *R*5(64.83) (Table 1). *R*6 showed the least variation, ranging from *R*4 and *R*5 by 17.6% and 15%, respectively. Vermicast is often reported to be rich in nitrogenous nutrients and growth-promoting substances (Nagavallemma *et al*., 2004; Theunissen *et al*., 2010). Nitrogen is involved in several biochemical processes of photosynthesis, including reactions that occur in the chloroplast such as chlorophyll biosynthesis (Theunissen *et al*., 2010). The findings of this study are consistent with those of Atiyeh *et al*. (2000), who reported that using 10% or 20% vermicast mixed with pig solid or food wastes significantly increased chlorophyll content compared with other compost mixtures used in their study.

Table 1. Effect of coffee variety and vermicast rate on Seedling girth, primary branch number, number of leaf and leaf chlorophyll content of 7 months aged coffee seedlings

Factors	Variables			
Variety	SG	PBN	NL	LCC
Kotti	4.45^{A}	2.19^{B}	14.8^{C}	63.06^{A}
74112	4.19^{B}	2.54^{A}	18.93^{A}	60.92^{B}
Fayette	3.90^{C}	1.82^{C}	16.38^{B}	61.34^{B}
74110	3.55^{D}	1.41^{D}	13.66^{D}	60.42^{B}
LSD (P = 0.05)	0.1746	0.2758	0.9867	1.1587
Vermicast Rate				
*R*1	1.34^{E}	3.71^{D}	14.34^{D}	58.57^{E}
*R*2	3.99^{C}	1.72^{D}	15.48^{CD}	60.51^{D}
*R*3	4.15^{BC}	2.12^{C}	16.43^{BC}	62.75^{C}
*R*4	4.35^{B}	3.26^{A}	18.93^{A}	66.88^{A}
*R*5	4.64^{A}	2.53^{B}	17.55^{B}	64.83^{B}
*R*6	3.30^{E}	0.99^{F}	12.93^{E}	55.07^{F}
LSD (P = 0.05)	0.2138	0.3377	1.2085	1.4191
CV %	6.466203	20.63	9.22	2.81

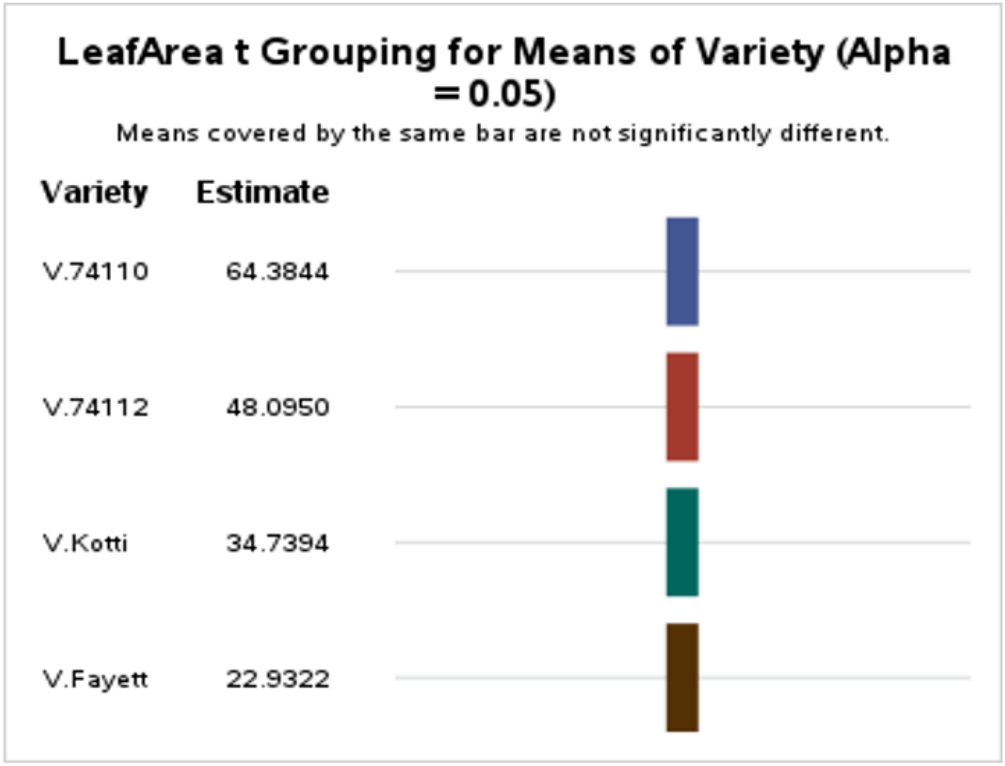
3.8 Effect of coffee variety and vermicast rate on Leaf area (cm^2)

The observed mean value for LA among varieties wide ranged between $66.11cm^2$ and $31.17cm^2$. The highest mean LA recorded from variety Kotti followed by Fayette (51.69) whereas the least mean LA recorded from Variety 74112 (Figure 4A). The genetic variations among varieties, could be a reason for the current variation in mean LA (Gizachew & Hussein 2017; Keiji Jindo, 2020).

This Genotypic variation may also explain the differences in seedling responses to environmental variables in which they grow, and this can provide a good basis for further improvements in the coffee industry (Fikadu *et al*., 2008).

Growth increases of up to 48% were observed in the leaf area of marigold, tomato, green pepper, and cornflower treated with vermicast (Bachman & Metzger, 2008). Leaves are known to function both as a source and a sink—serving as a center for photosynthesis and various physiological processes, as well as for the storage of metabolites such as nitrogen to increase leaf biomass (Adugna *et al*., 2018; Thomas *et al*., 1997).

In this study, *R*5 and *R*4 produced the highest first- and second-ranked mean leaf area (LA) values of 60.10 and 54.49, respectively, followed by *R*3(49.52) (Figure 4B). The increased leaf area observed in largely vermicast-treated seedlings may be due to the availability and concentration of nutrients and growth-promoting hormones that support vegetative growth in coffee seedlings (Arancon *et al*., 2003; Debela & Ayalew, 2018; Edwards *et al*., 1988). The findings of the present study are consistent with those reported by Arancon *et al*. (2005), who established that humic acid extracted from vermicast using the citric acid/alkaline fractionation technique increased the leaf area of tomato. They also reported that $1kg$) of vermicast has the potential to yield $4g$ of humic acid. Furthermore, applying 15^{th} of vermicast increased growth variables, including leaf area (Chandan & Azad 2015)



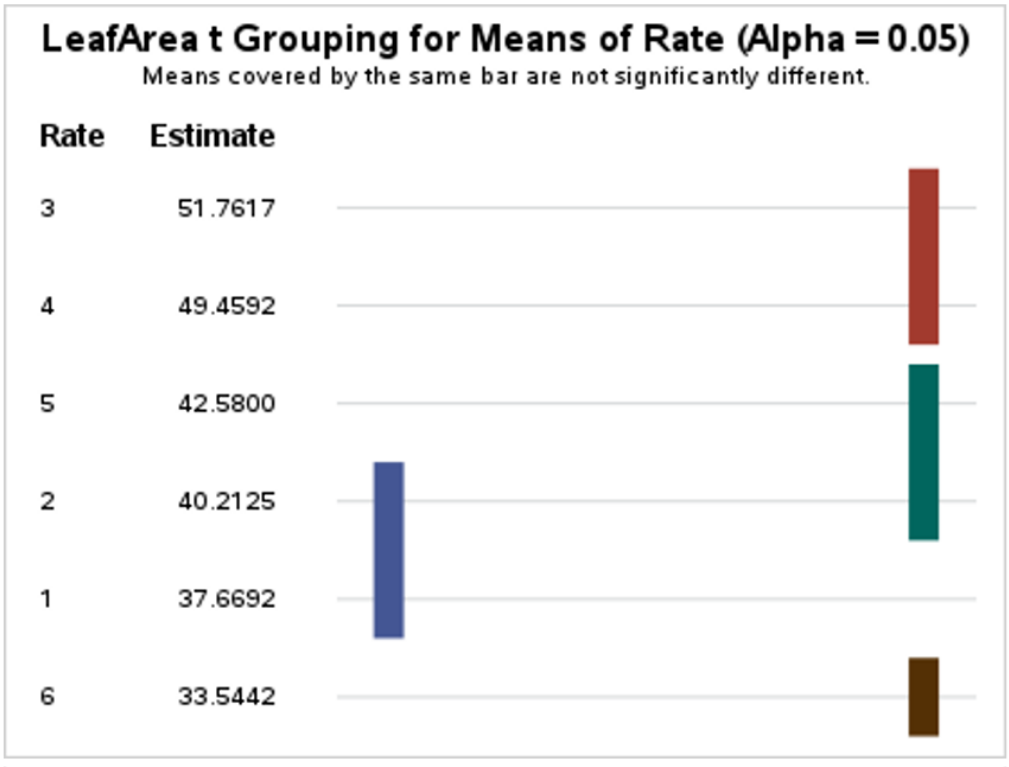


Figure 4. A: Effect of variety on Leaf area of 7 months aged coffee seedlings; **B:** Effect of Vermicast rate on Leaf area of 7 months aged coffee seedlings

3.9 Effect of variety and vermicast rate on Specific Leaf area (cm^2)

Specific leaf area (SLA) measures leaf thickness and is one of the most important traits in its sensitivity to environmental conditions (Amanullah *et al*., 2007). SLA is also a preferred soft plant trait for assessing soil fertility compared with leaf dry matter content (LDMC) (Hodgson *et al*., 2011). Higher SLA generally indicates greater potential productivity and a better relative growth rate (Li *et al*., 2004; Poorter, 2001).

The highest SLA value ($64.38cm^2$) was recorded from variety 74110, followed by $48.09cm^2$ and $30.66cm^2$ for varieties 74112 and Fayette, respectively (Table 2). The possible reason for the higher SLA of variety 74110 may be its greater photosynthetic capacity and improved nutrient-use efficiency, which are genetically regulated (Arancon *et al*., 2003).

Table 2. Effects of coffee variety and vermicast rate on Specific leaf area, primary branch length, dry weight of 7 months aged coffee seedlings

Factors	Variables		
Variety	SLA	PBL	DW
Kotti	34.74^{C}	14.51^{B}	26^{B}
74112	48.09^{B}	16.20^{A}	30.78^{A}
Fayette	22.93^{D}	12.84^{C}	19.05^{C}
74110	64.38^{A}	11.11^{D}	21.72^{C}
LSD (P = 0.05)	2.35	1.62	2.8718
Vermicast Rate			
*R*1	37.67^{C}	10.16^{E}	18.58^{E}
*R*2	40.21^{BC}	12.58^{D}	22.25^{D}
*R*3	51.76^{A}	14.75^{C}	26^{C}
*R*4	49.46^{A}	19.39^{A}	34.58^{A}
*R*5	42.58^{B}	17.35^{B}	30.16^{B}
*R*6	33.54^{D}	7.77^{F}	14.75^{F}
LSD (P = 0.05)	3.33	1.98	3.51
CV %	9.52	17.69	17.55

Among the vermicast rates, the highest and statistically comparable mean SLA values were $51.89cm^2$ and $49.32cm^2$, recorded for *R*3 and *R*4, respectively. In contrast, *R*6 produced the least mean value ($32.96cm^2$) (Table 2). The nutrient content of vermicast is often higher and more readily available than that of other organic nutrient sources used in different studies (Govindapillai *et al*., 2018; Grapelli *et al*., 1985; Indrakumar & Chauhan, 2009). The promotion of plant growth by nutrients and growth-promoting substances such as *N*, *P*, and *K* involves several physiological processes that directly influence plant development. Therefore, the variations observed among treatments may be associated with improved soil physicochemical properties resulting from the increased vermicast rate applied (Arancon *et al*., 2005; Atiyeh *et al*., 2002).

3.10 Effect of coffee variety and vermicast rate on Primary branch length

Primary branches and lateral branches are responsible vegetative parts of the coffee tree that help determine the number of secondary lateral branches and inflorescences (Adriana & Thiago, 2015). The analysis of variance showed that the main effects of variety and vermicast rate were significant ($P \leq 0.01$) for primary branch length (PBL).

For the tested varieties, the mean PBL ranged from 11.11 to $16.21cm$. Variety 74112 produced the highest mean PBL, followed by variety Kotti ($14.51cm$) and Fayette ($12.85cm$) (Table 2). Similarly, the mean PBL values across vermicast rates ranged from 7.77 to $19.40cm$. The highest mean PBL was recorded for seedlings treated with *R*4 (followed by *R*5 at $17.35cm$ and *R*3 at $14.75cm$), whereas the control treatment produced the least mean value (Table 2).

The differences observed among the mean PBL values of the tested varieties and vermicast rates may be due to genetic variability and their interaction with the environment (Fikadu *et al*., 2008; Keiji Jindo, 2020). In addition, improvements in the physicochemical properties of the growing medium, which depend on the level of vermicast applied, may also explain the variation (Debela & Ayalew, 2018). The results of this study are consistent with findings reported by Arancon *et al*. (2005) and Atiyeh *et al*. (2000), who reported that nutrients and humic acid in vermicast improved plant growth in their experiments.

3.11 Effect of variety and vermicast rate on seedling dry weight

Seedling dry weight (DW) influences leaf photosynthetic capacity and the plant's nutrient-using capacity by reflecting nutrient availability and uptake ability of nutrients supplied through vermicast (Arancon *et al*., 2005; Atiyeh *et al*., 2002; Sheng & Hunt, 1991). The highest mean DW (30.78*g*) was recorded for variety 74112, while the lowest (19.05*g*) was recorded for Fayette (Table 2). Variety 74112 was superior to all other tested varieties, possibly due to its efficient nutrient uptake and utilization (Sheng & Hunt, 1991).

With respect to vermicast rate, seedlings treated with *R*4 recorded the highest mean DW (34.58*g*) compared with all other rates (Table 2). Increasing the vermicast rate up to a certain level increased the DW of the coffee seedlings. This may be because vermicast improves the availability and uptake ability of both nutrients and growth regulators (Arancon *et al*., 2003; Arancon *et al*., 2005; Stancheva & Mitova, 2002).

The results of the post-experimental soil analysis further showed that all growing media amended with vermicast had increased total nitrogen (TN), phosphorus (*P*), percent organic carbon (%OC), and organic matter (OM).

3.12 Effect of coffee variety and vermicast rate on seedling biomass

The interaction between vermicast rate and variety had a significant ($P \leq 0.05$) effect on seedling biomass (BM). The highest BM (62.17*g*) recorded from variety Kotti when treated with *R*4 while the least mean value recorded from variety Fayette when treated as control (Figure 5). One of the possible reasons for variation in BM among evaluated seedlings is change in physiology that influenced by growth regulating hormones which impacts are mainly in relation to micro flora and /microbial metabolites that are capable of influencing plant metabolism, growth and development (Edwards *et al*., 1988; Tomati; *et al*., 1988). The level of reaction of seedlings to growth hormones that are contented in vermicast and nutrients such as *N* use efficiency is possibly associated to the genetic condition of the seedlings (Herminia *et al*., 2020). This result is in line with the findings of (Arancon *et al*., 2003; Arancon *et al*., 2005) who reported that Vermicast as organic nutrient source significantly improved seedlings biomass.

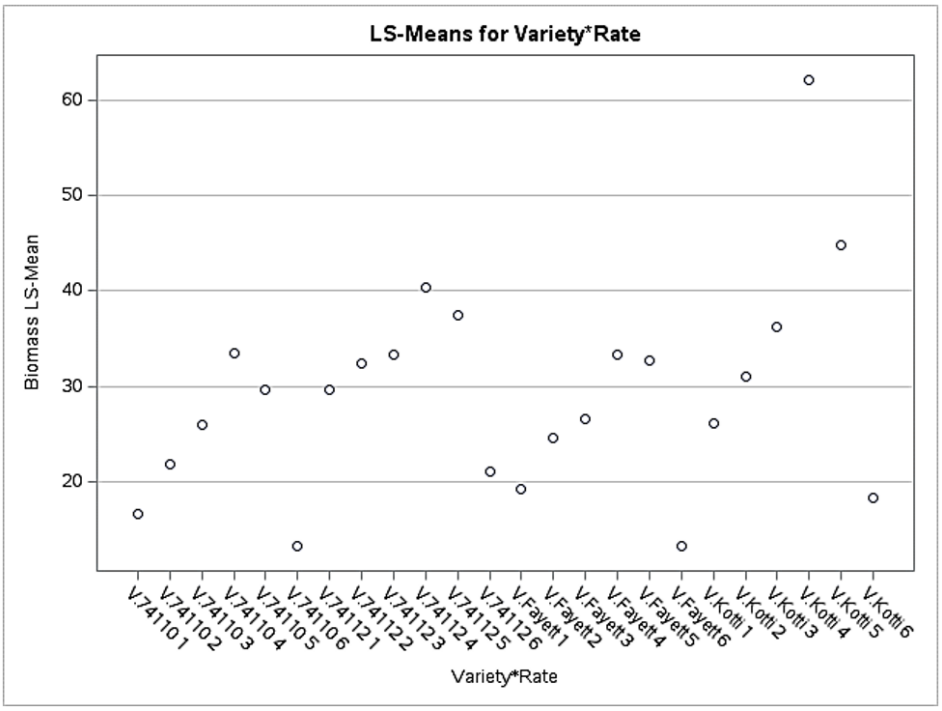


Figure 5. Effect of variety and Vermicast rate on seedling Biomass of 7 months aged coffee seedlings

4 Summary and Conclusion

In this study, twelve variables were evaluated to determine how selected improved coffee varieties responded to different vermicast application rates.

The results of the analysis revealed that both factors significantly affected 50% emergence, number of nodes, and seedling height. Both factors also significantly influenced seedling girth, number of primary branches, number of leaves, leaf chlorophyll content, leaf area, specific leaf area, primary branch length, biomass, and dry weight. However, only vermicast application rate significantly affected days to first emergence, whereas variety had no significant effect.

For most of the evaluated variables, the trends in the graphs showed that increasing the vermicast application rate enhanced coffee seedling growth up to a certain level. Growth, however, began to decline when the application rate exceeded $9.9t\ ha^{-1}$. This reduction may be attributed to vermicast phytohormones reaching concentrations that negatively affect growth processes. The findings are consistent with approximately 95% of previous studies on vermicompost, which reported that vermicast improves plant growth up to an optimum concentration due to its nutrient content, phytohormones, and humic substances (Oyege & Balaji Bhaskar, 2023; Prisa & Jamal, 2025; Rehman *et al*., 2023).

The mechanisms controlling the availability, uptake, and activity of growth-promoting substances in vermicast are not yet fully understood. Further research is therefore needed to identify the types and concentrations of growth hormones present in cow dung vermicast, how they distribute and persist in the growing medium, their uptake by coffee seedlings, and the threshold concentrations beyond which they no longer promote growth.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Abdallah, M.M.F., Smith, A.R., & Hall, H.A. (1986). Effect of soil application of chloroethylphosphonic acid upon the growth and yield of tomatoes. *Acta Horticulturae*, 383-387.

Adhikary, S. (2012). Vermicompost, the story of organic gold: A review. *Agricultural sciences*, 3(7), 905-917.

Adriana, F., & Thiago, F.d.S. (2015). The coffee plant and beans: An introduction. *Elsiever Inc*, 5-9.

Adugna, D., Bote, Zewdneh, Z., Fikre, L.O., & Jan, V. (2018). Analysis of coffee (*Coffea arabica* L.) performance in relation to radiation level and rate of nitrogen supply II. Uptake and distribution of nitrogen, leaf photosynthesis and first bean yields. *European Journal of Agronomy*, 92, 107–114.

Aline, C.S., Fábio, L.O., Lázaro, E.P.l., Alessandro, P., & Luciano, P.C. (2022). *Plant hormone crosstalk mediated by humic acid* (Vol. 9). Chemical and biological technologies in Agriculture.

Amanullah, M.J., Nawab, K., & Ali, A. (2007). Response of specific leaf area (SLA), leaf area index (LAI) and leaf area ratio (LAR) of maize (*Zea mays* L.) to plant density, rate and timing of nitrogen application. *World Applied science Journal*, 2, 235-243.

Arancon, Edwards, C.A., Bierman, P., Metzger, J.D., & Lee, S.W., C. (2003). Effects of vermicomposts on growth and marketable fruits of field-grown tomatoes, peppers and strawberries. *Pedobiologia*, 47.

Arancon, Norman, Q., Edwards, C.A., Bierman, P., & James, D.M. (2005). Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field. *Pedobiologia*, 49, 297—306.

Arora, V., Singh, C., Sidhu, A., & Thind, S. (2011). Irrigation, tillageand mulching effects on Soybean yield and water productivity in relation to soil texture. *Agric Water Manag*, 98(4), 563-568.

Atinafu, G., & Mohammed, H. (2017). Association and Path Coefficient Analysis of Yield and Yield

Attributes of Coffee (*Coffea arabica* L.) Under Sidama Specialty Coffee Growing Area, Awada, Southern Ethiopia. Adv Crop Sci Tech, 5, 307.

Atiyeh, R.M., Arancon, N.Q., Edwards, C.A., & Metzger, J.D. (2002). The influence of earthworm-processed pig manure on the growth and productivity of marigolds. *Bioresour. Technol.*, 81, 103–108.

Atiyeh, R.M., S, S., C, A.E., & G, B. (2000). Effects of vermicomposts and composts on plant growth in horticultural container media and soil. *Pedo biologia*, 44, 579–590.

Atiyeh, R.M., Subler, S., Edwards, C. A., & Bach, G. (2000). Effects of vermicomposts and composts on plant growth in horticultural container media and soil. *Pedo biologia*, 44, 579–590.

Bachman, G.R., & Metzger, J.D. (2008). Growth of bedding plants in commercial potting substrate amended with vermicompost. *Bioresource Technology*, (99), 3155–3161.

Chandan, S., Ahirwar, & Azad, H. (2015). Effect of Vermicompost on Growth, Yield and Quality of Vegetable Crops. *International Journal of Applied And Pure Science and Agriculture*, 1(8), 50-56.

Debela, A., & Ayalew, B. (2018). Shade and Nitrogen Levels Affected Physiological and Leaf Characteristics of Coffee.

Dida, G. (2022). Coffee production: Opportunities, challenges and genetic diversity in Ethiopia. *International Journal of Research Studies in Agricultural Sciences*, 8(3), 1-9.

Edwards, Clive, A., & Burrows, I. (1988). *The potential of earthworm composts as plant growth media*..

EUmRSON, R. (1929). Chlorophyll content and rate of photosynthesis. *Journal of General Physiology*, 15.

Faujiah, N.R., Dandan, Z., Yihui, Z., Runxian, S., Cheng, L., Jingjuan, L., & Jianwei, G. (2023). The Roles of Gibberellins in Regulating Leaf Development. *Plants*, 12, 1243.

Fikadu, T., Melaku, A., Bayetta, B., Behilu, A., Tadesse, B., & Ashenafi, A. (2008). Developing improved pureline coffee varities for different coffee growing areas of Ethiopia. 62-69.

Fufa, N., Bekele, D., & Ibirahim, J. (2020). Adaptability and performance evaluation of coffee (*Coffea arabica* L.) varieties on growth, yield and assosiation of traits at mid highland area of Western Ethiopia. *Ecology and Evolutionary Biology*, 5(4), 159-163.

Gizachew, A., & Hussein, M. (2017). gro-Morphological Characterization of Sidama Coffee (*Coffea arabica* L.) Germplasm Accession under its Specialty Coffee Growing Area, Awada, Southern Ethiopia. *International Journal of Research Studies in Science, Engineering and Technology*, 4(12), 11-23.

Govindapillai, S.R., Patheri, K.K., Devani, E., Mundarath, P.S., & Vellaore, N.M. (2018). Effects of vermicompost and plant growth enhancers. 8, 83–88.

Grapelli, A., Tomati, U., Galli, E., & Vergari, B. (1985). Earthworm casting in plant propagation. *HortScience*, 20, 874–876.

Heber, U., Egneus, H., Hanck, U., Jensen, M., & Koster, S. (1978). Regulation of photosynthetic electron transport and phosphorylationin intact chloroplasts and leaves of Spinacia oleracea L. *PLanta*, 143, 41-49.

Herminia, E.P.M., Bruna, P.d.S., Eveline, T.C., Felipe, P.d.C., & Junia, M.C. (2020). Water deficit changes nitrate uptake and expression of some Nitrogen related genes in coffee plants (*Coffea Arebica* L.). *Scientia Horticalturae*, 267.

Hilhorst, H.W.M., & Karssen, C.M. (2000). Effect of chemical environment on seed germination. In Seeds: *The Ecology of Regeneration in Plant Communities*, 293–310.

Hodgson, J.G., Montserrat-Martı, G., Charles, M., Jones, G., Wilson, P., & B. Shipley, M.S.B.E.L.C., J.H.C. Cornelissen, S.R. Band, A. Bogard, P. Castro-D ´ez, &J. Guerrero-Campo. (2011). Is leaf dry matter content a better predictor of soil fertility than specific leaf area? *Annals of Botany*, 108, 1337–1345.

Indrakumar, S.N., & Chauhan, J., S. (2009). Response Of French Bean (*Phaseolus Vulgaris* L.) To Organic Manures And Inorganic Fertilizer On Growth & Yield Parameters Under Irrigated Condition. *Nature and Science*, 52-54.

Keiji Jindo, L.P.C., Alfonso Albacete, Lidiane Figueiredo dos Santos, Rafael Luiz Frinhani Rocha, Daiane Carvalho Baia, Natália Oliveira Aguiar Canellas, Travis Luc Goron, & Fábio Lopes Olivares (2020). *Interaction between Humic Substances and Plant Hormones for Phosphorous Acquisition*, (Vol. 10). Agronomy

Li, Y., Douglas, A., Johnson, Y.S., Jianyuan, C., & Tonghui, Z. (2004). Specific leaf area and leaf dry matter content of plants growing in sand dunes. *Bota Bulletin of Academia Sinica*, 46, 127-134.

Maryo, M., Fitamo, D., & Kebede, F. (2025). Soil fertility status and nutrient management implications for Arabica coffee (*Coffea arabica* L.) in the Gedeo Zone's agroforestry systems, Southern Ethiopia. *Agroforestry Systems*, 99(8), 1-20.

Nagavallemma, K., Wani, S., Lacroix, S., Padmaja, V., Vineela, C., Babu, R.M., & Sahrawat, K. (2004). *Vermicomposting: Recycling wastes into valuable organic fertilizer*. 20.

Netsere, A. & Takala, B. (2021). Progress of soil fertility and soil health management research for arabica coffee production in Ethiopia. *Plant*, 9(3), 70-80.

Nijhawan, S. & Kanwar, J. (1951). Physio-chemical properties of earth worm casting and their effect on the productivity of soil. *India JAgric Sci*, 22(4), 357-373.

Norman, Q.A., Clive., A.E., & Stephen, L. (2006). Effects of humic acids from vermicomposts on plant growth, (Vol. 42). *European Journal of Soil Biology*.

Oyege,I. & Balaji Bhaskar, M.S. (2023). Effects of vermicompost on soil and plant health and promoting sustainable agriculture. *Soil Systems*, 7(4), 101.

Poorter, L. (2001). Light-dependent changes in biomass allocation and their importance for growth of rain forest tree species. *Func Ecol*, 15, 113-123.

Prisa, D. & Jamal, A. (2025). Vermicompost in agricultural production: Mechanisms, importance, and applications. *Multidiscip. Rev*, 8, 2025325.

Rehman, S.U., De Castro, F., Aprile, A., Benedetti, M., & Fanizzi, F.P. (2023). Vermicompost: Enhancing plant growth and combating abiotic and biotic stress. *Agronomy*, 13(4), 1134.

Sarirahayu, K. & Aprianingsih, A. (2018). Strategy to improving smallholder coffee farmers productivity. *The Asian Journal of Technology Management*, 11(1), 1-9.

Sheng, Q. & Hunt, L. A. (1991). Shoot and root dry weight and soil water in wheat, triticale and rve. *Can. J. Plant Sci*., 71, 4f-49.

Sisay, B.T. (2018). Coffee production and climate change in Ethiopia. *In*: Sustainable agriculture reviews 33. *Climate impact on agriculture*, (pp. 99-113). Springer.

SRD, J. (2014). *Soil Analysis Manual*. RECS International Inc.& NTC International Co., Ltd

StAnchevA, I. & MitovA, I. (2002). Effects of different sources and fertilizer rates on the lettuce yield and quality under controlled conditions. *Bulgarian Journal of Agricultural science*. 8(2/3), 157-160.

Tadesse, T., Tesfaye, B., & Abera, G. (2020). Coffee production constraints and opportunities at major growing districts of southern Ethiopia. *Cogent Food & Agriculture*, 6(1), 1741982.

Theunissen, J., Ndakidem, P.A., & Laubsche, C.P. (2010). Potential of vermicompost produced from plant waste on the growth and nutrient status in vegetable production. *International Journal of the Physical Sciences*, 5(13), 1964-1973.

Thomas, C.V., Smith, W.K., DeLucia, E.H., Bell, D.T., & Shepherd, K A. (1997). Leaf Form and Photosynthesis: Do leaf structure and orientation interact to regulate internal land carbon dioxide? *BioScience*, 47, 785-792.

Tomati, U., Grappeili, A., & Gail, E. (1988). The hormone-like effect of earthworm casts on plant growth. *Biol Fertil Soils*, 5, 288-294.

Wang, N., Jassogne, L., van Asten, P. J., Mukasa, D., Wanyama, I., Kagezi, G., & Giller, K. E. (2015). Evaluating coffee yield gaps and important biotic, abiotic, and management factors limiting coffee production in Uganda. *European Journal of Agronomy*, 63, 1-11.

Woyesa, T. & Kumar, S. (2021). Potential of coffee tourism for rural development in Ethiopia: a sustainable livelihood approach: T. Woyesa, S. Kumar. *Environment, development and sustainability*, 23(1), 815-832.

Ying, L., Nianpeng, H., Jihua, H., Li, X., Congcong, L., Jiahui, Z., Qiufeng, W., Ximin, Z., & Xiuqin, W. (2018). Factors Influencing Leaf Chlorophyll Content in Natural Forests at the Biome Scale. *Front. Ecol. Evol.*, 6(64).