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Response of Mung Bean (Vigna Radiata (L.) R. Wilczek) Varieties to Bradyrhizobium Inoculation at Gimbo District, Southwestern Ethiopia

Andualem Gadisa [1],*, Degife Asefa [2], Dereje Tsegaye [2]

Abstract

Globally, mung beans are grown in tropical and subtropical climates as an essential pulse crop. However, lack of appropriate nutrient management combined with the best responsive varieties is a major problem in enhancing productivity of mung bean. Thus, this field experiment was conducted in Gimbo district, Southwest Ethiopia, during the 2024–2025 rain-fed cropping season to evaluate the response of mung bean varieties to Bradyrhizobium inoculation. The treatments comprised factorial combinations of four improved mung bean varieties (Rasa, Boreda, NVL-1, and Showarobit), two Bradyrhizobium (with and without inoculation). Three replications of a randomized complete block design were used to set up the treatments in a factorial experiment. Analysis of variance revealed that two-way interaction of Bradyrhizobium with varieties significantly affected phenology and yield components of mung bean. The results indicated that the interaction effects of Bradyrhizobium with variety showed significantly ($p < 0.05$) highest grain yield (2.48 t ha^{-1}) compared to others. According to the partial budget analysis, a high net benefit (Birr 77,700.00) was obtained at inoculation of Bradyrhizobium. Therefore, for optimal mung bean grain yield, the Bradyrhizobium inoculation and the Showarobit variety was recommended under rain-fed conditions at Gimbo district and areas with similar agro-ecological zone. However, further study is needed across different locations and seasons for conclusive recommendation.

Keywords: Bradyrhizobium inoculation, grain yield, improved varieties, mung bean, rain-fed agriculture

INTRODUCTION

Background and Justification

Mung bean (*Vigna radiata* (L.) R. Wilczek) is an environmentally friendly, drought-resilient crop cultivated widely across the tropics and subtropics, including East Africa [4, 37]. In Ethiopia, it is a relatively new pulse crop with production potential primarily in the Amhara and Benishangul Gumuz regions, and it is notable for its high marketable surplus, estimated at around 90% [11, 22]. Beyond its grain, the plant is also valued as a palatable and digestible fodder [14]. The mung bean's capacity to develop a symbiotic association with Rhizobia bacteria, allowing for Biological Nitrogen Fixation (BNF), is a major agronomic advantage. This process can contribute significantly to soil fertility and plant development, providing between 17–80 kg N ha^{-1}, with an average of roughly 63 kg N ha^{-1} [15, 16]. Furthermore, the correct application of nitrogen fertilizer can synergize with the plant's natural BNF, potentially boosting mung bean output

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by 20–45% [15]. Biological nitrogen fixation (BNF) through the symbiosis of mung bean and bacteria like *Bradyrhizobium* is a proven, eco-friendly method to reduce reliance on synthetic nitrogen fertilizers by converting atmospheric nitrogen into a plant-available form [1, 7, 15].

In Ethiopia, mung bean is a promising, drought-tolerant crop, yet a significant yield gap exists between research stations (1.650 t ha^{-1}) and farmer fields (1.074 t ha^{-1}) [9, 10]. This low productivity is attributed to a lack of improved varieties, pests, diseases, and poor agronomic practices, exacerbated by farmer inexperience in newer growing regions like the southwest [10]. Although several improved mung bean varieties have been released for different agro-ecological zones [20], a critical research gap remains. Specifically, there is a lack of information on the response of these varieties to the combined application of bio-fertilizers (like *Bradyrhizobium*) and no locally recommended application rates exist. Therefore, this research is initiated to evaluate the response of mung bean varieties to *Bradyrhizobium* inoculation in Gimbo, southwest Ethiopia, to address this gap.

MATERIAL AND METHODS

Description of the Study Area

The study was conducted during the 2024 cropping season in the Gimbo district (Shombakichib farmer field), Kafa Zone, Southwest Ethiopia. In Figure 1, the site is located at 07°39' N, 36°31' E, at an altitude of 1464 meters above sea level, approximately 426 km southwest of Addis Ababa. With an average annual temperature of 21.4 °C and an average annual rainfall of 1710 mm, the climate is described as semi-arid. According to Tiruneh [35], the soil at the experimental site is a volcanic-origin clay loam, classified as an andosol with a slightly to moderately acidic pH range of 5.5–6.5. The region supports diverse agriculture. The primary staple crops are rice and maize, supplemented by sorghum, wheat, and pulses like common beans. The area also produces fruits, including bananas and mangoes, and vegetables such as tomatoes, onions, and peppers.

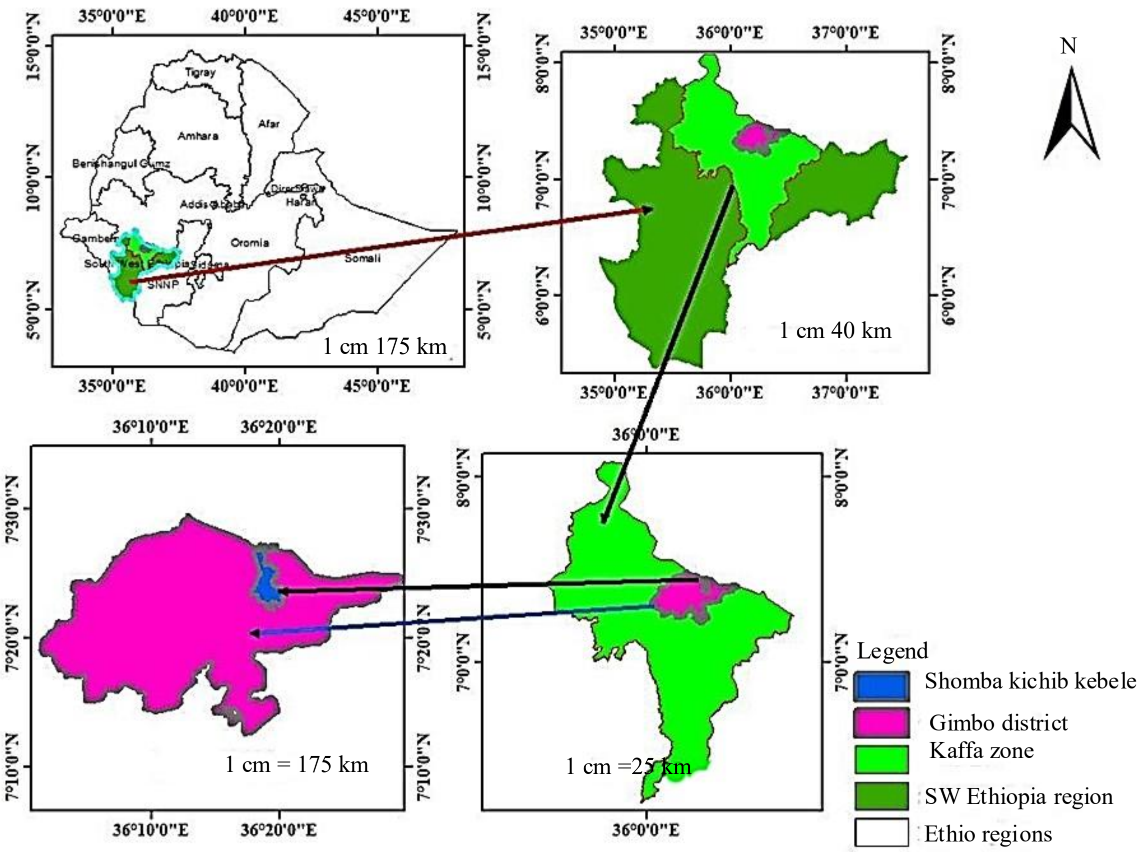

Figure 1. Location map of the study area.

Table 1. Morphological characteristics of Mung bean varieties.

Characteristics	Varieties			
	Boreda	***Rasa(N26)***	***Showarobit***	***NVL-1***
Altitude(m.a.s.l)	900–1,670	900–1,670	900–1,670	450 1,650
Rainfall(mm)	350–550	350–550	350–550	350–550
Temperatures	27-30ºc	27-30ºc	27-30ºc	27-30ºc
Maturity group	Medium	Medium	Medium	Medium
Flower color	White	Yellow	White	Yellow
Yield in research field (kgha^{-1})	1350	1500	1500	1500
Yield in farmer field (kgha^{-1})	1000	500-1000	500-1000	500-1000
Yearof release	2008	2011	2011	2014
Breader	AWRC	MARC	MARC	MARC

Source: [19, 24, 25, 26]

Experimental Materials

In Table 1, the experimental materials used for the study were mung bean varieties (Showarobit, Boreda, Rasa, and NVL-1) which were obtained from Gondar Agricultural Research Centers and Debre Berhan Agricultural Research Centers. *Bradyrhizobium* strain which was purchased from Addis Ababa Menagesha Biotech, Private Company and applied as per the company's recommended rate 500 g ha^{-1} was used for the study.

Treatments and Experimental Design

The treatments consisted of 4x2 factorial combinations of four improved mung bean varieties (Boreda, Showarobit, Rasa, and NVL-1) with two levels of *Bradyrhizobium* inoculation (with and without inoculation). The study used a randomized complete block design (RCBD) and was repeated three times for each treatment in a factorial combination. There were eight treatments in all, with a distance of one and half meters between blocks and plots, respectively. Each treatment has a 3 m x 1.8 m (5.4 m^2) area. Having net plot size of 3 m x 1.2 m (3.6 m^2) consisted of four central rows. The spacing between plant and rows was 10–30 cm respectively.

Experimental Procedures, *Bradyrhizobia* Inoculation, and Agronomic Managements

The field was prepared between June and July 2024 using oxen for primary tillage and was harrowed twice by hand. The soil was cleared of debris and leveled before the experimental layout was established, with treatments assigned randomly to plots. A critical pre-planting treatment involved seed inoculation with *Bradyrhizobium* bacteria. Specifically, 0.27 g of the strain per plot was mixed with 10 mL of a 5% (w/v) 0.5 g sugar solution, which served as an adhesive. The mung bean seeds were soaked in this mixture to ensure uniform coating, facilitating rapid bacterial colonization after germination. The coated seeds were then shade-dried for approximately 30 minutes. Sowing took place on August 30, 2024, with two seeds placed per hill. These were later thinned to a single plant per hill after establishment. Fertilizer was applied at sowing using a hand-drilling method within the rows. All other management practices were uniformly applied across all plots in accordance with the official recommendations for mung bean production.

Crop Data Collection

The data was recorded for phenological parameters that included days to 50% flowering and days to 90% physiological maturity. The data was recorded for growth parameters that included plant height using a meter scale; the average heights of five randomly chosen plants were measured in centimeters from root to tip using the net plot area (3.6 m^2) of each plot, excluding waste at harvest. The average number of nodules plant^{-1} was calculated by carefully counting the number of nodules on five randomly chosen plants from each plot at the mid-flowering stage. The number of effective nodules plant^{-1} was calculated by using a sharp knife to cut each nodule. The nodules' red or pink interior, which is caused by leghaemoglobin, indicates that functional nitrogen fixations were tallied. For every plot, the average number of effective nodules was determined. Nodule diameter was calculated by measuring the diameter of each of the six nodules that were collected. Each plot was chosen at random, and the average result was recorded. Nodules were weighed using a sensitive balance as soon as their numbers were recorded to record Nodule fresh weight. The same nodules were oven-dried at 70 °C for 48 hours after the fresh weight was recorded to record Nodule dry weight. The data was recorded for yield and components of yield parameters that included Number of pods plant^{-1}, Number of Seeds pod^{-1}, weight of 100 seeds, Above-ground Biomass Yield, Grain yield and Harvest Index.

Statistical Analysis

Using statistical analysis software (SAS, version 9.0), data obtained for a variety of growth, yield, and yield-related factors were subjected to Analysis of Variance (ANOVA). Mean separation was performed using the least significant difference (LSD) test at the 5% P level, and interpretations were made using the methodology outlined by Gomez and Gomez (1984). Simple correlation analysis was done using SAS, version 9.0 to determine the relationship between plant parameters as affected by rhizobia and NPS fertilizer.

RESULTS AND DISCUSSION

Specific Physicochemical Characteristics of the Experimental Site's Soil

Composite soil samples (0–20 cm depth) were collected from the experimental location prior to planting, and a few physicochemical properties were assessed. The soil analysis's findings were displayed in Table 2.

Phenological Parameters of Mung Bean

Days to 50% flowering

The results of the analysis of variance showed that variety impacts had a substantial ($p < 0.05$) influence on the number of days till 50% flowering. However, their two-way interactions were not significant ($p < 0.05$). Accordingly, the maximum day to flowering (44) was captured from variety Showarobit, whereas a lowest day to flowering (39) was obtained from variety Boreda (Table 4).

Days to 90% physiological maturity

The number of days to 90% physiological maturity was significantly ($p < 0.05$) impacted by the main effect of variety, *Bradyrhizobium* inoculation, according to the findings of the analysis of variance. The maximum days to maturity (77.72) were recorded from variety Showarobit, whereas lowest days to maturity (69.11) were obtained from variety Rasa (Table 4). The long maturity period (72 days) was recorded with *Bradyrhizobium* inoculation, while the shortest (70 days) occurred without inoculation (Table 4). This is due to the soil already contains moderate nitrogen levels, uninoculated plants might access enough nitrogen to mature faster without the "lag phase" seen in inoculated plants. In contrast, Bradyrhizobium-inoculated plants might rely more on biological nitrogen fixation, which takes time to become fully efficient [30]. The prolonged maturity with higher N levels might be attributed to the role of nitrogen (N) in promoting vegetative growth. Similar findings were reported by Kawte et al. (2020), who noted that nitrogen enhances vigorous vegetative growth, thereby delaying maturity in mung bean. In contrast, Tadesse, and Dechassa [31] found no significant effect of sulfur (S) application (0–60 kg ha^{-1}) on days to maturity in common bean.

Growth Parameters of Mung Bean

Leaf area

According to the results of the analysis of variance, the main effects of variety on leaf area were extremely significant ($p < 0.05$); however, the effects of inoculation and their two interactions were not significant ($p < 0.05$). The highest leaf area (0.78) was recorded for variety Showarobit, while the lowest value (0.56) was recorded from variety Rasa (Table 4). Thus, the maximum mean leaf area was observed due to genetically different characteristics of the varieties. The highest leaf area plant^{-1} might also be attributed to the improved photosynthesis process following better supply of nutrients in balanced quantity to the plants at growing stages. This result is consistent with the findings of Kalwiani [18].

Table 2. Results of soil physical and chemical properties of the study site before sowing of mung bean.

Soil character	Values	Rating	Reference
Soilparticlesize			
Sand(%)	58		
Clay(%)	24		
Silt (%)	18		
Textural class	SandyClayloam	Mediumtexture	USDA (c1987)[36]
pH (water)	6.01	Slightlyacidic	Tekalign(1991)[32]
TotalN (%)	0.21	Moderate	Landon (c1991)[21]
Electro-conductivity (mS/cm)	2.72	Veryslightly saline	Tekalign(1991)[32]
OrganicC(%)	2.5	Medium	Tekalign(1991)[32]
CEC (%)	24.8	Medium	Tekalign(1991)[32]
AvailableP(mg/kg)	5.68	Low	Olsen*et al.* (1954)[27]
AvailableS(mg/kg)	12.28	Medium	Horneck *etal.(*2011)[17]

Leaf area index

According to the results of the analysis of variance, the leaf area index was significantly impacted by the main effects of cultivars ($p \leq 0.05$). Notably, variety Rasa had the lowest leaf area index (4.71), while variety Showarobit had the highest (6.5) (Table 3).

Plant height

Plant height was significantly ($p \leq 0.05$) affected by the primary effects of variety, according to analysis of variance data. As shown in Table 4, the maximum plant height was recorded for the variety Showarobit (50.08 cm) and the minimum for Rasa (33.31 cm). The superior status of Showarobit is likely due to its natural varietal traits, which enhance overall crop growth and root development. Another possibility is that the research period's favorable climate, particularly the timely rainfall during the growing season, contributed to physiological maturity.

Number of primary branches

The analysis of variance revealed that the variety had a substantial ($p < 0.05$) impact on the number of primary branches plant^{-1}. The maximum (2.83) branch number was recorded for Showarobit, whereas the lowest primary branch number (1.66) was noted for variety NVL-1 (Table 4). There was no significant main effect of Bradyrhizobium and NPS rate and interaction effect between both two and three way interaction on the number of branches plant^{-1}. As a result of the genetically distinct traits of the types, the highest mean was found. These results are in disagreement with those of Eyaya et al[12]. who reported non-significant effect on the main factor variety.

Nodulation Parameters of Mung Bean

Total nodule per plant

According to the analysis of variance, the main effects of varieties and Bradyrhizobium inoculation had a significant ($p < 0.05$) impact on the total number of nodules per plant; however, the two way interaction effects of varieties and Bradyrhizobium were not significant. The Showarobit variety had the most nodules per plant (30.39), whereas the Rasa variety had the fewest nodules per plant (26.89) (Table 3). The highest number of nodules per plant of (29.97) was recorded in *Bradyrhizobium* inoculation, while the lowest number of nodules per plant (25.89) was recorded in non-inoculation treatment (Table 4). The possible reason for the greater number of nodules developed on the root of mung bean after inoculation might be a stronger symbiotic partnership between Bradyrhizobium and the host plant is crucial because it leads to more efficient nitrogen fixation. This reduces the need for synthetic fertilizers, lowers costs, and promotes sustainable crop production. Likewise, *Bradyrhizobium* bacteria are sensitive to soil acidity and require P, adequate soil moisture for their multiplication as suggested by Bekere et al[5]. and Tigist Adisu et al[34].. NPS application combined with *Bradyrhizobium* also supplied sufficient S which is very essential in nodule formation. According to

Fageria [13], S also performs a number of crucial roles in the growth and development of plants, including the production of nitrogen and chlorophyll, the formation of nodules, and the activation of enzymes.

Effective nodule per plant

Bradyrhizobium inoculation and variety main effects all had a substantial ($p < 0.05$) impact on the number of effective nodules per plant. Thus, according to Table 4, the Showarobit variety had the most effective nodules per plant (19.44), while the NVL-1 variety had the fewest effective nodules per plant (16.72). Bradyrhizobium inoculation produced the most effective nodules per plant (19.61), whereas the control group produced the fewest effective nodules per plant (16.05) (Table 5). The maximum number of effective nodule per plant was due to the positive role of *Bradyrhizobium* inoculation initial nodule formation and development. This result is in line with fact that legume nodules are having dark pink or red centers denoting the presence of leghaemoglobin that is used as an indicator for effectiveness of the nodules and has positive coloration with N2 fixation [3, 8].

Nodule diameter

Analysis of variance showed that the main effect of variety had shown a significant ($p < 0.05$) effect on the nodule diameter. Maximum nodule diameter (3.31) was recorded from variety Boreda followed by variety Rasa with (3.28), whereas the lowest nodule diameter (2.79) was recorded from variety NVL-1 (Table 4). This may be because phosphorus promotes microbial and root activity in the plant's root zone, which in turn increases nutrient absorption and fixation and, eventually, increases the number and diameter of nodules per plant.

Nodule fresh weight

Bradyrhizobium, variety, and the interactions all had non-significant effects ($p \leq 0.05$) according to the analysis of variance.

Dry weight of nodules

The analysis of variance revealed that the dry weight of nodules was not significantly affected ($p \leq 0.05$) by the main effect of variety, Bradyrhizobium, and NPS fertilizer rates as well as their interaction. The plant's limited growth and development as well as its buildup of dry matter may be the cause of the decrease in nodule dry weight with the growing phosphate shortage. According to Thilakarathna & Raizada [33], fresh and dry nodule weights plant^{-1} are amplified by an increased sulfur fertilizer rate.

Mung Bean Yield and Yield Components

Pod number per plant

The primary effect variety had a significant impact on the number of pods per plant ($p \leq 0.05$). The maximum pods number (12.22) was recorded for Showarobit, whereas the lowest pods number (7.39) was also obtained from Rasa (Table 4). The highest number of pods plant^{-1} for variety Showarobit might be due to genotypic differences as individual varieties have different genetic makeup and nutrient absorption. This study is consistent with research findings of Mequannit and Tefera [23], who reported significant effect of varieties on pod production per plant in mung bean with a maximum number of pods in each plant (16.83) obtained from variety Showarobit. Similarly, mung bean cultivars significantly affected the amount of pods per plant, according to Wedajo [38] and Rasul et al[29].

Number of seeds per pod

The result revealed that seeds number per pod was significantly ($p \leq 0.05$) influenced by the two-way interaction effect of *Bradyrhizobium* inoculation and variety. Variety Rasa had higher (10.89) number of seeds pod^{-1} in non-inoculated rate plots than variety Showarobit though it was statistically at par with it. On the other hand, the lowest (9.33) seeds number pod^{-1} was obtained from NVL-1 with non-inoculation/untreated plots (Table 3). The increase in the numbers of seeds per pod might be due to the response of different varieties to *Bradyrhizobium*. However, the current study is not consistent with the result of Bhuiyan et al[6]., who reported non-significant effect of two way interactions on the amount of seeds pod^{-1} of mung bean.

Table 3. Number of seeds per pod, dry biomass and grain yield as affected by mung bean varieties and *Bradyrhizobium* inoculation interaction.

		NSP	DBM(t)		GY(t)	
Varieties	***Inoculated***	***Un-inoculated***	***Inoculated***	***Un-inoculated***	***Inoculated***	***Un-inoculated***
Showarobit	10.67^{a}	10^{ab}	1.58^{d}	1.14^{e}	2.48^{a}	1.41^{b}
NLV-1	10.78^{a}	9.33^{b}	1.70^{d}	1.12^{e}	1.21^{c}	0.69^{d}
Rasa	10.33^{a}	10.89^{a}	3.37^{a}	2.26^{b}	1.34^{bc}	0.70^{d}
Boreda	10.78^{a}	10.44^{a}	1.95^{c}	1.22^{e}	1.44^{b}	0.79^{d}
LSD(0.05)	0.9		0.18		0.14	
CV%	9.18		10.8		11.58	

NSP = Number of seed per pod, DBM = dry biomass, GY = grain yield, CV = coefficient of variance, LSD = least significant difference. According to least significant difference tests, values in rows and columns that are followed by the same letter or letters do not differ substantially from one another at p < 0.05.

Aboveground Dry Biomass

The two-way interactions of Bradyrhizobium with variety had a significant ($p < 0.05$) impact on aboveground dry biomass for the mung bean plant under study notably the largest dry biomass (3.37 t ha^{-1}) was obtained by Bradyrhizobium inoculation with variety Showarobit, whereas the lowest dry biomass (1.12 t ha^{-1}) was obtained by uninoculation with variety Rasa (Table 3). The inoculation with Bradyrhizobium and the genetic difference across the kinds allowed for the largest dry biomass.

Hundred Seed Weight

The weight of one hundred seeds was significantly ($p < 0.05$) impacted by the principal effect of variety. The variety NVL-1 had the highest hundred seed weight (6.72 g), followed by variety Rasa (6.61 g), which were statistically comparable to it. The variety Showarobit had the lowest hundred seed weight (5.61 g) (Table 3). The cultivars' innate genetic traits may be the cause of this variation in hundred seed weight. Dinsa et al[10]. found that the N–26 variety had the highest hundred seed weight (5.05), followed by the Arkebe variety, while the Showarobit variety had the lowest hundred seed weight (3.88). These findings support this conclusion. This is the fact that assimilated photosynthesis can be translocated from vegetative plant parts to the seed, thus considerably enhancing seed weight.

Grain Yield

The main effects of variety and Bradyrhizobium, as well as the two-way interactions of Bradyrhizobium with variety are significantly ($p \leq 0.05$) affected grain yield, according to the analysis of variance. While variety NVL-1 produced the lowest grain yield (0.95 t ha^{-1}), variety Showarobit produced the highest grain yield (1.95 t ha^{-1}) (Table 4). The variation in the variety's genetic traits allowed for the achievement of this maximum grain yield. While the uninoculated plot yielded the lowest grain yield (0.9 t ha^{-1}), Bradyrhizobium inoculation produced the highest grain yield (1.62 t ha^{-1}). It's possible that Bradyrhizobium inoculation led to this maximum grain yield. The maximum grain yield (2.48 t ha^{-1}) was found for *Bradyrhizobium* inoculation with variety Showarobit, while, significantly, the lowest yield (0.69 t ha^{-1}) was observed from un-inoculation with variety NVL-1 (Table 3). This highest grain yield was attained due to the difference in genetic characteristics of the variety and its response to *Bradyrhizobium* inoculation. These results were nearly identical to those of Abbas [2], who found notable variations in the yield of several cultivars. Mequannit and Tefera [23] found that the mung bean varieties NVL-1 (2326.8 kg/ha), Showarobit (2302.6 kg/ha), and N–26 (1946.3 kg/ha) produced more grain. Boreda (205.7 kg/ha) and Showarobit (200.7 kg/ha) yielded lower yields than the national average (800.6 kg/ha) for mung bean types in Jinka, Ethiopia, according to Wedajo [37]. Additionally, Wedajo [37], Rasul et al[29]., and Omid [28] demonstrated a significant impact of mung bean genotypes on grain yield.

Table 4. Phenological, growth, nodulation, and yield parameters as affected by mung bean varieties.

Varieties	DF	DM	LA(m^2)	LAI	PH	NBP	TNN	EN	ND	NPP	HSW(g)
Showarobit	44.33^a	77.72^a	0.78^a	6.50^a	50.08^a	2.83^a	30.39^a	19.44^a	2.83^b	12.22^a	5.61^b
NLV-1	39.72^b	69.44^b	0.63^{bc}	5.27^{bc}	35.67^b	1.83^b	26.89^b	16.72^b	3.28^a	7.61^b	6.72^a
Rasa	39.33^b	69.11^b	0.56^c	4.71^c	33.31^b	1.61^b	26.94^b	17.28^b	2.79^b	7.39^b	6.61^a
Boreda	39^c	69.61^b	0.65^b	5.43 ^{b}	35.47^b	1.72^b	27.5^b	17.89^b	3.31^a	7.78^b	6.55^a
LSD(0.05)	1.08	1.72	0.06	0.63	2.78	0.34	2.04	1.34	0.43	1.08	0.35
CV%	4.58	3.58	17.14	17.16	10.74	25.54	10.92	11.2	20.86	18.36	8.34

LSD = least significant difference, CV = Coefficient of variance. DF = days to flower, DM = days to maturity, LA = leaf area, LAI = leaf area index, PH = plant height, NBP = number of branches per plant, TNN = total number of nodules, EN = effective nodules, ND = nodule diameter, NPP = number of pods per plant, HSW = hundred seed weight. Values in columns and row followed by the same letter(s) are not significantly different to each other according to least significant difference tests at p ≤ 0.05.

CONCLUSION AND RECOMMENDATIONS

Mung bean is an important food and cash crop in Ethiopia. However, poor soil fertility, especially low levels of nitrogen and phosphorus, has been demonstrated to be a major constraint to the production of the crop in the country. To ascertain the economics of Bradyrhizobium inoculation on mung beans in Gimbo District, Southwest Ethiopia, the study was carried out during the 2024–2025 cropping season in the Kaffa Zone of Southwest Ethiopia Regional State. Four improved mung bean varieties (Showarobit, Boreda, NVL-1, and Rasa) with two Bradyrhizobium inoculations (with and without inoculation) arranged in a Randomized Complete Block Design (RCBD) with three replications comprised the treatments under investigation. This study found that mung bean growth and yield parameters were improved due to the main and interactive effects of variety and *Bradyrhizobium* inoculation. The current study allows for the conclusion that nearly all mung bean growth, yield, and yield-related characteristics are impacted by Bradyrhizobium inoculation and variations. Numerous agronomic variables showed extremely significant ($p < 0.05$) changes in response to the main and two-way interaction effect of cultivars and Bradyrhizobium inoculation. The current study's findings showed that the use of Bradyrhizobium inoculation significantly ($p < 0.05$) affected the phenological characteristics and yield of mung beans. Similar to this, inoculating *Bradyrhizobium* caused a noticeable improvement in harvest index and pod number. 100 seed weight, grain yield, and dry biomass were all positively impacted by the application of *Bradyrhizobium* inoculation. Applying *Bradyrhizobium* inoculation with variety improved grain yield. For smallholder mung bean farmers in Gimbo (Kaffa Zone) and similar areas, the use of the Showarobit variety with *Bradyrhizobium* inoculation is recommended based on both agronomic and economic performance. However, further field testing across multiple seasons and locations is necessary before large-scale adoption.

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