World Journal of Food Science and Technology
2024, Vol. 8, No. 3, pp. 52-61
https://doi.org/10.11648/j.wjfst.20240803.11

SciencePG
Science Publishing Group

Research Article

Improved Mung Bean (Vigna radiate L.) Technology Demonstration and Promotion Under North-West Ethiopia

Zeru Yimer Kebede*, Birhanu Kasim

Department of Field Crops Improvement Program (Lowland Pulse Breeding & Genetics), Ethiopian Institute of Agricultural Research (EIAR), Pawe Agricultural Research Center (PARC), Pawe, Ethiopia

Abstract

North-West Ethiopia, particularly metekel area, was conducive for the production of lowland pulses including mung beans. However, because of some known and unknown factors the productivity of mung beans was not that much improved regardless of the study area's potential. Due to this, a two season field experiment was conducted to demonstrate and promote improved mung bean varieties under pawe district for 2021 and 2022 consecutive cropping seasons. During 2021 and 2022 main seasons, demonstration and promotion of improved mung bean varieties with the direct involvement of stakeholders (farmers, agricultural experts, government officials, researchers) field day event was carried out. The improved mung bean varieties demonstrated and promoted were NVL-1, N-26 (Rasa), Shoarobit (as a check) and MH-97-6 (Borda). Small scale farmers and agricultural experts even district government officials were purposely selected from the nearby district (pawe) followed that theoretical trainings about the production of mung bean, were given during the event. Each event participants have set their own variety selection parameters; with this majority of the participants selected and promoted N-26 (Rasa), NVL-1 mung bean varieties based on high grain yield, more number of pods per plant, larger grain size, uniformity and earliness, the rest of the participants preferred Shoarobit (as a check) based on high biomass and grain yield whereas MH-97-6 (Borda) was selected and promoted based on medium duration and high yield. The author suggested that, those selected and promoted mung bean varieties (mainly N-26 (Rasa), NVL-1 and MH-97-6 (Borda) have been recommended for production under the study area and similar agro-ecologies to satisfy the seed demand raised by small scale farmers and other agents.

Keywords

Demonstration, Improved, Mung Beans, Promotion, Stakeholders, Varieties, Yield

1. Introduction

The most important lowland grain legumes which grow in most parts of the country (Ethiopia) include common bean /haricot beans (Phaseolus vulgaris L), cowpea (Vigna unguiculata (L.) Walp.), pigeon pea (Cajanus cajan (L) Millsp.) and mung bean (Vigna radiata (L.) Wilczek) [1].

Mung bean (Vigna radiate L.) is one of the most important lowland pulse crops under Ethiopian condition. It has multiple uses such as source of proteins, minerals, and other essential ingredients that are directly important for humans and livestock [2]. According to the research of Goa et al., mung bean is an important pulse crop grown in drier areas in south Ethiopia for household consumption and as a source of family

*Corresponding author: zeruyimer2000@gmail.com (Zeru Yimer Kebede)

Received: 3 August 2024; **Accepted:** 3 September 2024; **Published:** 29 September 2024

cash income [3].

In addition, supplementation of sheep with pigeon pea (Cajanus cajan L.) 52% leaves was found to be the best level under farmer condition especially in the lowland areas [4]. It is an important food and cash legume crop in Asia. Development of short duration varieties has paved the way for the expansion of mung bean into other regions such as Sub-Saharan Africa and South America [5].

In Ethiopia, legume crops are the second most important next to cereals in area coverage and production. Mung bean, a warm season legume crop, is grown mainly for its edible seeds [6].

Currently under Ethiopia, mung bean covers about 48,022.34 ha of land and produces 515,686.55 quintals in main cropping season per annum with average productivity of 1.074 ton per hectare [7].

However, the production and productivity of mung beans in Ethiopia is hindered by multiple challenges; among these were biotic, abiotic and socioeconomic factors [2]. Furthermore, a review article generated and discussed by, Zeru, Y. [2] reported diseases and pests, market access and fluctuation, socio economic factors, shortage of standardized storage, poor extension system, land sharing coverage, lack of mechanization, low soil productivity, use of traditional threshing method, less attention of beans nutrition-based importance and other factors were common bean research and development obstacles for the study area. Mung bean productivity is constrained by biotic and abiotic factors [5].

Furthermore, socioeconomic factors like, imitation of demonstration and pre-scale up of improved technologies, finance to purchase agricultural inputs, access to seeds, and others have limited the production of sweet lupin under the study area [8]. In line with this, Yirga, Masreshaw, et al [9] reported; to exploit the high yield advantage of the varieties and partly solve the food self-sufficiency in the country, major emphasis should be given for early generation seed multiplication, well organized demonstration and popularization of the varieties to farmers.

Despite considerable efforts to improve breeding practices in Ethiopia, increasing varietal release does not necessarily imply that farmers have access to innovative varietal choices. [10]. But, the use and application of improved agricultural crop varieties and generated information, currently, helped to enhance the yield of currently cultivating crops regardless of the promotion works. To support more the paragraph, currently the interest of small-scale farmers to use improved crop varieties is getting sound [2].

According to Shumeta, Z et al., [11] report, improved agricultural technologies largely focusing on increasing yield and market value have an important role in increasing productivity, income and building household food security. In line with that, improved agricultural technologies, management practices, and inclusion of resource poor household for enhanced technological access also have a proven track record on improving food security and decreasing susceptibility to individual stresses. Furthermore, Kebede, E. [12] reported; the adoption of new agricultural technologies and improved practices are particularly important in increasing agricultural production. This comprises strengthening legumes adoption and production as it contributes to better food security and more sustainable farming systems.

Similar field experiment conducted by, Ersulo, D et al., [13] revealed improved common bean cultivars performed well under the study area (South Western Ethiopia).

However, under the study area, the use and application of improved mung bean varieties was limited due to shortage of well adapted and performed cultivars. Thus, improved Mung bean (Vigna radiate L.) technology demonstration and promotion under North-West Ethiopia was implemented with the objective:

1. To demonstrate the field performance of improved mung bean varieties or technologies under on station and on farm condition
2. To promote improved mung bean varieties or technologies with the direct participation of stakeholders
3. To collect feedback from stakeholders (farmers, experts and district level government officials) on the field performance of mung bean varieties

2. Materials and Methods

2.1. Description of the Study Area

The improved Mung bean (Vigna radiate L.) technology demonstration and promotion work was conducted under Pawe Agricultural Research Center (On-station) and on three farmer’s field (On-farm) under North-West, Ethiopia. Pawe district and the surrounding areas is suitable for the production of field crops including mung beans. The area between 11 °19' 0"N latitude and 36 °24' 0"E longitude. The mean annual minimum and maximum temperature is 16.3 and 32.6 Degree Celsius respectively. The area has unimodal rainfall pattern extended from early June up to mid of October. The dominant soil type is vertisol however the experiment was conducted on nitisol.

2.2. Event Participants (Clients)

The two-year research work (field work) involved different groups; most of the participants were small-scale farmers, followed by agricultural experts, district government officials and researchers. The demonstration and promotion work were implemented under Metekel zone Pawe district; for this task model or front-line small-scale farmers were purposely selected, and randomly selected kebeles (sub-districts) were considered.

2.3. Mung Bean Varieties Demonstrated and Popularized

Four improved mung bean varieties were demonstrated and popularized. Each variety has its own merit. The varieties released by various years under different research centers. The four improved mung bean varieties demonstrated and popularized were NVL-1, N-26 (Rasa), Shoarobit (as a check) and MH-97-6 (Borda).

2.4. Design and Layout

Single plot with dimension 10 m by 10 m was employed for each demonstrated and popularized mung bean varieties. The area of each plot was 100 m^2. The distance between each plot was 1.5 m. Thus, the total area of the site was 10 m by 43.5 m which is 435 m^2. The farmers' field was used as replications. The design and layout of treatment randomization was presented in. (Figure A1).

2.5. Experimental Design

The treatments laid out in non-replicated design. The plot size was 10.0 m × 10.0 m which was equal to 100.0 m^2 with 0.1 m intra-row spacing with 25 row of 0.40 m inter-row spacing. The Net plot size was 10.0 m × 9.2 m which is equivalent to 92.0 m^2 whereas the distance between independent plots was 1.5 m. Therefore; the total experimental area was 43.5 m× 10.0 m which was 435.0 m^2. Sowing of mung bean varieties was conducted on July 30/2021, for the first season and August 08/2014, and August 05/2015 respectively. The sample plants were taken randomly from each plot and data recorded with standard procedure.

Rank estimation with excel function:

To classify the promoted mung bean varieties, based on the actual data (observed values), we have applied an excel function as it shown below (Table 1).

Table 1. *Excel Rank Function Formula.*

No.	Variety	Scale	Rank
1	NVL-1	4	=RANK (C2,$C$2:$C$5,0)
2	N-26 (Rasa)	5	=RANK (C3,$C$2:$C$5,0)
3	Shoarobit	2	=RANK (C4,$C$2:$C$5,0)
4	MH-97-6 (Borda)	3	=RANK (C5,$C$2:$C$5,0)

Chi Square Test (X^2):

We are going to compare observed data (collected data) from the observation experiment to expected values calculated under the null hypothesis.

Generalized Hypothesis:

The null hypothesis would be the status quo:

The grain yield means of the mung bean varieties are equal/similar:

Ho: VarietyA = VarietyB=VarietyC=VarietyD

The alternative hypothesis would be the grain yield means of the mung bean varieties are different

Ha: VarietyA # VarietyB # VarietyC # VarietyD

We can use the Chi Square (X^2) Goodness of Fit Test to solve this problem.

$$X_c^2 = \sum_{i=1}^{k} \frac{(Oi-Ei)^2}{Ei}$$

Where:

Oi = observed frequency of category i

Ei = expected frequency of category i

k= number of categories

C= degree of freedom = (#Row-1)*(#Column-1)

Note: the test statistic has a chi square distribution with k-1 df if the expected frequencies are 5 or more for all categories.

2.6. Sowing Date and Applied Agronomic Practices

The mung bean varieties were sown end of July 2021 (30/07/2021) and 29/07/2022 consecutively due to the reason that mung bean in its nature can grow and develop with limited moisture (residual moisture) plus to that most of the varieties were early to medium maturing cultivars (on average 65-78 days to mature) under pawe district. The land sown was ploughed and managed well (two to three plowed) recommended seed and fertilizer rate was applied as per the recommendation. The recommended seed rate per hectare was 25-30 kilogram and chemical fertilizer (NPS) with 100 kilogram per hectare was applied. Weeding carried out each stage of the crop, fifteen days after planting, applied as first weeding, and the second weeding was carried out after one month and the last weeding was applied end of the crop maturity even to keep the sanitation of the field for the next crop (for the coming season). The farmers' field was used as replications and all farm operations conducted under main research station was also implemented under farmers' field to keep the uniformity of the two sites. However, all other agronomic practices implemented started from appropriate site selection to postharvest operations.

For more information, the experimental mung bean varieties and their unique characters is presented in (Table 2).

Table 2. *The four improved mung bean varieties demonstrated and popularized under Pawe district (2021-2022).*

No.	Mung bean variety	Year of release	Releasing center	Merit
1	NVL-1	2014	Melkassa Research Center	Early mature, high yield

No.	Mung bean variety	Year of release	Releasing center	Merit
2	N-26 (Rasa)	2011	Melkassa Research Center	Early mature, high yield
3	Shoarobit	2011	Melkassa Research Center	Medium mature, high biomass
4	MH-97-6 (Borda)	2008	Hawassa Research Center	Medium mature, high biomass

3. Results

The result part has two components:

Part I: Social aspect data

For this section, the different stakeholders had taken part in selecting and ranking the demonstrated mung bean varieties (NVL-1, N-26, Shoarobit, and MH-97-6) based on the field performance of the varieties. Each participant of the event has voted and ranked the improved mung bean varieties based on field performance both at main testing site (Pawe) and on farm. The unique growth habit of the varieties enabled the participants to decide which variety is good for which trait of interest. In general, based on the observation and overall performance, the farmers, agricultural experts, development agents and researchers voting and ranking of the varieties was presented in (Table 3), (Table 4), (Table 5), (Table 6), and (Table 7) respectively.

Table 3. *Participants mung bean variety selection and rank based on numbers of pods per plant.*

Pods/plant:			
No.	**Variety**	**Scale**	**Rank**
1	NVL-1	4	2
2	N-26	5	1
3	Shoarobit	2	4
4	MH-97-6	3	3
Note:			
Scales	Remark		
5	Excellent		
4	Very good		
3	Good		
2	Poor		
1	Very poor		

Table 4. *Participants mung bean variety selection and rank based on seeds per pod.*

Seeds/pod:			
No.	**Variety**	**Scale**	**Rank**
1	NVL-1	4	2
2	N-26	5	1
3	Shoarobit	2	4
4	MH-97-6	3	3

Table 5. *Participants mung bean variety selection and rank based on grain yield.*

Grain yield:			
No.	**Variety**	**Scale**	**Rank**
1	NVL-1	4	2
2	N-26	5	1
3	Shoarobit	2	4
4	MH-97-6	3	3

Table 6. *Participants mung bean variety selection and rank based on biomass yield.*

Biomass yield:			
No.	**Variety**	**Scale**	**Rank**
1	NVL-1	2	4
2	N-26	3	3
3	Shoarobit	5	1
4	MH-97-6	4	2

Table 7. Participants mung bean variety selection and rank based on overall field performance.

Overall field performance:			
No.	**Variety**	**Scale**	**Rank**
1	NVL-1	4	2
2	N-26	5	1
3	Shoarobit	2	4
4	MH-97-6	3	3

Majority of the participants of the event selected and gave first rank for N-26 (Rasa) variety, in terms of grain yield, (Table 4). This result is in line with Kassa, Y., [14], revealed that among the tested improved variety Rasa (N-26), was selected first by the farmers followed by the variety NVL-1.

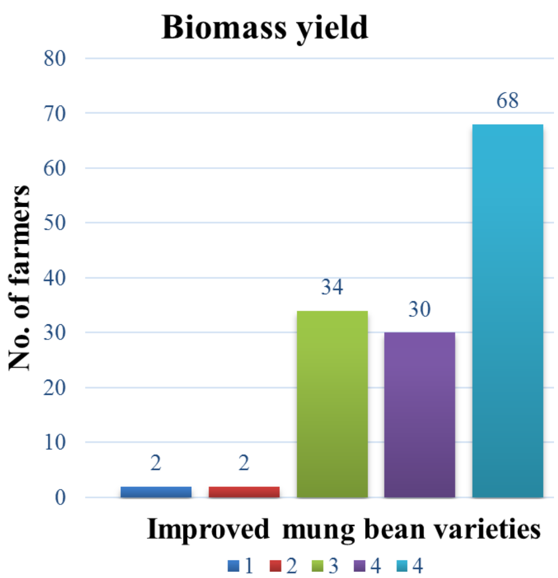

Figure 1. Numbers of farmers who preferred mung bean varieties in terms of biomass yield.

The preference of farmers on biomass yield attribute revealed that 50% of the participant farmers has selected Shoarobit mung bean variety, followed by MH-97-6 (Borda) and N-26 or NVL-1 with values of 44.12%, 2.94 and 2.94% respectively. In terms of biomass yield Shoarobit variety was preferred and ranked first by stakeholders followed by MH-97-6 (Borda) (Figure 1).

The interest of farmers on overall field performance (disease tolerance, more numbers of pods per plant, more numbers of seeds per pod, high grain yield and others) revealed that 33.3% of the participant farmers has selected both NVL-1 and N-26 (Rasa) mung bean varieties, followed by Shoarobot and MH-97-6 (Borda) with values of 16.67%, and 16.67% respectively. The selection and ranking of mung bean varieties by the participants is presented in (Figure 2). Similar results were reported by Kassa Y, et al., [14] by stating, the existence of a strong and statistically significant association between the actual values rank and the farmers' preference rank for both grain and biomass yields. Another findings reported by Lema, M., et al., [15] indicated, there was significant difference among cultivars observed for total dry biomass.

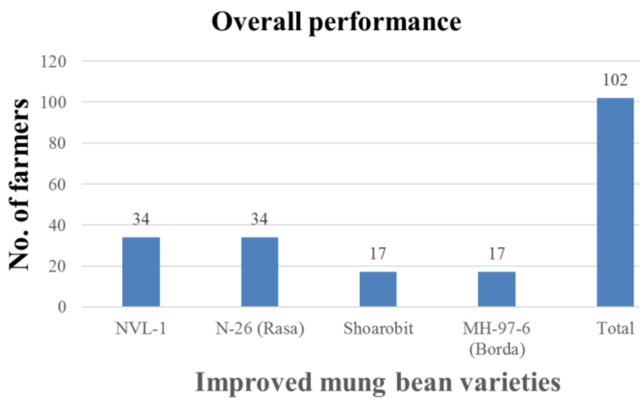

Figure 2. Numbers of farmers who preferred mung bean varieties in terms of overall field performance.

Part II: Experimental data

For this section of the manuscript, well standard data for each parameter collected, analyzed and interpreted with meaningful scientific procedures.

Note: Sch=Stand count at harvest=Days to 50% flowering, Dm=Days to 95% pod maturity, Ph=Plant height (cm), Pods-plant=Number of pods per plant, Seeds-pod=Number of seeds per pod, Hsw=Hundred seeds weight (g), Adj. Yield=Adjusted yield per hectare at 12.5% seed moisture content, Biomass=Biomass yield (ton/ha), CV=Coefficient of variation, LSD=Least Significant Difference.

The tested mung bean varieties showed significant difference for most of the studied parameters (Table 8). For nstance, biomass yield as a trait; Shoarobit variety was highest scorer, followed by MH-97-6 (Borda), N-26 (Rasa), and NVL-1 with mean values of 39.05,35.88,30.60, and 29.05 ton/ha respectively (Figure 3).

Table 8. Mean separation values of tested mung bean varieties traits over year (2021-2022).

Variety	Sch	Df	Dm	Ph (cm)	Pods-plant	Seeds-pod	Hsw (g)	Adj. Yield	Biomass
MH-97-6 (Borda)	195.5 a	51.125 a	71 b	57.1 b	12.9 c	11.5 b	4.6 bc	10.9 bc	35.875 b
N-26 (Rasa)	197 a	43.25 b	65 c	45.5 c	14.225 a	13 a	5.45 ab	13.1 a	30.6 c
NVL-1	195.5 a	42.25 b	63.5 c	44.7 c	13.7 b	12.85 a	5.5 a	11.95 ab	29.05 c
Shoarobit	194.5 a	53.05 a	75 a	62.75 a	11.9 d	10.1 c	4.35 c	10.45 c	39.05 a
Mean	195.63	47.42	68.63	52.51	13.18	11.86	4.98	11.6	33.64
CV	0.80	1.44	0.99	1.39	0.55	1.41	5.57	3.54	1.59
LSD (∂=0.05	4.99	2.18	2.15	2.32	0.23	0.53	0.88	1.31	1.71
F-test	ns	0.0012	0.0012	0.0003	0.0002	0.0011	0.0522	0.0226	0.0009

*Means with the same letter under the same column are not significantly different!

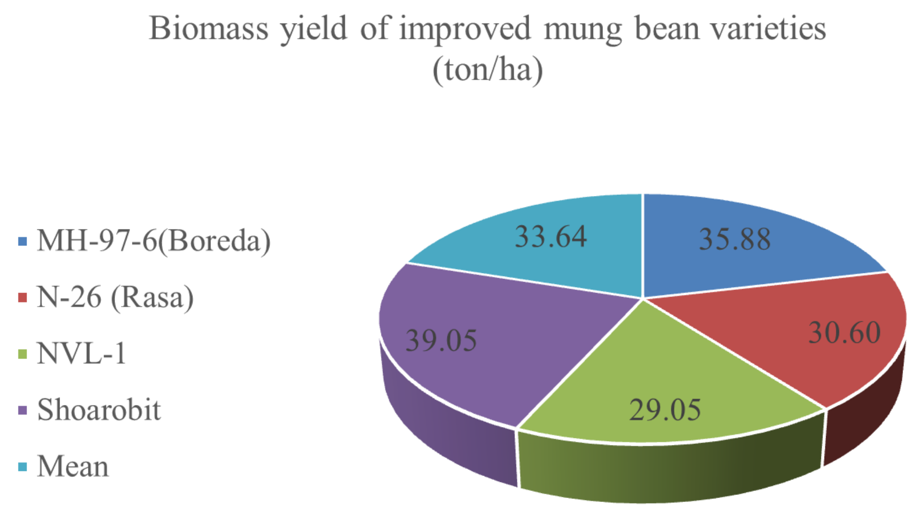

Figure 3. Biomass yield of improved mung bean varieties (2021-2022).

4. Chi-Square Test (X^2) [Goodness of Fit-Test]

Table 9. Observed values (Collected data) for adjusted grain yield.

	R1	R2	R3	R4	Total
MH-97-6 (Borda)	1209.71	1165.66	1070.52	1011.71	4457.61
N-26 (Rasa)	1483.08	1430.10	1334.96	1448.75	5696.89
NVL-1	1435.99	1331.25	1442.82	1325.74	5535.80
Shoarobit	980.66	988.39	876.68	866.19	3711.92
Total	5109.44	4915.41	4724.98	4652.39	19402.21

Table 10*. Expected values (Predicted data) for adjusted grain yield.*

	R1	R2	R3	R4	Total
MH-97-6 (Borda)	1173.88	1129.30	1085.55	1068.87	4457.61
N-26 (Rasa)	1500.24	1443.26	1387.35	1366.04	5696.89
NVL-1	1457.81	1402.45	1348.12	1327.41	5535.80
Shoarobit	977.51	940.39	903.96	890.07	3711.92
Total	5109.44	4915.41	4724.98	4652.39	19402.21

Based on the field collected data, the actual grain yield is presented by (Table 9). Whereas the expected value is presented by (Table 10).

Table 11*. Chi -Square (Calculated value).*

MH-97-6 (Borda)	1.09	1.17	0.21	3.06
N-26 (Rasa)	0.20	0.12	1.98	5.01
NVL-1	0.33	3.62	6.65	0.00
Shoarobit	0.01	2.45	0.82	0.64

The calculated value, in this case, the chi-square test, is presented by (Table 11).

Chi-Square (X^2) (Calculated value) = (1.09+1.17+0.21+3.06+---+0.64) = 27.35

Degree of freedom (df) = (#Row-1)*(#Column-1) = (4-1)*(4-1) = (3)*(3) =9

Critical value (CV) = CHISQ. INV. RT (0.05, H25) =(0.05,9)= 16.92

Pvalue = CHITEST (actual range: expected range) =CHITEST (H4: K7, H12: K15)= 0.001221795

Test statistics =CHISQ. INV. RT (H27, H25) = CHISQ. INV. RT (pvalue, df)= (pvalue, 9)=27.35

P value approach:

Compare p value with ∂

Rule for P value approach:

Reject Ho: if p-value < ∂ (Significance level or alpha)

Do not Reject Ho: if p-value > ∂

Now, 0.001221795 is < .05

Therefore, Reject Ho: Because there is an evidence of a difference in the mean grain yield of mung bean varieties.

Rule for Critical value (CV) approach:

Critical value: (CV)

= chisq. inv. rt (probability, df)= (.05,9) = 16.92

Calculate Test Statistic= X^2= 27.35

Look up critical value = CV= 16.92

Compare and come to a statistical conclusion:

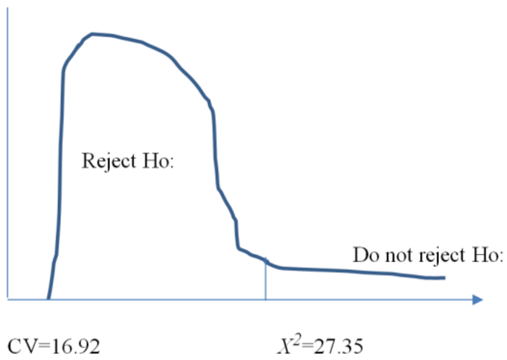

Figure 4*. Values of Chi square in Chi-Square distribution.*

The rejection and non-rejection region of the Null hypothesis is represented by (Figure 4).

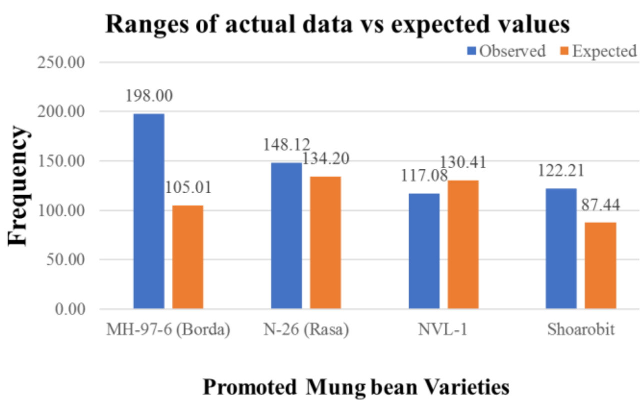

Figure 5*. Representation of actual (observed) data against expected values.*

The deviation (range) of collected or observed data against the expected (predicted) values for adjusted grain yield is presented by (Figure 5) whereas the graphical representation of error bars or uncertainties is presented by (Figure 6).

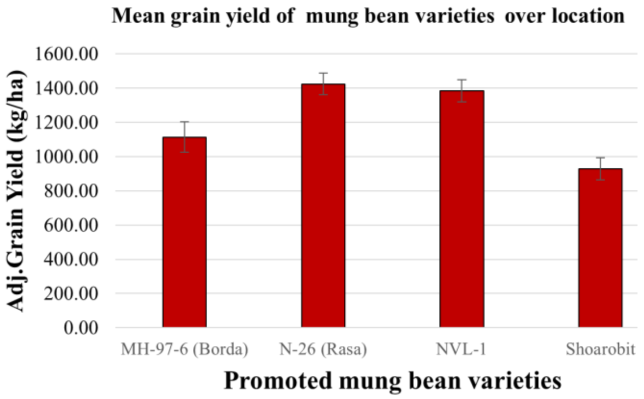

Figure 6. *Variability of mung bean varieties grain yield (error bars representation).*

5. Discussion

There is a significant difference among mung bean varieties, for the tested parameters such as Days to 50% flowering, Days to 95% pod maturity, Plant height (cm), Number of pods per plant, Number of seeds per pod, Hundred seeds weight (g), Biomass yield, and Adjusted yield per hectare (except stand count at harvest (Table 7). This findings was agreed with the findings of Kassa et al, [16] reported that there is a difference among the means of the mung bean varieties for grain yield, pod length and hundred seed weight are significant at 5% probability level. Another finding reported by Kassa, Y., [14] indicated, the combined analysis of variance revealed that there was highly significant variation ($p < 0.01$) of grain yield among the genotypes while the environments and genotype by environment interaction are found insignificant. Days to 50% flowering ranges from 42.25 to 53.05, whereas Days to 95% pod maturity ranges from 63.5 to 75 (Table 7). Plant height (cm) ranges from 44.70 to 62.75, on the other hand yield contributing trait, number of pods per plant ranges from 11.9 to 14.25, number of seeds per pod ranges from 10.1 to 12.85 whereas hundred seeds weight (g) ranges from 4.35 to 5.50 respectively (Table 7). The other important trait, adjusted yield per hectare ranges from 10.45 to 13.10 respectively (Table 7).

Among the demonstrated and popularized mung bean varieties N-26 (Rasa) and NVL-1 were preferred by the event participants in terms of grain yield and overall field performance. The other two varieties Shoarobit and MH-97-6 were also having their own merits such as high biomass yield and medium maturing habits. In addition, Zewdu, Z. [17] reported, red colored bean varieties with good agronomic performance were the primary choice for farmers. Similarly, Bassa D et al., [18], reported farmers and researchers selection criteria sounds more for future production of improved chickpea varieties under the study area. In the same way, Dembi, K et al., [19] reported based on multiple farmers' preference criteria, the need for improved bean variety scale up and popularization requested more.

According to Berihun, T et al., [20] report mung bean variety N-26 (Rasa) was selected and promoted by the farmers, for production, under the study area due to its several merits like vigorous, disease tolerance, a greater number of pods per plant, a greater number of seeds per plant, large seed size, and overall performance under field condition. Similarly, Kassa, Y et al., [14] reported that the mung bean variety N-26 (Rasa) was preferred by farmers based on grain yield and marginal rate of return on investment under the study area. Another field experiment conducted by, Kassa, Yehuala, et al., [21] reported that the introduction of the improved variety Rasa (N-26) which has a large seed size, high biomass, and grain yield attracts the attention of farmers, experts, and local traders. Similar findings reported by Mulu Baza et al., [22] stated, the combination of the N-26 (Rasa) variety with 150 kg NPS produced the highest number of pods per plant, seeds per pod, grain yield, and biomass.

A recent field research conducted by Goa, Y et al., [3] reported that the two mung bean varieties, Borda (MH-97-6) and Rasa (N-26), were performed well and preferred by farmers based on yield parameter and other yield contributing traits.

The improved technology of mung bean varieties promotion work under the study area was properly implemented with the direct involvement of various stakeholders. The information generated from the study can directly benefit for agricultural experts, researchers, government policy makers, agro-processors and other agents who was interested in production and promotion of lowland pulses. The study has given clue for the production of mung beans under the study area and similar ecologies because, currently, most of the production area is covered by other crops with different commodities such as soybeans, maize, rice and horticultural crops. This is because of cropping system of the study area one or other way needs improvement, which is soil fertility declined from season to season. Thus, rotation and intercropping of pulse crops with cereals is believed to be an alternative solution. Finally, the demonstrated and popularized mung bean varieties has had probabilities to pave the way for future improvement and widely scale up of lowland pulse commodities particularly well performed and preferred cultivars for production and utilization. In general, due to the physiological nature of the crop, majority of mung bean cultivars, those under production, are early mature types. This growth habit, can help the crop to grow and perform well even under harsh conditions, like the case of climate variability. This statement was in line with, Assefa, Z. B, et al., [23] stated that, mung bean can play an important role in climate resilience and increasing food security.

6. Conclusion

Generating or adapting improved varieties or information of any field crops or horticultural commodities does not guarantee to enhance the production and productivity but also promotion and demonstration works has to be given attention and implementing it on time properly. To make effective more our field works; participation of small scale farmers, agricultural experts, government officials, and researchers has great role in demonstration and promotion of improved crop varieties thereby to exploit the potential of the improved cultivar under the study area.

Abbreviations

cm	Centi Meter
CV	Critical Value
df	Degrees of Freedom
EIAR	Ethiopian Institute of Agricultural Research
m	Meter
No.	Number
PARC	Pawe Agricultural Research Center
$\sum$	Summation
χ^2	Chi-Square

Significance Statement

The study examined and overviewed the demonstration and promotion of elite mung bean varieties under the study area in detail and revealed the future improvement of the production in general. The generated information and technology can directly benefit the various stakeholders with the aim to promote and cultivate these commodities under small scale and large scale level.

Acknowledgments

The author acknowledged PAPER (Pastoral and Agro-Pastoral and Emerging Regions Research Directorate) for supporting the field work with budget and Pawe Agricultural Research Center for facilitating and supporting the work with full packages.

Data Availability Statement

The availability of the recorded and adjusted data to be presented as per the request.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

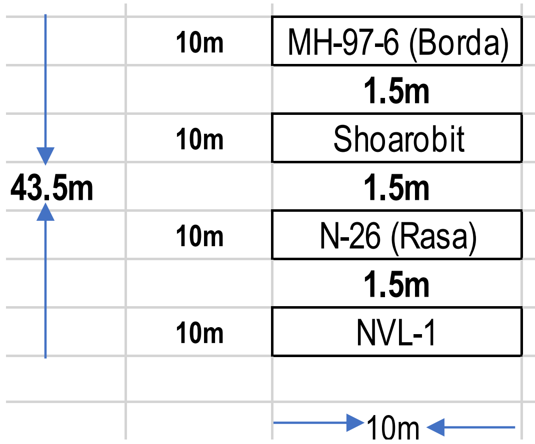

Figure A1. *Field layout for demonstrated and popularized mung bean varieties (2021-2022).*

References

[1] Amsalu, B., Tumsa, K., Negash, K., Ayana, G., Fufa, A., Wondemu, M., & Rubyogo, J. C. (2016). Lowland pulses research in Ethiopia: achievement, challenges and future prospect. Agricultural Research for Ethiopian Renaissance.

[2] Zeru Yimer Kebede. (2022). Opportunities of mung beans production and development under, Pawe District, North-West Ethiopia: A review. Int. J. Adv. Res. Biol. Sci. 9109): 38-41. http://dx.doi.org/10.22192/ijarbs.2022.09.10.004

[3] Goa, Yasin, and Demelash Bassa. "Participatory Adaptation and Demonstration of Improved Mung Bean (Vigna radiata L.) Varieties in Selected Districts of Gamogofa and Wolayta Zones, Southern Ethiopia." *Asian Journal of Plant Science & Research* (2021).

[4] Netsanet, B., & Yonatan, K. (2015). Participatory evaluation of dual purpose pigeon pea (Cajanus cajan) leaves for sheep feeding. *Journal of Biology, Agriculture and Healthcare*, *5*(13), 224-230.

[5] Nair, Ramakrishnan M., et al. "Biotic and abiotic constraints in mung bean production—progress in genetic improvement." Frontiers in Plant Science 10 (2019): 1340.

[6] Baraki, F., Gebregergis, Z., Belay, Y., Berhe, M., & Zibelo, H. (2020). Genotype x environment interaction and yield stability analysis of mung bean (Vigna radiata (L.) Wilczek) genotypes in Northern Ethiopia. *Cogent Food & Agriculture*, *6*(1), 1729581.

[7] CSA. "The federal democratic republic of Ethiopia central statistical agency report on area and production of major." Statistical Bulletin, 2021/2022.

[8] Zeru Yimer Kebede. (2022). Research report on proven sweet lupin varieties demonstration under North-West Ethiopia. Int. J. Adv. Res. Biol. Sci. 9(7): 207-211. http://dx.doi.org/10.22192/ijarbs.2022.09.07.020

[9] Yirga, Masreshaw, et al. "Performance of Introduced Climbing Bean (Phaseolus vulgaris L.) Varieties for Registration in Ethiopia." Ethiopian Journal of Crop Science 10.1 (2022).

[10] Geda, S. A., & Kühl, R. (2021). Exploring smallholder farmers' preferences for climate-smart seed innovations: empirical evidence from southern Ethiopia. *Sustainability*, *13*(5), 2786.

[11] Shumeta, Z., & D'Haese, M. (2018). Do coffee farmers benefit in food security from participating in coffee cooperatives? Evidence from Southwest Ethiopia coffee cooperatives. *Food and nutrition bulletin*, *39*(2), 266-280.

[12] Kebede, E. (2020). Grain legumes production and productivity in Ethiopian smallholder agricultural system, contribution to livelihoods and the way forward. *Cogent Food & Agriculture*, *6*(1), 1722353.

[13] Ersulo, D., & Dana, A. (2018). Evaluation of common bean varieties for yield and yield component in segen area peoples zone SNNPRS, Ethiopia. *Evaluation*, *72*.

[14] Kassa, Y., Abie, A., Mamo, D., & Ayele, T. (2022). Exploring farmer perceptions and evaluating the performance of mung bean (Vigna radiata L) varieties in Amhara region, Ethiopia. *Heliyon*, *8*(12).

[15] Lema, M., Mekonnen, B., & Gudero, G. (2018). Performance and Growth Analysis of Three Mungbean (Vigna Radiate (L.) Wilczek) Genotypes at Hawassa, Ethiopia. *Current Trends Biomedical Engineering & Biosciences*, *16*(2), 85-88.

[16] Kassa, Y., Admasu, D., Tigabe, A., Abie, A., & Mamo, D. (2018). Participatory on farm evaluation of improved mungbean technologies in the low land areas of North Shewa Zone Amhara Region, Ethiopia. *Journal of Agricultural Extension and Rural Development*, *10*(8), 158-164.

[17] Zewdu, Z. (2020). Participatory Varietal Selection and Agronomic Performance Evaluation of Common Bean (Phaseolus vulgaris L.) Genotypes in MetekelZone, North Western Part of Ethiopia. *International Journal of Research*, *6*(6), 11-16. http://dx.doi.org/10.20431/2454-6224.0606002

[18] Bassa D, Goa Y (2022) Participatory Evaluation of Chickpea (cicer arietinum L.) Varieties in Wolayta Zone, Southern Ethiopia. Biol Syst Open Access. 11: 046.

[19] Dembi, K., Basha, K., & Girma, A. (2021). Pre-Extension Demonstration of Improved Haricot Bean Technologies at Midland Districts of Guji Zone, Southern Oromia, Ethiopia. *International Journal of Food Science and Agriculture*, *5*(2), 285-292.

[20] Berihun, T. T. B., Belay, A., Sefane, G., Ali, Y., Demeke, B., Gashaw, A., & Gashaw, M. (2021). Promoting Improved Mung Bean Production Technologies in Eastern Amhara. *Innovations for Food and Livelihood Security*, 161.

[21] Kassa, Yehuala, et al. "Scaling up of improved mung bean technology in the potential areas of North Shewa Zone Amhara Region." International Journal of Agricultural Extension 9.2 (2021): 135-141. https://doi.org/10.33687/009.02.3257

[22] Baza, M., Shanka, D., & Bibiso, M. (2022). Agronomic and economic performance of mung bean (Vigna radiata L.) varieties in response to rates of blended NPS fertilizer in Kindo Koysha district, Southern Ethiopia. *Open Life Sciences*, *17*(1), 1053-1063.

[23] Assefa, Z. B., Dinku, A. M. & Jemal, A. M. Value chain analysis of Mung Bean (*Vigna radiata* L. Wilczek thrive) in Kalu Woreda, Ethiopia. *Agric & Food Secur* 11, 54 (2022). https://doi.org/10.1186/s40066-022-00393-2