American Journal of BioScience
2024, Vol. 12, No. 6, pp. 174-181
https://doi.org/10.11648/j.jps.20241206.11

Research Article

Haricot Bean (*Phaseolus vulgaris* L.) Varieties Adaptation Trial in Buno Bedele and Ilu Ababor Zones, South West Oromia

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Abstract

Haricot bean is one of the most economically important pulse crops cultivated in Ethiopia. However, its average yield reported at national level remains far below the potential yield to be attained. This is partly due to low soil fertility management, inappropriate agronomic packages and diseases and pest problems and lack of improved varieties. Hence, this experiment was conducted with the objectives of to test the performance of released improved Haricot bean varieties on yield and yield related components and Insect and disease resistant varieties for the study at Western parts of Oromia. The experiment was conducted in Buno Bedele (D/Hana) and Ilu Ababor (Bure) districts during 2020 to 2021 cropping season. Nine (9) improved Haricot bean varieties were used as testing materials. The experimental design was RCBD with three replications. Data were collected on six quantitative morphological traits like days to 50% flowering, days to maturity, number of seed per pod, pod length and grain yields. Analyses of data revealed significant varietal differences (P<0.05) in grain yield, days to 50% flowering, days to 95% maturity, seed per pod and for plant height. However, no significant varietal differences were observed in Number of pods per plant. SER 119 and SER 125 varieties were significantly yielder than the rest and recommended as promising variety under the study area. Therefore, these two varieties are recommended for demonstration and further scaling up.

Keywords

Haricot Beans, *Phaseolus vulgaris L.*, Adaptations, Varieties

1. Introduction

The importance of the common bean cannot be overemphasized. Apart from providing the subsistence needs such as food to many people in the world [1]. Beans are also sold in local markets and urban areas to provide cash to farmers and traders. They are the leading grain legume crop taking up 30% of the total pulse production and grown on more than 14 million hectares worldwide [2]. Of the five domesticated species of Phaseolus, the common bean (P. vulgaris) is the most widely grown, occupying more than 85% of production area sown to all Phaseolus species in the world [3]. It is produced primarily in tropical low-income countries, which account for over three quarters of the annual world production. Economic significance of common bean in Ethiopia is quite considerable since it represents one of the major food and cash crops. It is often grown as cash crop by small-scale farmers and used as a major food legume in many parts of the coun-

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Received: 24 April 2023; **Accepted:** 16 October 2024; **Published:** 11 November 2024

try where it is consumed in different types of traditional dishes [4]. All species of the genus of common beans (*Phaseolus vulgaris* L.) are diploid and most have 22 chromosomes (2n =22). A few species show an aneuploidy reduction to 20 chromosomes. The genome of common bean is one of the smallest in the legume family at 625 Mbp per haploid genome. The genus Phaseolus contains some 50 wild-growing species distributed only in the American. Asian Phaseolus have been reclassified as Vigna [5]. These species represent a wide range of life histories (annual to perennial), growth habits (bush to climbing), reproductive systems, and adaptations (from cool to warm and dry to wet). The genus also contains five domesticated species. Common bean belongs to family Fabaceae. Common bean plays a paramount role in human nutrition and market economies in the world. World common bean production can be conveniently grouped into twelve regions, the most important of which are Brazil, Mexico and Eastern African highlands. Beans are a major staple in these regions, which together contribute to half of the world’s production. Latin America, the center of origin for the common bean particularly central Mexico is the leading common bean production in the world [6].

Common bean is a major legume crop with significant nutritional importance. It is a major source of calories and protein source in many developing countries throughout the world [7]. According to [8] With regard to morphological variation of Ethiopian common bean germplasm introductions, no study has been done in the past. Since common bean is grown in most parts of Ethiopia with a wide range of variation in altitude, rain fall, temperature, agricultural system and socio-economic factors, it is essential to assess the pattern of character variations among and between accessions to resolve the problems in different regions and adaptation zones. It is grown best in warm climates at temperatures of 18 to 24 ℃ [9]. Economic significance of common bean in Ethiopia is quite considerable since it represents one of the major food and cash crops. It is often grown as cash crop by small-scale farmers and used as a major food legume in many parts of the country where it is consumed in different types of traditional dishes [10]. The estimated production area and yield of common bean in Ethiopia in 2020/2021 cropping season were 208,295.03 hectares and 3,670,300.05 quintals, with respective increment of 2.99 % and 2% in area and production, respectively. In addition, the average national yield was reported to be 17.62 Qt/hec [11].

The largest common bean production areas are found in Oromiya, Benshangul-Gumuz, SNNPR, Tigray and in Amhara regional states [12]. Somalia and Gambela regional states also produce a considerable amount of common bean. Production and productivity of common bean is increasing from year to year in western Oromia [13]. Access to new and improved agricultural technologies is limited in Buno Bedele and Ilu Abba Bora zones of Oromia most probably due to remoteness from the center and inaccessibility of improved agricultural technologies in the areas. The potential of pulse crops is not exploited in this part of the region due to lack of improved varieties, poor management practices, biotic factors (weeds, diseases and insect pests etc.), and a biotic factors (soil acidity, high intensity and long duration of rainfall). Also low yield is attributed to various constraints such as moisture stress, the absence of improved high-yielding varieties, low soil fertility, and losses due to insect pests and disease [14].

So far, the national and regional research institutions in the country have released many varieties for commercial Production. However, these technologies did not tested for their adaptability potential under western part of Oromia and did not reach the smallholder farmers living in western parts of Oromia. Therefore, to overcome the above stated problems and to acquaint smallholder farmers with new technologies of widely grown pulse crops production, the well-performed, adaptable and high yielding haricot bean varieties were tested and identified to study area. Therefore, the objective of this activity was to evaluating and selects better adapted haricot bean varieties for yield and yield components for the study areas and other similar agro-ecologies.

2. Materials and Methods

Description of the study area

The experiment was conducted at Dabo Hana district (Dhaye sub-site) in Buno Bedele and Bure (Toli cheka sub-site) district during 2020-2021 main cropping seasons.

Bure District

Bure is one of Southwest of Ethiopia located in Ilubabor Zone of Oromia Region. The district is bordered on the south by Nono, on the west by Kelem Welega Zone, on the north east by Metu, and on the Southwest by Gembela Region. The administrative center of this district is Bure. The district is located 683 km away from the capital city of the country and 80 km away from Ilu Aba Bora Zone. The district is located at an average elevation 1730 m.a.s.l and located at $08^{0}17$’to $08^{0}18$’55.4” N latitude and $035^{0}6$’to $035^{0}311$’.6” E longitude.

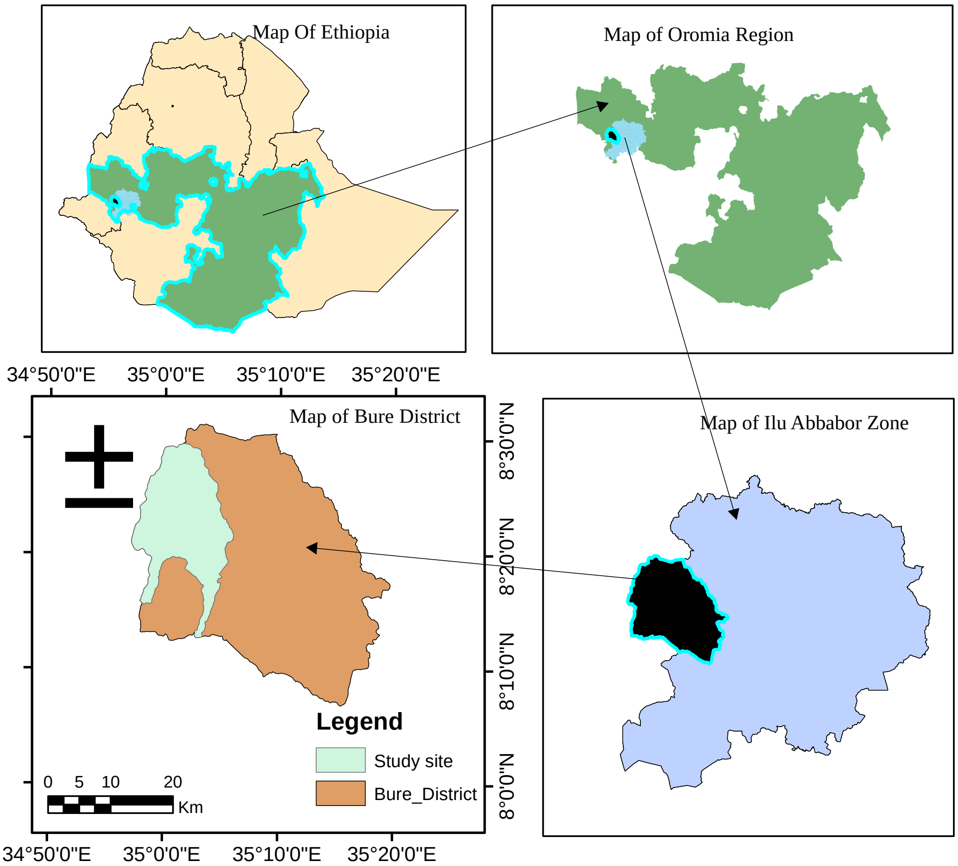

Figure 1. Map of the study area (Bure) district.

It is generally characterized by warm climate with a mean annual maximum temperature of 89 °F (31.66 °C) and a mean annual minimum temperature of 50 °F (10 °C.) The driest season lasts between June and September, while the coldest month being November.

The annual rainfall ranges from 2000 mm. The soil of the area is characterized as an old soil called Nito soils. The economy of the area is based on mixed cropping system and livestock raring agricultural production system among which dominant crops are Coffee, Hot paper, sorghum and haricot bean, sesame and also horticultural crops.

Dabo Hana District

Dabo Hana is one of the districts in Buno Bedele Zone, Oromia Regional State Southwest part of Ethiopia. The district is bordered on the south by Chora, on the west by Chawaka, on the north by Nekemte, and on the east by Bedele. The administrative center of this district is kone. The district is located 521 km away from the capital city of the country and 38 km away from Bedele Town of Buno Bedele Zone. The district is located at an average elevation 1190-2223 m.a.s.l and 8°30″ 21' N-8°43″29' N latitude and 36°5″27' E-36°36″19' E longitude.

It is generally characterized by warm climate with a mean annual maximum temperature of 28 °C and a mean annual minimum temperature of 11 °C. The driest season lasts between December and January, while the coldest month being December. The annual rainfall ranges from 900 mm-2200mm. The soil of the area is characterized as an old soil called Nit soils. The economy of the area is based on mixed cropping system and livestock raring agricultural production system among which dominant crops is maize, sorghum and coffee and also horticultural crops like hot paper.

Table 1. Description of Haricot bean varieties used in the experiment.

S. №	Variety Names	Altitude ranges (m.a.s.l)	Year of Release	Use/Type	Maintainer
1	Dimtu	1200-1800	2003	Food	MARC/EIAR
2	Dinkinesh	1400-1850	2006	Food	MARC/EIAR
3	Dursitu	NA	2008	Food	HU

S. №	Variety Names	Altitude ranges (m.a.s.l)	Year of Release	Use/Type	Maintainer
4	Dandesu	1300-1650	2013	Food	MARC/EIAR
5	Nasir	1200-1800	2003	Food	MARC/EIAR
6	SER 119	1450-2000	2014	Food	MARC/EIAR
7	SER 125	1450-2000	2014	Food	MARC/EIAR
8	SCR15	NA	2019	Food	MARC/EIAR
9	Anger	NA	2005	Food	BARC/OARI

MARC=Melkessa Agricultural Research Center, BARC= Bako Agricultural Research Center, HU=Haramaya University, OARI= Oromia Agricultural Research Institute, EIAR= Ethiopian Institute of Agricultural Research, NA= Non-available.

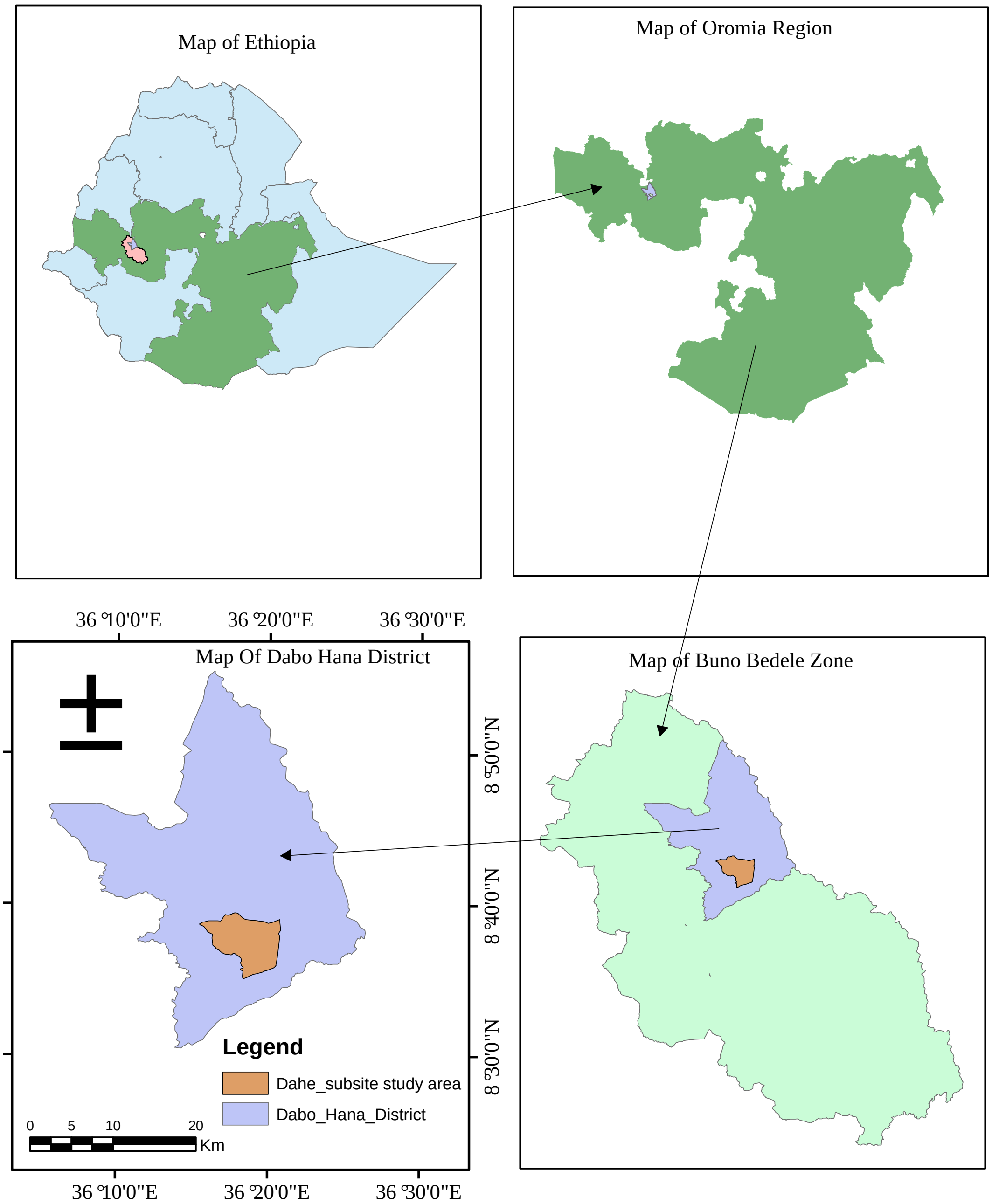

Figure 2. *Map of the study area (Dabo Hana) district.*

Experimental Materials and Design

Nine (9) haricot bean varieties were brought from Melkasa Agricultural Research Center and evaluated as experimental materials. These materials were randomly assigned to the experimental block and the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The spacing between blocks and plots was 1m and 0.5m, respectively. The gross size of each plot was 7.2m^2 (3m x 2.4m) having six rows with a row-to-row spacing of 40cm. The total area of the experimental field was 285.2m^2 (31m x 9.2m). Planting was done by keeping the distance between plants to the spacing of 10cm. NPS fertilizer was applied at the rate of 100kg ha^{-1} at the time of planting. All other recommended agronomic management practices were applied properly.

Data collected

Data were collected both at plot and plant basis. The four central rows were used for data collection based on plots, such as days to flowering, days to maturity and 1000 seed weight. Five plants from the central rows were randomly selected for data collection on plant basis and the averages of the five plants in each experimental plot were used for statistical analysis for traits such as plant height, number of pods/plants and number of seeds/plants.

Days to 50% flowering initiation: this was determined by counting the number of days from planting to the time when first flowers appeared in 50% of the plants in a plot by counting the number of plants.

Days to physiological maturity: it was determined as the number of days from planting to the time when 90% of the plants started senescence of leaves (yellowing of the foliage) and pods started to turn yellow. This was done by counting the number of plants.

Plant height (cm): it was measured at physiological maturity from the base to the tip of a plant for randomly pre-tagged ten plants in harvestable rows using meter tape and averaged on a plant basis.

Number of pods per plant: it was recorded based on five pre-tagged plants in each net plot area at harvest and the average was taken as number of pods per plant.

Pod length (PL) (cm): was determined by measuring the length in cm from 15 randomly taken pods from 5 sampled plants at physiological maturity using a ruler.

Number of seeds per pod: the total number of seeds in the pods of five plants was counted and divided by the total number of pods to find the number of seeds per pod.

Number of Seeds per Pod (SPP): Average number of seeds per pod, counted at physiological maturity in 15 randomly taken pods per five sampled plants.

Grain yield (kg ha-1): Grain yield was measured by harvesting and threshing of the crop from the net plot area. The moisture was adjusted to 10%.

Data Analyses

Analysis of variance was done using Genstat 18th computer software. Mean separations were estimated using Least Significant Difference (LSD) for the comparison among the experimental varieties at 0.05 probability level as stated in Gomez and Gomez [15]. Combined analysis of variance for both years and seasons was done to test the response of varieties to both environment and seasons after testing the homogeneity of the data.

3. Results and Discussions

The combined analysis of variance across the two locations was presented in Table 2. The mean square from the analysis of variance over the two test locations showed significant location effects ($p \leq 0.05$) for all of the traits evaluated except number of pods per plant. Based on the individual location, the highest seed yield was observed at the two districts from SER-119 Variety produced 33.27 Qt/ha followed by SER-125 which produced 29.72Qt/ha, while the lowest yield at both tested locations was observed from variety Dandessu 17.96Qt/ha. The existence of genotypic variation in grain yield and yield components of common bean has been reported by various authors, reported that, wide genetic variation in yield and its related traits among different common bean varieties

The current result was in agreement with the finding of were showed that reported the presence of the significant effect of genotype, environments and their interaction on common bean grain yield.

Table 2. *Combined mean ANOVA of 9 Haricot bean varieties for grain yield in qt ha^{-1} in 2020-2021 cropping season.*

SOV	Degree of freedom	Sum of squares	Mean of squares	F-Value	Pr(<F)
Var	8	7885.7	985.7	6.95	<0.001**
Loc	1	5887.3	5887.3	41.48	<0.001**
Var*Loc	8	609.5	76.2	0.54	0.828
Year	1	8705.4	8705.4	61.34	<0.001**
Year*Loc	1	3093.3	3093.3	21.80	<0.001**

SOV	Degree of freedom	Sum of squares	Mean of squares	F-Value	Pr(<F)
Year*Var	8	1139.5	142.4	1.00	0.434
Year*Loc*Var	8	822.6	102.8	0.72	0.67
Residuals	232	32926.0	141.9		

Remarks: Var=variety, Loc=Location, **significant at 0.01 probability level,

Based on combined mean separation (Table 4), the highest days to 90% maturity was obtained for variety Dursitu (87.18 days) followed by Anger (86.82 days) and the lowest days to 90% maturity was obtained for variety Dandessu (75.82days) followed by SER-119 (80.30 days) which indicated that Ser119 and Dandessu were matured earlier.

The highest plant height was recorded for variety Nasir (74.52 cm) followed by Dinkinesh variety (70.72 cm) and the lowest plant height was recorded for Dandessu variety (38.97 cm). The highest number of of pods per plant was obtained from Dursitu (21.82 pods/plant), while the lowest number of pods per plant was obtained for Dandessu (18.49) followed by SCR-15 (18.71). Maximum number of seeds per pod was noted in SER-119 variety (2.69), whereas, the lowest number of seeds per pod (1.52) was obtained for Dandessu Variety (Table 4). Grain yield was ranged from 1491.60 kg ha-1 (variety Sab 632) to 2929.70 kg ha-1 (variety Nasir). Therefore, the maximum grain yield ((33.27Qt/ ha) was recorded for variety SER-119 followed by Ser125 (29.72Qt.ha) and Nasir (29.52 Qt/ha) (Table 3). Likewise, Kassaye (2006), Yayis *et al*, (2011), and Solomon (2016) were indicated that differences in yield among different common bean genotypes.

Table 3. *Combined mean grain yield (qt ha^{-1}) of Haricot bean varieties tested at D/Hana and Bure districts for two years (2020/21-2021/22) years.*

S. No	Varieties	Dabo Hana District			Bure District			Over All Combination
		1st year	2nd year	Combined	1st year	2nd year	Combined	
1	Dimtu	25.81b	22.06bc	24.56c	21.60c	21.99bc	21.76cde	23.29c
2	Dinkinesh	27.89b	15.21de	23.67cd	22.84c	14.58d	19.54de	21.79cd
3	Dursitu	27.43b	18.10cde	25.39c	21.14c	18.52cd	20.09de	22.98cd
4	Dandesu	23.38bc	12.45e	18.66d	23.46bc	7.64e	17.13e	17.96e
5	Nasir	34.49a	26.69ab	31.89ab	27.16abc	25.93ab	26.67abc	29.52b
6	SER 119	38.77a	30.46a	36.00a	29.17ab	31.25a	30.00a	33.27a
7	SER 125	36.00a	22.08bc	31.36ab	30.25a	24.07bc	27.78ab	29.72ab
8	SCR15	19.33a	19.88cd	19.51d	22.07c	15.04d	19.26de	19.40de
9	Anger	34.61a	23.52bc	30.91b	25.46abc	21.99bc	24.07bcd	27.80b
GM		29.75	21.16	26.88	24.79	20.11	22.92	25.08
LSD 5%		5.49	6.18	5.00	6.09	6.74	5.00	3.65
CV%		22.8	25.1	28.4	26.1	28.8	30.2	30.1
P-v		**	***	***	*	***	****	***

GM=Grand mean, LSD= Least significant different, **=significant at P<0.01, *=significant at P<0.05, CV= coefficient of variation

Table 4. Combined mean yield related traits of Haricot bean varieties tested at Bure and Dabo Hana districts for two years.

Varieties	DM (days)	PH (cm)	NPPP	NSPP	PL (cm)
Dimtu	85.27[a]	66.66[a]	19.84	1.93[bc]	9.06bcd
Dinknesh	86.09[a]	70.72[a]	21.36	1.88[bc]	9.46b
Dursitu	87.18[a]	65.07[a]	21.83	1.97[bc]	8.66de
Dandesu	75.82[c]	38.97[b]	18.49	1.52[c]	8.51e
Nasir	86.64[a]	74.52[a]	21.37	2.46[ab]	8.86cde
SER-119	80.30[b]	66.38[a]	19.99	2.69[a]	9.52b
SER-125	79.33[bc]	65.23[a]	20.62	2.40[ab]	9.17bc
SCR-15	85.55[a]	66.42[a]	18.71	1.71[c]	10.01a
Anger	86.82[a]	70.02[a]	20.87	2.35[ab]	9.06bcd
GM	83.67	64.89	20.31	2.11	9.16
LSD 5%	4.15	11.69	3.53	0.61	0.47
CV %	10.3	37.2	36.00	60.5	10.8
P-Value	**	**	NS	*	***

DM= Days to Maturities, PH= Plant height (cm), NPPP= Number of Pod per plant, NSPP=Number of seed per plant, PL= Pod length, GM= Grand mean, LSD= Least significant different, CV= Coefficient of variation,*=significant at P<0.05 level, **=significant at P<0.01, ***= very highly significant

Correlation between yield and yield-related traits

Phenotypic correlations between yield and yield-related traits based on data averaged over two locations are reported in Table 5. The table revealed that grain yield had positive associations or higher magnitude values were obtained for the phenotypic correlations with plant height (r=0.32*), Number of pod per plant (r=0.40*) and number of seed per pod (r=0.25*) at P< 0.01 probability. While grain yield had a negative association with pod length (r=-0.38*). According to the results of the present study, grain yield showed a positive and high level of relationship with plant height, number of seed per pod and number of pod per plant. This suggests that the selection of high-yielding varieties with considerations of those traits.

Table 5. Correlation coefficients among evaluated between grain yield and yield related traits of nine (9) Haricot bean varieties Adaptation trials for two consecutive years.

Traits	DM	PH	NPP	PL	NSPP	GY(Kg/ha)
DM	1					
PH	0.07	1				
NPP	0.23*	0.23*	1			
PL	0.02	-0.47*	-0.41	1		
NSPP	0.12	0.35*	-0.08	-0.32	1	
GY(Kg/ha)	0.18	0.32*	0.40*	-0.38*	0.25*	1

DM= days to maturity, PH= plant height, NPP= Number of pod per plant, PL= Pod length, NSPP=Number of seed per plant

4. Conclusion and Recommendation

Common bean is an important food and cash crop in Ethiopia and the estimate of genetic progression, the evaluation of high-yielding and stable cultivars are necessary. Different haricot bean varieties are released by different research centers but the adaptability and genetic progression of these varieties were not tested in Buno Bedele and Ilu Ababor Zones. Considering this nine improved haricot bean varieties were tested at Dabo Hana and Bure districts for two consecutive years. Generally, the present study entails the presence of significant variations among common bean varieties for grain yield and yield related traits. The analysis of variance indicated that there was a significant difference among varieties for days to flowering, days to maturity, plant height, and pod length, number of seed per pod and grain yields. From the combined results of the two years across the two locations revealed that SER-119 (33.27 Qt/ha), showed the highest yielder variety followed by SER-125 (29.72 Qt/ha). Hence, these two varieties are recommended to be demonstrated and popularized to the small-scale holder farmers, that they can boost the income of poor farmer.

Abbreviations

SNNPR	Southern Nations, Nationality & Peoples Region
ANOVA	Analysis of Variance
m.a.s.l	Meters Above Sea Level
qt	Quintals
OARI	Oromia Agricultural Research Institute

Acknowledgments

The authors would like to acknowledge Oromia Agricultural Research Institute (OARI) for funding the project "Adaptation trial of improved Haricot bean varieties under agro ecology of western Oromia" from 2020-2022 and Bedele Agricultural Research Center for facilitating the working conditions throughout the research period and also Melkassa Agricultural Research center highly acknowledged for providing the improved Haricot bean varieties for the experiment.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] CIAT (2004). Regional bean variety testing in southern Africa. Highlights, CIAT in Africa No. 20, December 2004. Pp. 1-2.

[2] Singh SP (2001). Broadening the Genetic Base of Common Bean Cultivars: A review. Crop Sci. 41: 1659-1675.

[3] Habtu A., 1994. Epidemiology of bean rust in Ethiopia, Ph.D Thesis. The Netherlands: Wageningen Agricultural University. 172p.

[4] ADA (American Dietetic Association) 2004. Position of the American Dietetic Association and dietitians of Canada: nutrition intervention in care of persons with human immunodeficiency virus infection. JADA 104: 1425-1441.

[5] Binam, J. N., Kalilou, S., Diarra, I., and Nyambi, G. (2003). Factors affecting technical improve of common bean. Broughton WJ, Hernandez G, Blair M, Beebe S, Gepts P, Vanderleyden, J. (2003). Beans (Phaseolus spp.) model food legumes. Plant and Soil 252: 55-128.

[6] CSA (Central Statistical Agency of Ethiopia). 2021 Statistical report on area and production country forecast of major crops: Agricultural sample enumeration surveys, various issues, Addis Ababa, Ethiopia.

[7] Gepts, P., Osborn, T. C., Rashka, K. and Bliss, F. A. 1998; NARO 2000. Phaseolin protein variability in wild forms and landraces of the common bean (Phaseolus vulgaris): evidence for multiple centers of domestication. *Economic Botany*, 40: 451–468.

[8] Kruzich LA, Marquis G. S, Carriguiry A. L, Wilson C. M, Stephensen C. B. (2004). A US youth in the early stages of HIV disease has low intakes of some micronutrients important for optimal immune function. J Am Diet Assoc 104: 1095-1101.

[9] Safari, A. 1978. A yield component selection experiment involving American and Iranian cultivars of common bean. *Crop Sci.* 18: 5-7.

[10] Assefa, T., Abebe, G., Fininsa, C., Tesso, B., & Al-Tawaha, A. R. M. (2005). Participatory bean breeding with women and small holder farmers in eastern Ethiopia. World Journal of Agricultural Sciences, 1(1), 28-35.

[11] CSA (Central Statistic Agency of Ethiopia). 2020. Statistical report on area and production country forecast of major crops: Agricultural sample enumeration surveys, various issues, Addis Ababa, Ethiopia.

[12] McClean P. E, Lavin M, Gepts P, Jackson, S. A (2008). Phaseolus vulgaris: a diploid model for soybean. In G. Stacey (Eds), Soybean Genomics. Springer, Berlin, pp 55-78.

[13] CSA (Central Statistic Agency of Ethiopia). 2005. Statistical report on area and production country forecast of major crops: Agricultural sample enumeration surveys, various issues, Addis Ababa, Ethiopia.

[14] Ferris, S., & Kaganzi, E. (2008). Evaluating marketing opportunities for haricot beans in Ethiopia. IPMS Working Paper.

[15] Gomez, K. A. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Ed., John Willey and Sons. Singapore.