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Evaluation of Haricot Bean [*Phaseolus vulgaris* (L.)] Varieties for Yield and Yield Components at Ebinat and Tach Gayint Districts of South Gondar Zone, Northwestern Ethiopia

Dejen Bekis Fentie[1], Alamir Ayenew Worku[2], Solomon Sharie Shferaw[2]

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ABSTRACT

Background: Haricot bean is the most important food legumes in Ethiopia. However, low productivity is the major problem in South Gondar zone, which is mainly associated with lack of recently released high yielder varieties in the areas. The aim of this study was an attempt to identify suitable high yielder haricot bean varieties for the study areas and similar agro ecologies.

Methods: This study was conducted during the rainfed season of 2021 and 2022 at Ebinat and Tach Gayint districts in South Gondar zone, Ethiopia. Four haricot bean varieties with one local check were used as a treatment and laid out in randomized complete block design with three replications.

Result: Analysis of variance showed a highly significant variability among the varieties for days to maturity, pod length, pods per plant, seeds per pod, grain yield and 100 grain weight. All these traits showed a highly significant difference by location variations. Variety by location interaction also showed a significant variation on days to maturity, pods per plant,100 grain weight and grain yield. SER119 was found the highest yielder variety with mean yield of 2861.00, 2887.50 and 2231.59kg ha^{-1} at Burkoch, Fenta and Balarb locations, respectively. This variety has a respective yield advantage of 59.41%, 47.01% and 38.70% over the local check. Whereas, Awash mitin showed a highest yield at Daka (2285.70 kg/ha) and Anseta (1995.50 kg ha^{-1}) locations with respective yield advantage of 33.96% and 39.95% as compared to the check cultivar. Therefore, SER119 and Awash mitin varieties could be recommended for Ebinat and Tach Gayint districts and similar agro-ecologies to each location.

Key words: Evaluation, Haricot bean, Location, Varieties, Yield.

INTRODUCTION

Haricot bean (*Phaseolus vulgaris* L; 2n= 22) is a diploid self-pollinated plant that belongs to the genus Phaseolus in the Fabaceae family (Pandey and Kumar, 2024), which has more than 80 cultivated and wild species in the world (Etana and Nebiyu, 2023). Haricot bean is the most important food and cash crops worldwide (Huang *et al*., 2021; Wodajo *et al*., 2021). Haricot bean is also one of the main staple crops in Africa (Zamukulu *et al*., 2023). According to FAO (2023), Africa is the third common bean producer (21.3% of the world production) after Asia (43.9%) and America (32.2%). In Africa, the major common bean-producing countries include Burundi, DR Congo, Ethiopia, Kenya, Rwanda, Tanzania and Uganda, indicating that East Africa is the most suitable bean production region on the continent (Buruchara *et al*., 2011; Tigist *et al*., 2023).

Haricot bean is the main cash crop and the least expensive protein source for farmers in many of the lowlands and midlands of Ethiopia. It is also exported to earn foreign exchange (Zebire and Gelgelo, 2019; Cholo *et al*., 2023). Haricot bean is the most widely cultivated in Ethiopia which covered 18.6% of land with 17.3% of grain production from pulse crops produced in 2021 (Ethiopian Central Statistics Agency/CSA, 2021). In Ethiopia, common bean covered about 339,350.34 hectares of land and 584,157.99 tons of grain was produced per annum in 2022 with average productivity of 1.72 tons per hectare (CSA, 2022). As the demand of common bean production is increasing in alarming rate, the area of production increasing from 280,834.99 ha in 2020 to 339,350.34 ha in 2022 (CSA , 2020; CSA, 2022).

Haricot bean is an important source of nutrients for more than 300 million people in parts of Eastern Africa and Latin America, representing 65% of total protein consumed, 32% of energy and a major source of micronutrients, *e.g.,*

[1]Departement of Field Crops Breeding, Ethiopian Institute of Agricultural Research, Fogera National Rice Research and Training Center (FNRRTC) at Woreta, Ethiopia.
[2]Departement of Field Crops Breeding, Ethiopian Institute of Agricultural Research, Debre Tabor Medium Agricultural Research Center at Debre Tabor, Ethiopia.

Corresponding Author: Dejen Bekis, Departement of Field Crops Breeding, Ethiopian Institute of Agricultural Research, Fogera National Rice Research and Training Center (FNRRTC) at Woreta, Ethiopia. Email: djbks21@gmail.com

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iron, zinc, thiamin and folic acid (Petry *et al*., 2015, Menbere, 2017). In addition to these, common bean is a non-sensitive crop to soil as long as it is well-drained and fertile (Rahman *et al*., 2014) and has also a big importance for nitrogen fixation which improves soil fertility while increasing crop production (Gebre-egziabeher *et al*., 2014; Menbere, 2017; Pandey and Kumar, 2024). The annual per capita consumption is higher among low-income people who cannot afford to buy nutritious food stuff, such as meat and fish (Arenas *et al*., 2013; Zebire and Gelgelo, 2019). Common bean is very preferred by Ethiopian farmers because of the possibility of maturing by around two months that enables households to get cash returns essential to pay for food and other household needs when other crops have not yet matured (Legesse *et al*., 2006). Early maturity and moderate degree of drought tolerance led the crop's vital role in farmers' strategies for risk aversion in drought prone lowland areas of the country (Fikru, 2007).

There are wide ranges of common bean types grown in Ethiopia including mottled, red, white and black varieties (Ali *et al*., 2006). The most commercial varieties are pure red and pure white color beans and these are becoming the most commonly grown types with increasing market demand (Ferris and Kaganzi, 2008). Among districts in South Gondar zone, the production of common bean is concentrated in the lowlands of Ebinat, Tach Gayint, Sediemuja and Estie districts due to the presence suitable environments to this crop. However, lack of improved varieties of common bean is the major problem for low production and productivity of the crop in these areas. Therefore, the study was initiated to identify and recommend suitable high yielder haricot bean varieties for the study areas and similar agro ecologies in northwestern, Ethiopia.

MATERIALS AND METHODS

Description of experimental sites

Field experiment was conducted by EIAR through Fogera National Rice Research and Training Center at two locations of Ebinat and three locations of Tach Gayint districts from July to September in 2021 and 2022 cropping season. The experimental locations were Burkoch kebele at Farmers Training Center (FTC)(Ebinat), Balarb/Qualisa-Ebinat, Anseta-Tach Gayint, Aduka/Fenta-Tach Gayint and Daka-Tach Gayint (the nearby Anseta) which are located in Amhara region of north western part of Ethiopia as shown in Fig 1.

Location, topography and agro-ecology of Ebinat District

Ebinat district is located in north western part of Ethiopia in Amhara region. Ebinat is located in between 11° and 12° north latitude and 37° and 38° east longitude with altitude ranges from 1800 m-2150 m above sea level. Ebinat; town of the district is located 107 km away from D/Tabor, 126 km from Bahirdar and 614 km from Addis Ababa. It is bordered by Centeral Gondar Zone (East Belesa woreda) on the north; Farta woreda in the south; North Wollo Administrative Zone of Bugna woreda and Waghimra Zone of Dihana woreda on the east; Lai Gayint woreda in the south east and Libo Kemkem woreda in the west (Gashaw, 2021).

Topographically, 45% of the woreda is mountainous, 35% hilly, 15% plain and 5% is valley. Ebinat has three agroecological zones with 50% kolla, 35% Woyina Dega and 15% Dega and water source for crop production is based on rain fed. Moreover, the average annual rainfall ranges from 500 mm to 1300 mm (South Gondar Administrative Zone Information and Communication Office, 2011; Melkegnaw, 2015; Gashaw, 2021).

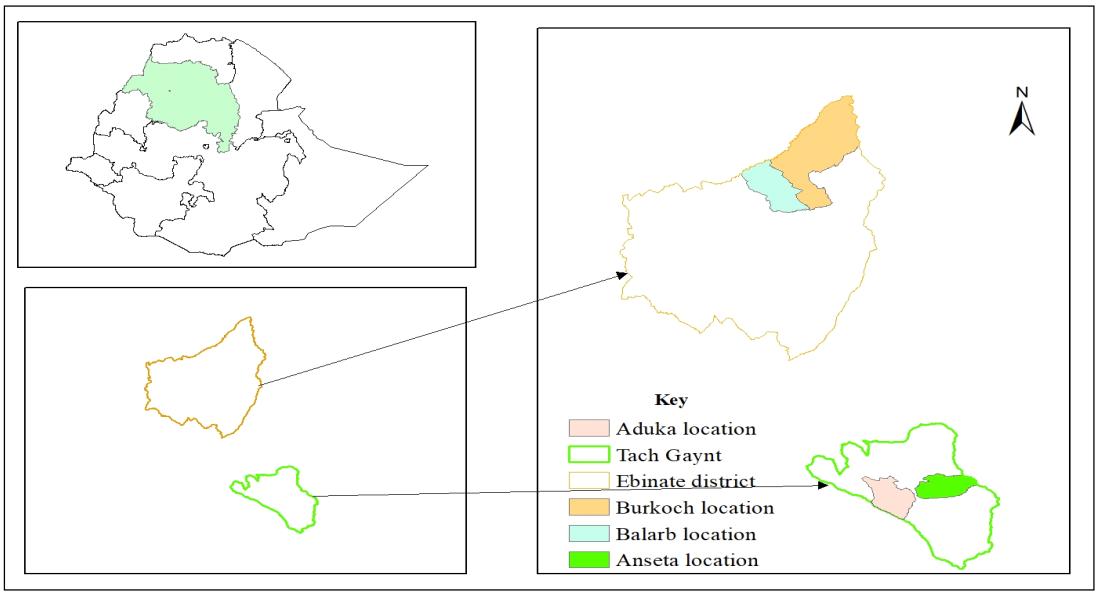


Fig 1: Map of experimental sites.

Location, Topography and Agro-ecology of Tach Gayint District

Tach Gayint is one of the districts in South Gondar zone of Amhara region of Ethiopia. Tach Gayint is located in between 11°29′59.99″ -11°15′36″ north latitude and 38°14′ 60″-38°37′42″ east longitude with altitude ranges from 750 to 2800 meters above sea level. Arb Gebeya; town of the district is located 100 km away from D/Tabor, 197 km from Bahirdar and 760 km from Addis Ababa. Tach Gayint is bordered on the south by the Bashilo River which separates it from the South Wollo Zone, on the west by Simada, on the north by Lay Gayint and on the east by the Checheho River which separates it from the North Wollo Zone (Google earth).

Topography of the district consists of gullies and rugged terrain (54%), mountains (23%) and plain (22%) and it is divided in to three agro-climatic zones. Dega (23%), Woina dega (63%), kola (23.7%) and water source for crop production is based on rain fed. Moreover, the average annual rainfall is 820mm. Above all a significant portion of the land is degraded. Repeated natural calamity has deteriorated the situation. Of these entire calamities drought is the major problem (South Gondar Administrative Zone Information and Communication Office, 2011, Aimro *et al*., 2023).

Description of the experimental materials

Four common bean varieties with one local check were used for this study. The improved common bean varieties were obtained from Melkasa Agricultural Research Center, Lowland Pulse Crops Research program. Some descriptions of the varieties are provided in Table 1.

Experimental design and management

The experiment was laid out in a randomized complete block design with three replications. Plot size was 16 m^2 consisting of 10 rows each 4 m long. The inter-row and intra-row spacing was 40 cm and 10 cm, respectively. The distance between plot and replication was 0.6 m and 1.5 m, respectively. One seed per hill seed rate was used. 150 kg NPS fertilizer per hectare which is 240 gm per plot basis was used and all applied during planting. Data were collected from six middle rows (9.6m^2) and these rows were harvested to record yield and related traits. All possible agronomic management practices were applied properly.

Data collection and statistical analysis

Experimental data were collected on individual plant basis for plant height, pod length, number of pods per plant, number of seeds per pod while on plot basis were collected on days to maturity, grain yield and hundred seed weight. Data were subjected to analysis of variance using SAS computer package version 9.4 at $P<0.05$. Least significant difference (LSD) was used to separate means at 0.05 and 0.01 probability levels of significance (Gomez and Gomez, 1984).

The linear mixed model was used in the analysis of variance to combine over locations.

$$Yijk= \mu+gi+ej+bk(j)j+(ge)ij+\varepsilon ijk$$

Where:

Yijk= Response of Y trait from the i^{th} varieties, grown in the k^{th} block of j^{th} location.

μ= Grand mean.

gi= Effect of the i^{th} varieties.

ej= Effect of j^{th} location.

bk (k) j= Effect of k^{th} rep in j^{th} location.

RESULTS AND DISCUSSION

Analysis of variance

The combined analyses of variance revealed a highly significant difference ($P<0.01$) for days to maturity, pod length, number of pods per plant, number of seeds per pod, hundred grain weight and grain yield. This indicated the presence of performance variation among the varieties for yield and related traits which helps to identify high yielder varieties for future use in those locations. The analysis of variance also showed significant difference ($p<0.01$) between locations for all studied parameters of this study (Table 2). The variety × location interaction was also showed significant difference for days to maturity, number of pods per plant, hundred grain weight and grain yield (Table 2).

Table 1: List of Haricot bean varieties used for the study.

Variety	Suitable agro-ecology	Suitable altitude	Color	Status	Yield at farmers field (kg ha^{-1})	Yield at research Site (kg ha^{-1})	Year of release	Source/ Maintainer
SER119	Lowland	1450-2000	Red	Released variety	2500	3500	2014	MARC
Awash -2	Lowland	1300-2000	White	Released variety	1800-2200	2800-3100	2013	MARC
Tafach (SAB 632)	Lowland	1450-2000	Speckled	Released variety	1900-2400	2200-2600	2015	MARC
Awash Mitin (Bifort small seeded-15)	Lowland	1500-1800	White	Released variety	1900-2300	2000-2500	2016	MARC
Local				Check cultivar				Tach-Gaynit

Note: MARC=Melkasa Agricultural Research Center.

Source: (Fentahun *et al*., 2017, @ EIAR, 2017).

This significant difference of variety × location interactions indicated the differential response of varieties to different agro ecologies for these characters while, pod length and number of seeds per pod showed stability among the testing locations. These findings are supported by the earlier works of Afeta *et al*. (2023) at four locations of Guji zone, Ethiopia that found a significant variation on days to maturity, number of pods per plant, thousand grain weight and grain yield of common bean varieties.

Analysis of variance for grain yield of each individual location

The analysis of variance revealed a highly significant difference among the varieties in all locations for grain yield (Table 2). The mean grain yield of varieties across locations ranged from 1425.90 kg ha^{-1} for local check at Anseta to 2887.50 kg ha^{-1} for variety SER119 at Fenta location with overall mean of 2012.16 kg ha^{-1} (Table 3).

At Burkoch, the mean grain yield ranged from 1794.80 kg ha^{-1} to 2861.00 kg ha^{-1} and genotype SER119 was found to be the best variety with the average grain yield of 2219.94 $kgha^{-1}$. At Balarb, the mean grain yield of two years of 2021 and 2022 ranged from 1507.49 kg ha^{-1} to 2231.59 kg ha^{-1} and the highest mean grain yield was recorded from the variety SER119. At Anseta, the mean grain yield ranged from Local cultivar (1425.90 kg ha^{-1}) to Awash mitin (1995.50 kg ha^{-1}) with average mean of 1752.50 kg ha^{-1}. At Fenta, the lowest mean grain yield recorded from Tafach variety (1852.20 kg ha^{-1}) while the highest yield was found at SER119 variety (2887.5 kg ha^{-1}). At Daka, the average yield ranged from 1706.20 kg ha^{-1} to 2285.70 kg ha; the highest grain yield was recorded from Awash mitin variety and the lowest was obtained from local check (Table 3).

The highest grain yield was obtained at SER119 variety at both locations of Ebinat district and at Fenta location of Tach Gayint district. Among the overall mean of the varieties across locations, SER119 variety provided the highest yield (2383.20 kg/ha) followed by Awash mitin variety (2092.54 kg/ha) (Table 3). Awash mitin also provided the highest yield at two locations of Tach Gayint district, 1995.50 kg/ha at Anseta and 2285.70 kg/ha at Daka locations. The high yielder variety at most locations was found with SER119

Table 2: The combined ANOVA table result of yield and yield related traits of haricot bean varieties tested at five locations in South Gondar zone during 2021 and 2022.

		MS of studied traits					
S.V	df	DM	PL	PPP	SPP	HGW	GY
Rep	2	19.6	0.75	5.66	0.04	2.85	31779.59
Var	4	26.44**	49.82**	270.76**	5.27**	1464.37**	1131092.09**
Loc	4	441.76**	5.84**	134.73**	3.76**	58.63**	977256.79**
Var*Loc	16	15.49*	2.04ns	27.58**	0.32ns	14.08**	154410.35**
Error	63	6.77	1.41	10.18	0.51	4.26	69510.57
R2		0.84	0.74	0.76	0.58	0.96	0.72
CV		3.12	11.43	20.7	13.15	7.82	13.32
Mean		83.3	10.39	15.41	5.41	26.4	1978.75

Rep= Replication, Var= Variety, Loc= Location, CV= Coefficient of variations, DM= Days to maturity, PL= Pod length in cm, PPP= Number of pods per plant, SPP= Number of seeds per pod, HGW= Hundred grains weight in grams, GY= Grain yield per hectare in kg.

Table 3: Mean grain yield (kg/ha) of haricot bean varieties evaluated at five locations of South Gondar zone during 2021 and 2022.

Varieties	Locations					
	Burkoch	Balarb	Anseta	Fenta	Daka	Mean yield of each variety
Awash2	2061.00bc	1966.02b	1690.80b	2329.40bc	2168.00ab	2043.04
Awash Mitin	2033.30bc	1744.32c	1995.50a	2403.90b	2285.70a	2092.54
Local	1794.80c	1608.92cd	1425.90c	1964.20cd	1706.20c	1700.00
SER119	2861.00a	2231.59a	1917.70ab	2887.5a	2018.20abc	2383.20
Tafach	2349.60b	1507.49d	1732.60b	1852.2d	1768.20bc	1842.02
Mean of yield in each location	2219.94	1811.67	1752.50	2287.44	1989.26	2012.16
CV%	11.62	8.61	7.70	8.94	10.69	
LSD	485.63	189.18	254.19	384.93	400.29	
F-test	**	**	**	**	**	

*= Significant difference at p<0.05, **= Highly significant difference at p<0.01, CV= Coefficient of variation, LSD= Least significance difference and means within a column followed by same letter(s) are not significantly different at 5% according to LSD.

variety which indicates the presence of genetic potential for resistance of varies stress conditions for creating this stability of yield potential across locations. However, the lowest overall average yield was obtained with local check cultivar (1700.00 kg/ha). Similarly, Loha *et al*. (2023) obtained a significant difference on grain yield of studied common bean varieties at Areka, Southern Ethiopia that grain yield ranged from 2009 to 2413 kg ha^{-1} with the highest grain yield (2413 kg ha^{-1}) was recorded from variety SER 119 followed by variety Awassa Dume.

Generally, the varieties respond differently to diverse environments leading to the essence of identification of a potential variety for specific location. Most of the varieties at Fenta and Burkoch locations exhibited best performance with average yield of 2287.44 kg/ha and 2219.94 kg/ha, respectively. Whereas, Anseta location exhibited lowest average yield (1752.50 kg/ha) as compared to other experimental locations (Table 3). The existence of wide genetic variation in grain yield and yield components of common bean has been reported by various authors (Zelalem, 2014; Ketema, 2022; Afeta *et al*., 2023; Etana and Nebiyu, 2023; Loha *et al*., 2023).

Analysis of variance for yield related traits at each individual location

The analysis of variance at individual location revealed a significant difference among genotypes for pod length, number of seeds per pod, hundred grain weight except number of seeds at Anseta location (Table 4, 5 and 6). This indicated the genetic variability of the varieties for these traits that may affected the grain yield in different extent. Significance difference among haricot bean g enotypes for yield related traits were reported by (Wodajo *et al*., 2021; Tigist *et al*., 2023; Etana and Nebiyu, 2023).

Days to maturity (DM)

There was highly significant difference among genotypes in days to maturity at Balarb location (Table 4). However, all other locations showed a non-significant difference for days to maturity. Though most individual locations showed non-significant difference for day to maturity. However, overall anova table showed a significant difference between varieties, locations and variety * location interaction for days to maturity. Numerically, SER119 and Tafach had the shortest days to maturity at Burkoch location with the values of 73 days. At Balarb, varieties Tafach and SER119 were early matured with respective values of 81.33 and 82.5 days. On the other hand, Awash-2 and local check had longest time of maturity at Balarb with respective values of 89.0 and 87.0 days (Table 4).

Except Fenta location, Tafach variety matured earlier at all tested locations than other varieties which indicated the advantage of this variety for escaping moisture stress condition of Ebinat and Tach-gaynit districts in South Gondar Zone. Tigist *et al*. (2023) studied on 144 genotypes of common bean at three locations of Oromiya region Ethiopia and indicated that days to maturity showed a significant difference between varieties, locations and GXE interactions. Therefore, the genotype and environment components are recognized as the primary sources of variability in agronomic and genetic studies.

Pod length (PL)

There was significant difference ($p<0.05$) for pod length at Burkoch and highly significant difference at other locations ($p<0.01$) (Table 4). Tafach variety exhibited the highest pod length at Burkoch, Fenta and Daka experimental sites with the value of 13.93 cm, 13.33 cm and 13.2 cm, respectively. Tafach variety also showed the

Table 4: The varieties mean performance on days to maturity and pod length traits in each testing environment of South Gondar zone, Ethiopia.

Varieties	Traits									
	Days to maturity (day)					Pod length (cm)				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Awash-2	74.3a	89.0a	84.0ab	87.7ab	87.0ab	9.83c	9.17c	8.47d	8.27c	8.57c
Awash mitin	8.87bc	74.3a	84.2bc	83.0ab	88.0ab	85.67ab	10.73bc	9.42c	8.10d	8.90c
Local	74.3a	87.0ab	81.67b	84.00b	84.67b	9.33c	10.20bc	10.03b	8.73bc	10.6b
SER119	73a	82.5c	86.00a	89.67a	88.67a	13.07ab	11.18ab	9.27c	11.00ab	9.7bc
Tafach	73a	81.33c	81.00b	87.0ab	84.00b	13.93a	12.41a	12.90a	13.33a	13.2a
Mean	73.8	84.8	83.13	87.27	86	11.38	10.48	9.75	10.04	10.2
CV%	1.71	3.89	2.65	2.48	2.37	11.62	10.91	2.80	13.60	5.99
LSD	2.38	4.0	4.15	4.08	3.84	2.49	1.39	0.51	2.57	1.15
F-test	ns	**	ns	Ns	Ns	*	**	**	**	**

Note: *= Significant difference at $p<0.05$, **= Highly significant difference at $p<0.01$, CV= Coefficient of variation, LSD= Least significance difference and means within a column followed by same letter(s) are not significantly different at 5% according to LSD, E1= Burkoch location, E2= The combined analysis value of Balarb location in the year 2021 and 2022, E3=Anseta location, E4= Fenta location, E5=Daka location.

highest pod length at Anseta (12.90 cm) and Balarb (12.41 cm) but succeeded by SER119 variety (13.07 cm) at Burkoch location. At most locations higher pod length was also obtained with SER119 variety with correspondence higher yield that may indicates the positive association of pod length with grain yield of haricot bean varieties. However, Awash mitin variety had showed the shortest pod length at Aneseta location (8.10 cm) succeeded by Awash-2 variety at Fenta (8.27 cm), Anseta (8.47 cm) and Daka (8.57 cm) locations (Table 4). These results confirmed with the findings of Ketema (2022) that reported a significant difference in pod length among haricot bean varieties with range of 8 to 22.5 cm.

Number of pods per plant (PPP)

The interaction of haricot bean varieties with different locations as well as the varieties and locations alone revealed a highly significant (P<0.01) difference on number of pods per plant (Table 2). The higher number of pods per plant was recorded from SER119 (22.9) at Burkoch location with the highest mean of pod numbers (18.19) as compared to other testing locations. Awash-2 variety also provided the highest number of pods per plant (23.33) at Fenta and Daka locations of Ebinat District. Whereas the lowest was obtained from Tafach variety (7.0) at Anseta location.

However, it is difficult to conclude increment number of pod per plant can be increase yield per hectare; because total yield also influenced by the yield harvested from individual plant and number of plants per hectare. Etana and Nebiyu (2023) reported that number of pods per plant showed significant difference between four studied common bean varieties, of which, two from farmers cultivars and two from improved varieties.

Number of seeds per pod (SPP)

The varieties and locations alone revealed a highly significant (P<0.01) difference on number of seeds

Table 5: The varieties mean performance on number of pods per plant and number of seeds per pod traits in each environment.

Varieties	Traits									
	Number of pods per plant					Number of seeds per pod				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Awash-2	19.73ab	14.07ab	17.00a	23.33a	23.33a	7.18a	5.7a	5.00a	5.33abc	5.33ab
Awash mitin	14.69bc	14.87ab	14.50b	20.00b	20.00b	6.9a	5.9a	5.50a	6.00a	6.00a
Local	21.5a	13.18b	13.67b	14.33c	19.67b	6b	4.85b	5.17a	4.33c	4.67b
SER119	22.9a	16.07a	9.00c	21.00ab	18.00b	6.5ab	5.65a	5.33a	5.67ab	5.33ab
Tafach	12.13c	8.8c	7.00d	8.33d	8.33c	5c	4.48b	4.67a	4.67ab	4.67b
mean	18.19	13.40	12.23	17.4	17.87	6.32	5.32	5.13	5.2	5.2
CV%	17.17	13.44	8.34	9.27	6.22	7.44	7.55	9.15	10.24	9.29
LSD	5.88	2.18	1.92	3.04	2.09	0.88	0.49	0.89	1.00	0.91
F-test	**	**	**	**	**	**	**	ns	*	*

Note: *= Significant difference at p<0.05, **= Highly significant difference at p<0.01, CV=Coefficient of variation, LSD= Least significance difference and means within a column followed by same letter(s) are not significantly different at 5% according to LSD, E1= Burkoch location, E2= The combined analysis value of Balarb location in the year 2021 and 2022, E3=Anseta location, E4= Fenta location, E5= Daka location.

Table 6: The varieties mean performance on hundred grains weight in grams for each environment.

Varieties	Locations					
	E1	E2	E3	E4	E5	Mean
Awash-2	18.11d	17.45c	16.39c	16.26c	23.50c	18.34
Awash mitin	17.63d	16.19c	14.43c	16.57c	19.23d	16.81
Local	33.17b	39.33a	32.04a	33.18a	35.37b	34.62
SER119	25.10c	23.9b	21.85b	25.55b	24.80c	24.24
Tafach	38.54a	37.67a	34.31a	34.50a	42.30a	37.46
Mean	26.5079	26.91	23.81	25.212	29.04	26.30
CV%	5.39018	8.0	7.61	7.4733	4.17	
LSD	2.69	2.6	3.41	3.55	2.28	
F-test	**	**	**	**	**	

Note: *= Significant difference at p<0.05, **= Highly significant difference at p<0.01, CV= Coefficient of variation, LSD= Least significance difference and means within a column followed by same letter(s) are not significantly different at 5% according to LSD, E1= Burkoch location, E2= The combined analysis value of Balarb location in the year 2021 and 2022, E3=Anseta location, E4= Fenta location, E5= Daka location.

per pod (Table 2). Except Anseta location at Tach Gayint district, the analysis of variance of individual location showed a significant variation for number of seeds per pod (Table 5). Maximum number of seeds per pod was recorded from Awash-2 variety (7.18) followed by Awash mitin variety (6.9) at Burkoch location, whereas, the lowest number of seeds per pod (4.33) was obtained with local check cultivar at Fenta location of Tach-Gaynit district. The highest average number of seeds per plant (6.32) was recorded at Burkoch and the average minimum number of seeds per plant (5.13) was found at Anseta site. Etana and Nebiyu (2023) also reported that number seeds per pod showed a highly significant difference between the varieties in common bean.

Hundred grains weight (HGW)

The analysis of variance revealed a highly significant difference between the varieties, locations and their interactions for hundred grains weight (Table 2). Average hundred grains weight was ranged from 16.81g (Awash-mitin) to 37.46 g (Tafach) with overall mean of 26.30 g (Table 6). The highest hundred grains weight was recorded from Tafach variety (42.30 g) at Daka location followed by local check (39.33 g) at Balarb site. Except Balarb location, the highest grain size was obtained at Tafach variety followed by the local check cultivar. Whereas the lowest grain size was recorded from Awash mitin variety and succeeded by Awash-2 variety.

In addition to environmental influence, the existence of a significant genotypic variation for grain size of haricot bean might leads to consider for farmers preference to their locality end use advantage during variety development process. Similarly, Wodajo *et al*. (2021) noted that the 1000 seed weight showed significant differences between the studied four haricot bean varieties and the highest value was recorded from SER119 and SER125 while the lowest was found from Awash-2 variety.

CONCLUSION AND RECOMMENDATION

Introduction and performance evaluation of released varieties is the primary procedure to improve crop productivity for the targeted low production region. In this study, significant varietal differences ($P<0.01$) were observed in days to maturity, plant height, pod length, number of pods per plant, number of seeds per pod, hundred seed weight and grain yield. A highly significant differences was also obtained for all studied parameters across locations. The variety × location interaction was significant for days to maturity, number of pods per plant, hundred grains weight and grain yield. At Balarb, varieties Tafach and SER119 were early matured with respective values of 81.33 and 82.5 days after emergence. Except Fenta location, Tafach variety matured earlier at all tested locations than other varieties which helps to escape moisture stress condition started from the beginning of September in the lowlands of the study areas.

The highest and lowest yield at Burkoch was recorded from SER119 and Local with yield value of 2861.00 kg ha^{-1} and 1794.80 kg ha^{-1}, respectively. The highest yield at Balarb (2231.59 kg ha^{-1}) and Fenta (2887.5 k g ha^{-1}) was recorded from SER119 while the lowest yield was recorded from Tafach variety at Balarb and Fenta locations. Awash mitin variety provided highest yield at Anseta (1995.50 kg ha^{-1}) and Daka (2285.70 kg ha^{-1}) locations and the lowest yield was found from local check at both locations with yield value of 1425.90 kg ha^{-1} and 1706.20 kg ha^{-1}, respectively.

The highest overall average grain yield per hectare across locations was recorded from variety SER119 (2383.20 kg ha^{-1}) followed by variety Awash mitin (2092.54 kg ha^{-1}) and variety Awash-2 (2043.04 kg/ha) with respective yield advantage of 40.19%, 23.09% and 20.18% over the local check cultivar. The lowest average yield across locations was recorded at local check (1700.00 kg/ha). Therefore, SER119, Awash mitin and Awash-2 varieties can be recommended as promising varieties and to be promoted at lowland areas of South Gondar Zone and similar areas in north west Ethiopia.

Conflict of interest

The authors have not declared any conflict of interests.

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