***Original Research Article***

**Performance Evaluation of Released Haricot Bean (Phaseolus vulgaris L.) Varieties Under Irrigated and Rainfed Conditions in the Somali Region, Ethiopia.**

**Abstract**

Haricot bean (Phaseolus vulgaris L.) is a vital legume crop in Ethiopia, serving as a key source of protein, energy, and income for smallholder farmers. This study was conducted to evaluate the growth performance, yield, and yield-related traits of six nationally released haricot bean varieties under irrigated and rainfed conditions at two sites in the Somali Region, Fafen and Dollo-Ado, during the 2021 and 2022 cropping seasons, respectively. A randomized complete block design (RCBD) with three replications was employed. Data on phenological, morphological, and yield attributes were collected and analyzed using GenStat software. The results revealed significant varietal differences in major agronomic traits across both sites. At Fafen, the variety Seri 119 recorded the highest grain yield (1,484 kg/ha), while at Dollo-Ado, Seri 125 exhibited superior performance with the highest yield of 2,142 kg/ha. In contrast, Awash-2 and Awash-Mitin were the lowest-yielding varieties at the respective locations. These findings indicate that Seri 119 and Seri 125 are well adapted to the agro-ecological conditions of Fafen and Dollo-Ado, respectively, and hold promise for improving haricot bean productivity in the Somali Region. The results support targeted variety recommendations and underscore the importance of site-specific variety selection. Further multi-location and multi-year evaluations are recommended to confirm the consistency and stability of these varieties across diverse environments.

***Keywords*:** Haricot bean, Variety evaluation, Grain yield, Agro-ecological adaptation, Somali Region, Irrigated and rainfed agriculture.

1. **Introduction**

Haricot bean (*Phaseolus vulgaris* L.), locally known as *Digir*, is one of the most widely cultivated legume crops worldwide. It serves as a crucial food and income source, particularly for smallholder farmers in developing countries. Renowned for its high protein content and micronutrient density, haricot bean plays a vital role in enhancing household nutritional security (Worku, 2015). As a member of the Fabaceae family, it is an annual crop that thrives in warm climates with optimal temperatures between 18 and 24°C (Teshale et al., 2005).

In Ethiopia, haricot bean is among the most important grain legumes grown for both subsistence and commercial purposes. The crop is primarily cultivated in lowland and Rift Valley areas (Lemu, 2016), and its cultivation has expanded rapidly in recent years due to its role in improving rural livelihoods and contributing to foreign exchange earnings (Girma, 2009). Haricot bean performs best at altitudes ranging from 1,400 to 2,000 meters above sea level (Fikru, 2007). Its early maturity and moderate tolerance to drought make it a key option for climate-resilient agriculture, especially in moisture-stressed and lowland areas (Fikru, 2007).

Despite its increasing importance, the productivity of haricot bean in Ethiopia remains constrained by several factors, including the limited dissemination of improved varieties, poor agronomic practices, and underdeveloped market systems (Amanuel & Girma, 2018). In lowland and mid-altitude zones, the crop serves as a major source of dietary protein and household income (Beyene et al., 2020). However, certain regions such as the Somali Regional State (SRS) have received minimal research attention despite possessing agro-ecological conditions favorable for haricot bean production.

Given that haricot bean is a short-season crop with moderate drought resistance, it is particularly well-suited to the growing conditions in the Somali Region. Yet, its cultivation in the region remains limited due to the lack of locally validated improved varieties. Promoting haricot bean production in SRS, therefore, requires the identification and introduction of varieties that are well-adapted to local agro-ecological contexts. Therefore, this study was initiated with the objective of evaluating the agronomic performance and yield potential of nationally released haricot bean varieties under irrigated and rainfed conditions in the Somali Region, with the ultimate goal of selecting and recommending the most adaptable and high-yielding varieties for sustainable production.

1. **Literature Review**
	1. **Importance of Haricot Bean in Ethiopia**

Haricot bean (Phaseolus vulgaris L.) is one of the most widely grown pulse crops in Ethiopia, serving as a staple food and a major source of income for millions of smallholder farmers. It contributes significantly to food and nutritional security due to its high protein and micronutrient content (Worku, 2015). In addition to its domestic importance, haricot bean also serves as an export commodity, particularly in white bean markets (Girma, 2009).

* 1. **Variety Evaluation and Performance in Ethiopia**

Numerous trials have been conducted across Ethiopia to assess the performance of improved haricot bean varieties under different agro-ecological conditions. For instance, Teshome et al. (2018) evaluated haricot bean varieties in the Central Rift Valley and identified Awash-1 and Awash-Melka as high-yielding under irrigation. Similarly, Habtamu et al. (2017) tested released varieties in the Southern region and reported significant differences in yield and adaptation among varieties. Trials conducted in the lowlands of Oromia and SNNPR also showed that variety performance is highly influenced by altitude, rainfall pattern, and soil type (Fikru, 2007; Amanuel & Girma, 2018).

* 1. **Adaptation Trials in Eastern and Lowland Ethiopia**

In the eastern and lowland parts of the country, studies have confirmed the potential of haricot bean as a short-duration crop suitable for drought-prone areas. Beyene et al. (2020) demonstrated the success of variety Ibado in moisture-stressed lowlands of Eastern Hararghe. Similarly, research in Afar and Dire Dawa indicated that varieties like Awash-2 and SER-119 exhibited reasonable yield performance under irrigation (Alemu et al., 2019). These studies emphasize the importance of site-specific variety recommendations, as performance is often inconsistent across locations.

* 1. **Research Gaps in the Somali Regional State**

Despite the demonstrated adaptability of haricot bean to dryland conditions, the Somali Regional State remains largely underrepresented in national variety evaluation programs. Few, if any, studies have systematically assessed the performance of improved haricot bean varieties under both irrigated and rainfed conditions in this region. This lack of localized research has limited the ability of farmers and extension agents in SRS to make informed decisions about which varieties are best suited to their agro-ecological zones.

1. **Materials and Methods**

The experiments were conducted at the Dollo-Ado and Fafen research stations in 2021 and 2022, respectively, to evaluate the performance of six recently released haricot bean varieties. A Randomized Complete Block Design (RCBD) with three replications was employed at both sites. Each gross plot measured 6.4 m², consisting of four rows spaced 40 cm apart, with plants spaced 10 cm within rows. Data were collected from the two central rows to ensure accuracy and consistency. Fertilizer application and other agronomic practices were carried out according to site-specific recommendations. The experiment in Dollo-Ado was conducted under irrigation, while the Fafan trial was conducted under rainfed conditions, reflecting the differing environmental contexts of the two locations. Dollo-Ado, characterized by arid to semi-arid conditions, receives low and erratic annual rainfall ranging from 200 to 400 mm and experiences high temperatures often exceeding 35°C. The area is prone to significant climate variability, including recurrent droughts and occasional floods. In contrast, Fafan experiences a semi-arid climate with relatively higher annual rainfall between 500 and 600 mm. The mean monthly minimum temperature in Fafan ranges from 5.8°C in November to 14°C between July and September, while the mean maximum temperature varies from 25°C in July to 29°C in March and April.

Table 1. List of haricot bean varieties used for the experiment

|  |  |  |  |
| --- | --- | --- | --- |
| **No**  | **Variety name**  | **Year**  | **Source**  |
| 1 | Awash-2 | 2017 | Melkassa ARC |
| 2 | Awash mitin | 2017 | Melkassa ARC |
| 3 | Tefach | 2015 | Melkassa ARC |
| 4 | SER119 | 2014 | Melkassa ARC |
| 5 | SER 125 | 2014 | Melkassa ARC |
| 6 | Ada (KAT B1) | 2013 | Melkassa ARC |

* 1. **Data collection and analysis**

Data were collected on several parameters, including days to 50% emergence, days to 50% flowering, days to 50% maturity, plant height, number of pods per plant, number of seeds per pod, grain yield per plant, grain yield per plot, 1000-seed weight, and disease resistance. The collected data were subjected to analysis of variance (ANOVA) using GenStat 15 software. When the ANOVA indicated significant differences among treatments, mean comparisons were performed using the Least Significant Difference (LSD) test at a 5% probability level.

1. **Results and discussion**

**Days to Emergence:** Days to emergence were not significantly influenced by the tested varieties at either location (Table 2). The longest time to emergence was recorded for Awash-Mitin (6.00 days) at Fafen and Ada (7.00 days) at Dollo-Ado. The shortest emergence times were observed in Seri 125 (5.33 days at Fafen and 6.33 days at Dollo-Ado) (Table 2).

**Days to Flowering:** The mean number of days to flowering was also not significantly different among the varieties at both locations (Table 2). Awash-2 exhibited the highest number of days to flowering (56.67 days at Fafen and 41.00 days at Dollo-Ado), while Tefach showed the earliest flowering (55.33 days at Fafen and 39.67 days at Dollo-Ado) (Table 2).

**Days to Maturity:** In contrast, the mean number of days to maturity was highly significantly influenced by variety at both locations (Table 2). The longest time to maturity was recorded in Seri 119 (84.33 days) at Fafen and Ada (70.00 days) at Dollo-Ado, while the shortest was observed in Awash-2 (75.00 days) at Fafen and Seri 119 (69.00 days) at Dollo-Ado. The differences in flowering and maturity periods can be attributed to genetic variability among the varieties and differences in agro-ecological conditions. Similar findings were reported by Kwabena et al. (2016), Temesgen and Zewdu (2021), and Rezene et al. (2013), who noted that genetic differences among haricot bean varieties contributed to variations in phenological traits.

**Plant Height (cm):** Plant height was highly significantly (p < 0.01) affected by variety at the Dollo-Ado station but showed no significant difference at the Fafen station (Table 2). The tallest plants were recorded for SERI 119 (51.60 cm) at Fafen and Awash-Mitin (74.93 cm) at Dollo-Ado. Conversely, the shortest plants were observed in Awash-Mitin (41.73 cm) at Fafen and Tefach (49.73 cm) at Dollo-Ado (Table 2). The variation in plant height is mainly attributed to genetic differences among varieties and the influence of the growing environment. These results are consistent with findings by Welde (2022), Mekonen et al. (2012), and Wondwosen et al. (2018), who also reported significant variation in plant height among haricot bean varieties.

**Table 2:** Mean Mean growth and yield components of Haricot bean varieties at Fafen and Dollo-ado stations (2021–2022)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Fafen**  | **Dollo-ado** |
| **Varieties** | DE | DsF | DM | PH | NPPP | DE | DsF | DM | PH | NPPP |
| **Ada** | 6.333a | 56a | 80.33a | 45.60a | 22.67a | 7.000a | 40.33a | 70.00a | 50.53c | 12.53de |
| **AWASH-MITIN** | 6.000a | 57.33a |  75.33a | 41.73a | 18.33b | 6.667a | 41.00a | 69.33a | 74.93a | 22.40ab |
| **SER119** | 6.000a | 57.67a | 84.33a | 51.60a | 18.40b | 6.667a | 40.33a | 69.00a | 73.33ab | 19.13bc |
| **AWASH-2** | 5.667a | 56.67a | 75.00a | 44.33a | 18.60b | 7.000a | 41.00a | 69.33a | 69.80ab | 15.33cd |
| **Tefach** | 5.667a | 55.33a |  79.33a | 49.70a | 13.33c | 6.667a | 39.67a | 69.67a | 49.73c | 10.13e |
| **SER125** | 5.333a | 56.33a |  79.67a | 45.40a | 12.47c | 6.333a | 39.67a | 69.33a | 56.13bc | 25.27a |
| **Mean** | 5.83 | 56.56 | 79.0 | 46.4 | 17.30 | 6.72 | 40.33 | 69.44 | 62.4 | 17.47 |
| **CV%** | 11.7 | 2.7 | 5.5 | 14.0 | 6.4 | 7.0 | 2.0 | 1.0 | 15.4 | 13.9 |
| **LSD** | 1.243 | 2.772 | 7.94 | 11.82 | 2.028 | 0.858 | 1.485 | 1.228 | 17.54 | 4.428 |
| **Variable**  | **Mean square value** |
| **Replication**  | 0.0000 | 0.056 | 118.50 | 3.14 | 0.320 | 0.2222 | 2.0000 | 2.0556 | 2.31 | 43.287 |
| **Varieties**  | 0.3667ns | 2.222ns | 36.13ns | 39.37ns | 43.119\*\* | 0.1889ns | 1.0667ns | 0.3556ns | 452.52\*\* | 102.373\*\* |
| **Error**  | 0.1074 | 2.322 | 19.03 | 42.18 | 1.243 | 0.2222 | 0.6667 | 0.4556 | 68.29 | 5.924 |

**Keys**: \*, \*\*: significant at 5% and 1% respectively, CV=coefficient of variation, LSD= Least Significant Difference. Means followed by different letters within columns are significantly different by Duncan’s new multiple range test (P = 0.05), DF=days to flowering, DM=days to maturity, PH (cm)=plant height, NPPP=number of pods per plant

**Number of Pods per Plant:** The mean number of pods per plant was highly significantly (p < 0.01) influenced by the tested varieties at both locations (Table 2). The lowest numbers of pods per plant were recorded for Seri 125 (12.47) at Fafen and Tefach (10.13) at Dollo-Ado, while the highest were recorded for Ada (22.67) at Fafen and Awash-Mitin (74.93) at Dollo-Ado. The variation in the number of pods per plant among the varieties is likely due to genetic differences. This finding is consistent with the results reported by Welde (2022), Habtamu and Wakjira (2018), and Fahad et al. (2014), who also observed significant variability in the number of pods per plant among haricot bean varieties.

**Number of Seeds per Pod:** The mean number of seeds per pod was highly significantly (p < 0.01) influenced by variety at the Dollo-Ado location, while no significant difference was observed at Fafen (Table 3). The lowest number of seeds per pod was recorded for Tefach (5.267 at Fafen and 3.867 at Dollo-Ado), while the highest was recorded for Seri 118 (5.833) at Fafen and Seri 125 (6.333) at Dollo-Ado. The differences in the number of seeds per pod can be attributed to variations in seed size and environmental conditions. Similar results were reported by Degefa et al. (2021), Alemu and Getachew (2018), Habtamu and Wakjira (2018), and Fahad et al. (2014), who also found significant variability in the number of seeds per pod among haricot bean varieties.

**Thousand Seed Weight (g):** The mean thousand seed weight was significantly (P ≤ 0.05) influenced by variety at the Fafen station, while no significant difference was observed at Dollo-Ado (Table 3). The highest thousand seed weights were recorded in Tefach (48.33 g at Fafen and 25.33 g at Dollo-Ado), while the lowest were observed in Awash-Mitin (25.00 g) at Fafen and Seri 125 (18.67 g) at Dollo-Ado. The variation in thousand-seed weight among the varieties is likely due to differences in seed size, which are influenced by both genetic factors and growing conditions. These findings are in agreement with recent reports by Welde (2022), Degefa et al. (2021), Alemu and Getachew (2018), Touckia et al. (2021), and Daniel et al. (2014), who also reported highly significant variation in thousand-seed weight among haricot bean varieties.

**Table 3**. Haricot bean yield components affected by varieties at Dollo-ado, Fafen stations during 2021-2022

|  |  |  |
| --- | --- | --- |
|  | **Fafen**  | **Dollo-ado** |
| **Varieties**  | **NSPP** | **TSW** | **BY** | **GY** | **NSPP** | **TSW** | **BM** | **GY** |
| **Ada** | 5.600a | 43.00ab | 5038a | 1162b | 4.533b | 22.00a | 32917a | 972d |
| **AWASH-MITIN** | 6.000a | 25.00c | 3438b | 771c | 3.933b | 22.00a | 38611a | 716e |
| **SER119** | 5.833a | 36.00bc | 3757b | 1484a | 5.000b | 22.00a | 34306a | 1865b |
| **AWASH-2** | 5.400a | 28.33c | 2347c | 681c | 4.533b | 21.00a | 33056a | 1382c |
| **Tefach** | 5.267a | 48.33a | 2417c | 1071a | 3.867b | 25.33a | 33194a | 874d |
| **SER125** | 5.667a | 33.00bc | 3847b | 1153b | 6.333a | 18.67a | 38194a | 2142a |
| **Mean** | 5.63 | 35.6 | 3474 | 1054 | 4.70 | 21.83 | 35046.3 | 1325.1 |
| **CV%** | 11.0 | 17.0 | 8.5 | 11.1 | 12.6 | 18.9 | 18.7 | 6.5 |
| **LSD** | 1.130 | 11.01 | 538.8 | 213.1 | 1.077 | 7.508 | 11921.92 | 156.95 |
| **Variable**  | **Mean square value** |
| **Replication**  | 0.0406 | 14.00 | 274143 | 528 | 0.0350 | 6.50 | 325617 | 417 |
| **Variety**  | 0.2192ns | 681.33\*\* | 3032982\*\* | 141749\*\* | 2.4573\*\* | 13.83ns | 3617284\*\* | 996724\*\* |
| **Error**  | 0.3859 | 26.93 | 87713 | 11689 | 0.3503 | 17.03 | 330247 | 7442 |

**Keys**: \*, \*\*: significant at 5% and 1% respectively, CV=coefficient of variation, , LSD= Least Significant Difference. Means followed by different letters within columns are significantly different by Duncan’s new multiple range test (P = 0.05)., NSPP=number of seed per pod, TSW=thousand seed weight, BM (kg/ha) =biomass, GY (kg/ha) = grain yield.

**Biomass Yield (kg/ha):** A significant (P ≤ 0.05) variation was observed among varieties with respect to biomass yield at the Fafen station, while no significant variation was found at Dollo-Ado (Table 3). The highest biomass yield was recorded for Ada (5038 kg/ha) at Fafen and Awash-Mitin (38,611 kg/ha) at Dollo-Ado, whereas the lowest yields were observed in Awash-2 (2347 kg/ha) at Fafen and Ada (32,917 kg/ha) at Dollo-Ado (Table 3). This variation could be attributed to the heritable characteristics of the varieties and their differential responses to the environmental and ecological conditions of the two locations. These results are consistent with the findings of Welde (2022) and Wondimu and Tana (2017), who reported significant differences in biological yield among haricot bean varieties at harvest.

**Grain Yield (kg/ha):** Grain yield was highly significantly (p < 0.01) affected by variety at both Fafen and Dollo-Ado stations (Table 3). The highest grain yields were recorded by Seri 119 (1484 kg/ha) at Fafen and Seri 125 (2142 kg/ha) at Dollo-Ado, while the lowest were obtained from Awash-2 (680.6 kg/ha) at Fafen and Awash-Mitin (716 kg/ha) at Dollo-Ado. The superior performance of Seri 125 and Seri 119 could be attributed to their genetic potential and favorable adaptation to the growing environments. Differences in growth habits and morphological traits among the genotypes likely contributed to the observed differences in yield performance. These results align with findings reported by Degefa et al. (2021), Welde (2022), Daniel et al. (2014), Alemu and Getachew (2018), Habtamu and Wakjira (2018), and Touckia et al. (2021).

1. **Conclusion**

The production of haricot bean through the adaptation and selection of high-yielding, improved varieties could significantly contribute to improving the livelihoods of farmers in areas like the Somali Regional State (SRS), where the cultivation of improved haricot bean varieties is limited. Evaluating the adaptability of improved varieties is an essential first step in regions where no prior technology has been introduced.

Both genetic and environmental factors were found to cause considerable variations in the performance of the tested haricot bean traits. To improve productivity in the study area, it is important to focus on varieties that combine high yield potential with resistance to various biotic and abiotic stresses.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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