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Participatory evaluation and selection of faba bean (*Vicia faba* L.) varieties for yield and yield related traits at three locations of Hadiya Zone, Southern Ethiopia

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Abstract

Field experiment was conducted during 2021 main cropping season at three locations of Hadiya Zone (Wachemo, lambuda, and sanfa wasala kebele) with the objective of evaluating and selecting faba bean varieties for high yield and other agronomic traits through involvement of farmer's participation. Ten nationally released and one local check faba bean varieties were laid out in Randomized complete block design with three replications at each location. Yield, yield related traits and farmers' evaluation data were collected and analyzed. The results of this experiment showed that there were a significant ($p<0.05$) difference in all measured parameters except number of seeds per pod which was not statistically significant at each location. The highest grain yield (4.09 t ha^{-1}), and (4.03 t ha^{-1}), was recorded from varieties Tumisa and Hachalu respectively at Wachemo University main campus research site. Whereas the maximum grain yield was recorded for faba bean variety Tumisa (3.98 t ha^{-1}) followed by Dosha (3.6 t ha^{-1}) and Hachalu (3.58 t ha^{-1}) at lambuda research site. Similarly, the maximum grain yield was obtained from faba bean variety Dosha (3.98 t ha^{-1}) and Tumisa (3.87 t ha^{-1}) at Sanfe wasala kebele. Thus, faba bean varieties like Tumisa, Dosha and Hchalu showed a stable yield performance across all location which put them in prior rank. According to the farmers' preference, varieties Tumisa, Dosha and Numan were best performing with yield and yield related traits at each location. Therefore, based on both researchers and farmer's evaluation, varieties Tumisa, Dosha, Hachalu and Numan were recommended for further popularization and wider production by farmers of the study areas.

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Introduction

Faba bean (*Vicia faba* L.), which belongs to the family *Fabaceae*, is one of the most important cool-season food legumes grown in the world (Khalil *et al.,* 2015). It is the fourth most important pulse crop in the world with total average annual production of about 4.5 million tons in average (Merga *et al.,* 2019). The crop is widely cultivated and consumed as a valuable source of protein both in human and animal nutrition, either fresh or dried. The beans contains a large amount of protein, carbohydrate, B-group vitamins and minerals thus in developing countries partly compensating for the large deficiency in animal protein sources (Sarah *et al.,* 2009).

Ethiopia is one of the largest faba bean producing countries in the world next to China and accounts for about 12% of the world area and production (FAO, 2019). Thus, the country is considered to be secondary center of diversity and one of the nine major agro-geographical production regions of the crop (Hailu *et al.,* 2014).

It is the most important cool-season food legume crop in the country in terms of area coverage, production, foreign exchange earnings, protein source, soil amelioration and cropping system (Mulualem *et al.,* 2012) and reduces poverty by 3% (ICARDA, 2008). The crop is with manifold merits in the economy of the farming communities in the highlands and semi-highlands of the country and serves as a daily food and cash crop, feed and a valuable and cheap source of protein (Schatz and Endres, 2009).

In addition to food, faba bean plays a great role in every aspect of Ethiopian life not only as food but also the straw and the seed as feed for animals as well as straw or haulms as firewood, green manuring and silage-making (Comlanvi, 2011). Besides this, it also plays a significant role in soil fertility restoration during crop rotation through biological nitrogen fixation that provides agricultural sustainability (Almaz *et al*., 2016). Due to its multi-use, the demand of the crop is increasing and the gap between supply and demand continues to widen from time to time (ICARDA, 2008).

Despite its a number of potential uses and the availability of high yielding varieties (>3 t ha^{-1}) (MoALR, 2017) in Ethiopia, the national average yield of faba bean is not more than 2 t ha^{-1} under small-holder farmers (CSA, 2017) which is far below compared to Egypt and United Kingdom 3.47 and 3.83 t ha^{-1}, respectively (FAOSTAT, 2018); and the yielding potential of the crop under Ethiopian condition (2.25 – 6.9 t ha^{-1}) (MoA, 2014). The low productivity of the crop is attributed by both biotic and abiotic factors like poor soil fertility, inadequate plant nutrition, poor seed bed preparation, poor participation of farmers in the varietal selection process, untimely planting, improper weed and disease control, shortage of improved varieties and inadequate plant density (Mulualem *et al.,* 2012; Hailu *et al.,* 2014). Even though some improved faba bean varieties has been released by different regional and national research centers in Ethiopia, farmers are still focusing on few local low yielding faba bean varieties. In addition to this, in most parts of the country including the study area, farmers have little information about the released improved varieties ad their agronomic practice because most of the varieties were released without the participation of farmers. Based on the farmers' preferences, growing of high yielding varieties of faba bean is crucial to ensure the sustainability of the crop yield and food security by increasing production, productivity and thereby increasing income generation capacity for the farmer (Thijssen *et al.,* 2008).

In this regard, participatory varietal selection (PVS) has been proposed as an option to solve the problem which is the most important and cost-effective way of identifying farmer-preferred varieties and it ensures the adoption of new varieties (Witcombet *et al*., 1996). In addition to this, farmers' participation in varietal selection provides adequate exposure to new varieties and high rate of replacement, strong extension network, that generally gave farmers access to new cultivars, to maximize their productivity and to improve the livelihood of their families (Mulualem *et al.,* 2012). Moreover, participatory research increases the job efficiency of the researchers and farmers' knowledge that enables to be retained effectively from year to year (Bekele, 2016).

According to Yadaw *et al.* (2006) participatory varietal selection provides an opportunity of getting large number of varietal choices to farmers, enhances farmer's access to crop varieties and increase in diversity, increases production and ensures food security, helps to disseminate the adoption of pre and released varieties in larger areas, allows doing varietal selection in targeted areas at cost-effective way and also in a lesser time and helps seed production at community level. This indicates that, participating farmers' on varietal evaluation and selection is a major tool to understand farmers' variety selection criteria in order to determine high yielding and farmers' preferred varieties for a given specific area.

In the study area, even though faba bean production has been practiced for long period of time, participatory varietal selection on released faba bean varieties had not yet evaluated. To minimize such problem, participatory variety selection is the better option to fit the crop bring together of both target environments and user preferences. Therefore, the objective of this study was to evaluate and select high yielding faba bean variety/varieties through farmers' preferences and selection criteria to the study area.

Materials and methods

Description of Experimental Sites

Field experiments were conducted at major faba bean producing areas of Hadiya Zone two sites of Wachemo University Agricultural research centers (at the main campus and Lambuda sites) and one site of Farmers training center at Anelemo Woreda, Sanfe wasala kebele during 2021 main cropping season.

Table 1. Description of the locations used for evaluation of faba bean varieties.

№	Locations	Geographical position		Altitude	Soil type
		Latitude	Longitude		
	Main campus research site	7°32'38.6"N	37°52'54.6"E	2275m	Clay loam
	Lambuda research site	7°37'28.9"N	37°49'18.0"E	2400m	Clay loam
	Sanfe wasala FTC	7°37'47.4"N	37°58'43.9"E	2360m	Clay loam

Treatments and Experimental Design

Ten improved faba bean varieties (Ashabeke, Didi'a, Dosha, Gabalicho, Gora, Hachalu, Moti, Numan, Tumsa and Walki) which were obtained from Holleta Agricultural Research Center including the local check was evaluated for their better yield and yield contributing characters during 2021 main cropping season across three districts. The description of the selected varieties which were used for the trail is presented in table 2. The experiment was laid down in a randomized complete block design (RCBD) with three replications. Each plot was 2.4 m wide and 2 m long with total area of 4.8 m^2. Spacing between plants and rows were 10 and 40cm, respectively. The distance between the plots and blocks was maintained at 0.5 m and 1m respectively. Plants from the internal rows of net plot area were used for data collection and analysis of the parameters under study.

Table 2. Description of the selected faba bean varieties.

S.№	Variety	Year of release	Altitude	Productivity (t ha^{-1})		Breeder/maintainer
				On station	On farmers' field	
1.	Gebelcho	2006	1800-3000	2.5 - 4.4	2.0 - 3.0	HARC/EIAR
2.	Walki	2008	1800-2800	2.4 - 5.2	2.0 - 4.2	HARC/EIAR
3.	Moti	2009	1800-3000	2.8 – 5.1	2.3 – 3.5	HARC/EIAR
4.	Dosha	2009	1800-3000	2.8 - 6.2	2.3 - 3.9	HARC/EIAR
5.	Hachalu,	2010	1900-2800	3.2 - 4.5	2.4 – 3.5	HARC/EIAR
6.	Tumisa	2010	2050-2800	2.5 – 6.9	2.0 – 3.8	HARC/EIAR
7.	Gora	2013	1800-2800	3.0 - 5.0	2.0 – 4.0	KARC/EIAR
8.	Didi'a	2014	1800-2800	3.5 - 4.6	2.0 - 4.4	KARC/EIAR
9.	Ashebeka	2015	1900-2800	3.0 - 5.0	2.8 - 4.7	KARC/EIAR
10.	Numan	2016	1800-3000	3.6 - 5.1	2.2 - 3.8	KARC/EIAR

Source: (MoALR, 2017)

Agronomic practices

The experimental field was ploughed following the recommended practices for faba bean production before sowing at each site. The sowing activity was done at fourth week of June 2021 main growing season under rain fed condition.

Recommended rate of phosphorus fertilizer in the form of (NPSB) was applied at planting. Weeding and other agronomic practices were carried out in all experimental plots as per the recommendations.

Data Collection and Measurements

Data was collected on plant and plot bases on yield and yield related traits. Data on days to 50% flowering and 90% maturity was taken on plot bases. Whereas, data like plant height, number of branches per plant, numbers of pods per plant, and number of seeds per pod was determined on plant bases. From each plot of 4 middle rows 10 plants were randomly selected and pre-tagged for data collection. The phenological data like days to flowering and maturity were recorded by counting the number of days from sowing to the time when 50% and 90% of the plants flowered and fully matured, respectively. Plant height (cm), number of branches per plant, numbers of pods per plant, and number of seeds per pod was determined from the pre-tagged sample plants of each plot at maturity. Hundred seed weight (g) was determined by weighing samples of randomly drown 100 seeds of each plots using a digital balance. Grain yield (t ha^{-1}) for the experimental varieties of each plot was determined from the net harvestable area after adjusting the moisture at 10% by using grain moisture tester. Biomass yield (tha^{-1}) was determined by weighing above ground plant parts after harvesting. Harvest index (HI): It is the ratio of grain yield to biological yield and computed as grain yield divided by biomass yield.

Farmers variety evaluation and selection

The farmers who were participated to select and evaluate the trial was from nearby kebeles of the research sites and selected based on representativeness of the area and having long experience in faba bean production. A field demonstration was organized to evaluate the tested varieties based on farmers' perception using their own selection criteria at flowering and maturity stages. The traits of varieties which farmers considered for selection were plant establishments, overall performance, stem strength, number of branches, number of pods, number of seeds, seed size, plant height, disease resistance, leaf shading, grain yield and straw yield. The ranking procedure was explained for participant farmers and each selection criterion was ranked from 1 to 5 (1= very poor, 2= poor, 3= average, 4= very good and 5= excellent). During the evaluation and selection process about both 30 (5 females) farmers had been incorporated so as to avoid gender bias. Then farmers were given the chance to rank each variety based on the attributes listed. The ranking procedure was explained to participating farmers and the final ranking was done on consensus where differences were resolved through discussion (De Boef and Thijssen, 2007).

Data Analysis

All collected data were subjected to analysis of variance (ANOVA) using SAS version 9.20 (SAS, 2008) statistical computer software. Whenever the effects of the treatments were found to be significant, the means were compared using the Least Significant Differences (LSD) test at 5% probability level. Preference ranking of the tested varieties was made based on the perception of the farmers' evaluation criteria. A scale of 1-5 was used to compare their preferences in a manner indicating that higher preference =5, lower preference=1 (Gay *et al.,* 2016). Farmers' selection data were analyzed using the simple ranking method.

Result and discussion

Analysis of Agronomic, yield and yield related traits at three locations

From all the three locations, data on growth, yield and yield components faba bean varieties were collected and analyzed (Table 3, 4 and 5). Analysis of variance showed that there was highly significant difference ($p \leq 0.01$) among tested faba bean varieties in days to flowering, days to maturity, plant height, number of branch per plant, number of pod per plant, hundred seed weight, biomass yield, grain yield and harvest index at all the three districts. But number of seeds per pod was not shown statistically significant difference among the tested varieties at each location (Table 3, 4 and 5).

Days to flowering

Analysis of variance showed that highly significant difference ($p \leq 0.01$) was observed among tested faba bean varieties in days to 50% flowering. The maximum days to 50% flowering was recorded for variety Gora (61) followed by varieties Walki (60), Numan (60), Didi'a (59.66) and Dosha (59.33); while the shortest days to 50% flowering (52) was recorded on local variety followed by Moti (55) (Table 3). At lambuda site, The maximum days to 50% flowering was recorded for variety Gabalicho (60.33) and Hachalu (59.66) followed by variety Didi'a (58.33); while the shortest days to 50% flowering (50) was recorded on local variety followed by Moti (52) (Table 4). Finally, at sanfe wasala kebele, the maximum days to 50% flowering was recorded for variety Didi'a (61) and Gabalicho (61) followed by variety Hachalu (59.66); while the shortest days to 50% flowering (49) was recorded on local variety followed by Moti (52) (Table 5). The result indicates that varieties like Didi'a, Hachalu and Gebelcho are late flowering, while local and Moti are early flowering varieties at each location (Tables 3, 4 and 5). The difference response of varieties to days to 50% flowering might be attributed to their inheritance genetic variations and growing environments existing during their growth. Similar findings were reported by Mulualem *et al.* (2012), Bekele (2016), Yirga and Zinabu (2019) that faba bean varieties responded differently for days to flowering at different locations.

Days to maturity

Highly significant difference ($p \leq 0.01$) was observed among varieties in days to 90% maturity at each location. The longest days to maturity (142.33) was observed for variety Gabalicho followed by variety Didi'a with days to maturity of 141.66. The shortest days to maturity (127) was recorded for variety Moti followed by Local variety with days to maturity of 129 at main campus research site (Table 3). On the other hand, the maximum days to 90% maturity at Lambuda research site was recorded for varieties Tumisa (139.66), Gabalicho (139.33) and Hachalu (139) followed by Dosha (132.33) while the shortest days to 90% maturity was recorded for Local check (122.33) and Moti (124) (Table 4). Varieties Tumisa (135.66), Gabalcho (134.66) followed by Gora (132) were took longer days to mature after planting while local variety (117.66) followed by Moti (118.33) were early to mature at sanfe wasala kebele (Table 5). This result revealed that varieties like Gebelcho, Tumisa, Hachalu and Didi'a are late maturing varieties, while local and Moti are early maturing varieties at each location (Tables 3, 4 and 5). In this regard, early maturing varieties complete their life cycle in relatively shorter period of time. Thus, early maturing varieties have the advantage or adaptable over the late once in environments where rain begins late and ends early. The variations in days to maturity of varieties across locations may be due to the genetic variability of varieties in utilizing environmental resources and climatic conditions during growth period under different agro ecologies; which was similarly reported by (Mulualem *et al.*, 2012; Ashenafi and Mekuria, 2015; Tewodros *et al.,* 2015) that faba bean varieties responded differently for days to maturity at different locations.

Plant height

Analysis of variance showed that highly significant difference ($p \leq 0.01$) was detected among tested faba bean varieties in plant height at each location. At main campus research site, the maximum plant height was recorded from Hachalu, Tumsa, and Dosha varieties with a height of 184.66cm, 181cm and 180cm respectively; while the shortest plant height (152.33cm) and (153cm) was recorded on varieties Moti and Numan respectively (Table 3). At lambuda site, the tallest plant height (186cm) was recorded for variety Hachalu followed by Tumisa with plant height of 182cm while the shortest plant heights were recorded for varieties Local check (163.33cm), Moti (162cm) and Ashabeke (161cm) (Table 4). On the other hand, the maximum plant height was recorded from Tumisa (182.66cm) followed by Hachalu and Walki varieties with similar height of 176.66cm. whereas, the shortest plant heights were recorded for variety Gabalicho (151cm) at sanfe wasala kebele (Table 5). This result indicated that varieties Hachalu and Tumisa are the tallest whereas varieties local chek, Moti and Gabalicho were the shortest of all tested faba bean varieties at each location.

The differences in plant height among varieties across locations could be attributed to the difference in their genetic makeup and the soil type on which varieties were grown. In addition to this, Talal and Munqez (2013) suggested that plant height of faba bean is mainly controlled by the genetic makeup of varieties and it can also be significantly affected by the environmental factors. This result is in agreement with findings of Bekele (2016), Teame *et al.* (2017) and Yirga and Zinabu (2019) who suggested that there is variation on plant height for faba bean varieties across locations.

Number of branch per plant

Number of branch per plant was significantly affected by varieties. Highest number of branch per plant was recorded from variety Hachalu (5.13) and lowest branch per plant from varieties Dosha, (3.26), Ashabeke (3.2), Didi'a (3.2), Gora (3.06) and local check (3.11) at main campus research site (Table 3). The maximum number of branches per plant was recorded from Hachalu (5.13) followed by Tumisa (4.6), whereas the smallest number of branch per plant were recorded at Dosha (3.26), didi'a (3.2) Aahabeke (3.2) and local (3.11) varieties at Lambuda research site (Table 4). At sanfe wasala kebele, the highest number of branch per plant was recorded from variety Gablicho (2.83) followed by Hachalu (2.2) and lowest number of branch per plant from varieties Dosha, (1.2) and Gora (1.26) (Table 4). From this result, varieties Hachalu and Tumisa have the highest number of branches per plant whereas variety Dosha produced the lowest number of branches per plant among all tested faba bean varieties at each location. The difference in branch number among varieties within and across locations might be due to the genetic variability of faba bean varieties in utilizing environment resources and differences in growing environment. The result is in accordance with the works of Talal and Munqez (2013), and Yirga and Zinabu (2019) who indicated that faba bean varieties differ in number of branches per plant.

Number of pods per plant

Significant differences ($p<0.01$) were shown among varieties for the number of pods per plant. The largest number of pods per plant was recorded for the variety Walki (29.33) followed by Hachalu (27.33), while the lowest number of pods per plant was recorded for variety Numan (16) at main campus research site (Table 3). At lambuda site, the highest number of pods per plant were recorded from Tumisa (20.53) followed by Walki (19.26) whereas, Dosha (11.66) followed by local check (13.4) produced the lowest number of pods per plant (Table 4). The maximum number of pods per plant was recorded from Tumisa (21.33) followed by Gora (20), whereas the smallest number of pods per plant were recorded at Didi'a (13.4) followed by Numan (13.67) varieties at Sanfe wasala kebele (Table 5). From this result, varieties like Walki, Hachalu, Tumisa and Gora have the maximum pods per plant, whereas varieties like Numan, Dosha and Didi'a produced the smallest number of pods per plant at each location. The difference in pods number among varieties might be due to the genetic variability of faba bean varieties in utilizing environment resources which are used for plant growth and later for formation of greater number of branches and flowers per plant. The result is in accordance with the works of Mulualem *et al.* (2012), Tekle *et al.* (2015), Teame *et al.* (2017) [6, 27, 26] who indicated that faba bean varieties differ in number of pods per plant across locations.

Hundred seed weight

Analysis of variance showed that varieties exhibited significant differences on hundred seed weight (HSW). At main campus research site, the highest HSW (135.5g) was attained from variety Numan followed by variety Gora with HSW of 116.6g. The lowest HSW (80.56 g) was achieved from variety Walki (Table 3). Variety Numan (142.97g) followed by Ashabeke (125.21g) produced the highest hundred seed weight whereas variety Walki (90.75g) followed by Gabalicho (102.43g) produced the smallest hundred seed weight at Lambuda research site (Table 4). Of all tested varieties at Sanfe wasala kebele, Numan (136.97g) produced heaviest seed weight followed by Ashabeke (120.97g) and Gora (120.92g) while, Walki (80.72g) resulted the lowest HSW followed local check (92.57) (Table 5). In this result, varieties with larger seed size had produced highest

HSW while varieties with smaller seed size produced lower HSW. This result indicated that varieties Numan, Ashabeke and Gora can be considered as large seeded while variety Walki was small seeded variety in this study which resulted in lowest HSW. This finding clearly indicated that varieties exhibited inherent difference in assimilate partitioning efficiency to the seed (Tekle *et al.*, 2015). Hence, the variations in HSW of varieties within and across locations were likely reflected with the ability of genotypes in utilizing environment resources and partitioning dry matter into the seed. In line with result several researchers had reported that there is inherent variations in genotypes regarding the HSW (Ashenafi and Mekuria, 2015; Tamene *et al.*, 2015; and Yirga and Zinabu, 2019).

Biomass yield

Analysis of variance revealed that varieties showed significant differences on biomass yield. At main campus research site, the greatest biomass yield (11.9 t ha^{-1}) was found from local variety followed by varieties Hachalu, Numan, and Tumisa with mean biomass yields of 11.3 t ha^{-1}, 11.27 t ha^{-1}, and 11.22 t ha^{-1} respectively. The lowest biomass yield (7.01 t ha^{-1}) and (7.3 t ha^{-1}) was obtained from varieties Gabalicho and Moti (Table 3).

The highest mean biomass weight (10.22 t ha^{-1}) was recorded from variety Tumisa followed by varieties Walki, Gora, and Dosha with mean biomass yields of 10.22 t ha^{-1}, 9.96 t ha^{-1}, and 9.55 t ha^{-1} respectively whereas, the lowest biomass yield (6.03 t ha^{-1}) was obtained from varieties Gabalicho at Lambuda research site (Table 4). Similarly, the highest biomass weight was recorded from variety Dosha (11.59 t ha^{-1}) followed by variety Walki (10.91 t ha^{-1}) while the lowest biomass yield (6.25 t ha^{-1}) was recorded from variety Gabalicho at Sanfe wasala kebele (Table 5). Thus, the differences in biomass yield among varieties might be due to the genetic variability on the performance of varieties which was expressed on their ability to resource utilization which leads to difference on plant height, number of branch, pods and seeds. This result is in line with the works of Dahmardeh *et al.* (2010), Abdalla *et al.* (2015) and Tekle *et al.* (2015) who reported that biomass yield of faba bean was significantly varied for varieties.

Grain yield

Since grain yield is the final result from the interaction of various plant characters and the environmental factors during the life span of the plant development, the ranking of varieties based on grain yield can be considered as a reliable measure for varietal performance. Thus, the mean yield of the tested faba bean varieties evaluated in this research ranged from (2 t ha^{-1}) to 4.09 t ha^{-1}). In all the three locations, significant differences ($p<0.01$) were shown with in tested faba bean varieties on grain yield.

The highest grain yield (4.09 t ha^{-1}), and (4.03 t ha^{-1}), was recorded from varieties Tumisa and Hachalu respectively followed by local (3.9 t ha^{-1}), Numan (3.82 t ha^{-1}) and Dosha (3.82 t ha^{-1}) while the lowest grain yield (2.41 t ha^{-1}) was recorded for variety Moti followed by variety Gabalicho with mean grain yield of 2.76 t ha^{-1} at main campus research site (table 3). At lambuda research site, the highest grain yield was recorded for faba bean variety Tumisa (3.98 t ha $^{-1}$) followed by Dosha (3.6 t ha $^{-1}$) and Hachalu (3.58 t ha $^{-1}$) whereas, the lowest grain yield were recorded for Gabalicho (2.05 t ha $^{-1}$) and local check variety (2.16 t ha $^{-1}$) (Table 4).

At Sanfe wasala kebele, the highest grain yield were observed for faba bean variety Dosha (3.98 t ha $^{-1}$) and Tumisa (3.87 t ha $^{-1}$) followed by variety Walki (3.66 t ha $^{-1}$) but the lowest grain yield was recorded for variety Gabalicho (2 t ha $^{-1}$) (Table 5). In this result, faba bean varieties like Tumisa, Dosha and Hchalu showed a stable yield performance across all location which put them prior rank. Correspondingly, the high yielding performances of these varieties were reported earlier by Teame *et al.* (2017), Mogiso and Mamo (2018), and Yirga and Zinabu (2019).

The obtained high yielding potential of these varieties might be due to the genetic variability of faba bean varieties in adapting different locations and producing greater number of pods per plant,

branches, seeds per pod and highest seed weight when compared to other varieties.

Harvest index

Analysis of variance revealed significant differences on harvest index of faba bean varieties at all locations. At main campus research site, the maximum harvest index value was recorded from Gabalicho (39.27%) followed by Dosha (36.65%), Walki (36.63%) and Tumisa (36.53%). Similarly, the lowest harvest index was recorded from Local (32.9%), Moti (32.99%) and Didi'a (33.33%) varieties (Table 3). At Lambuda research site, the maximum harvest index value was recorded for variety Hachalu (39.51%), Tumisa (38.08%) and Dosha (37.75%) whereas the lowest harvest index was recorded for variety Moti (29.45%) (Table 3). At Sanfe wasala kebele the highest harvest index was recorded for variety Tumisa (39.65%) whereas the lowest harvest index was recorded for variety Didi'a (31.52%) (Table 5). This result is in conformity with findings of Gebremeskel *et al.* (2011), Abdalla *et al.* (2015) and Ashenafi and Mekuria (2015) who reported that HI varies for faba bean varieties.

Table 3. Mean grain yield and other agronomic traits of faba bean varieties at Wachemo University main campus research site during 2021 growing season.

Variety	DF	DM	PH (cm)	NB	NP	NS	HSW (g)	BY (t ha^{-1})	GY (t ha^{-1})	HI
Ashabeke	58.33^{bc}	131.66^{fg}	158.33^{def}	3.2^{e}	21.13^{cd}	3^{bc}	104.54^{de}	9.59^{c}	3.12^{cd}	33.69^{d}
Didi'a	59.66^{ab}	141.66^{ab}	154.66^{ef}	3.2^{e}	19.66^{d}	3^{bc}	99.99^{e}	9.43^{c}	3.15^{cd}	33.33^{d}
Dosha	59.33^{ab}	133.66^{def}	180^{a}	3.26^{e}	24.46^{bc}	3^{bc}	110.43^{bcd}	10.42^{bc}	3.82^{ab}	36.65^{b}
Gabalicho	59^{abc}	142.33^{a}	162^{cd}	4.03^{bcd}	21.66^{cd}	2.86^{c}	104.79^{bcd}	7.01^{d}	2.76^{de}	39.27^{a}
Gora	61^{a}	136.33^{cde}	170.66^{b}	3.06^{e}	19.26^{de}	3.06^{bc}	116.6^{b}	10.25^{bc}	3.68^{abc}	35.9^{bc}
Hachalu	58.33^{bc}	137.66^{bcd}	184.66^{a}	5.13^{a}	27.33^{ab}	3^{bc}	112.15^{bc}	11.3^{ab}	4.03^{a}	35.72^{bc}
Local check	52^{e}	129^{gh}	161.33^{cde}	3.11^{e}	23.4^{c}	2.93^{bc}	103.96^{de}	11.9^{a}	3.9^{ab}	32.9^{d}
Moti	55^{d}	127^{h}	153^{f}	4.23^{bc}	22.6^{cd}	3.93^{a}	109.16^{bcd}	7.3^{d}	2.41^{e}	32.99^{d}
Numan	60^{ab}	132.33^{efg}	152,33^{f}	3.66^{cde}	16^{e}	3.2^{b}	135.5^{a}	11.27^{ab}	3.82^{ab}	33.97^{cd}
Tumsa	56.66^{cd}	137.33^{bcd}	181^{a}	4.6^{ab}	23.2^{c}	2.93^{bc}	113.62^{b}	11.22^{ab}	4.09^{a}	36.53^{b}
Walki	60^{ab}	138.33^{abc}	167^{bc}	3.53^{de}	29.33^{a}	3^{bc}	80.56^{f}	9.45^{c}	3.47^{bc}	36.63^{b}
Mean	58.11	135.20	165.90	3.72	22.55	3.08	108.30	9.92	3.48	35.23
LDS	2.39	4.37	6.81	0.62	3.41	0.33	7.53	1.46	0.56	2.02
CV (%)	2.42	1.89	2.41	9.81	8.88	6.3	4.08	8.64	9.51	3.38

Means followed by different letters within columns are significantly different at 5% probability level, NS = not significant.

DF = days to flowering, DM = days to maturity, PH = plant height, NB = Number of branches per plant, NP = Number of pods per plant, NS = Number of seeds per pod, HSW= Hundred seed weight, BY = Biomass yield, GY = grain yield, HI = Harvest index.

Table 4. Mean grain yield and other agronomic traits of faba bean varieties at Lambuda site during 2021 growing season.

Variety	DF	DM	PH (cm)	NB	NP	NS	HSW (g)	BY (t ha^{-1})	GY (t ha^{-1})	HI
Ashabeke	54.66^{d}	130^{bc}	161^{f}	3.2^{e}	21.13^{cd}	2.96^{cd}	125.21^{b}	7.9^{dc}	2.39^{de}	30.29^{cd}
Didi'a	58.33^{b}	127.33^{cd}	167.66^{e}	3.2^{e}	14.2^{fg}	2.86^{d}	115.16^{cd}	8.83^{bc}	2.85^{cd}	32.15^{bc}
Dosha	56.66^{c}	132.33^{b}	178.66^{c}	3.26^{e}	11.66^{h}	3.2^{b}	112.37^{de}	9.55^{ab}	3.6^{ab}	37.75^{a}
Gabalicho	60.33^{a}	139.33^{a}	174^{d}	4.03^{bcd}	16.26^{de}	2.9^{d}	102.43^{f}	6.03^{e}	2.05^{e}	34.04^{b}
Gora	56^{c}	125.33^{def}	172.33^{d}	3.06^{e}	18.2^{bc}	2.93^{d}	119.43^{c}	9.96^{ab}	3.19^{bc}	31.99^{bc}
Hachalu	59.66^{a}	139^{a}	186^{a}	5.13^{a}	17.26^{cd}	3.16^{bc}	115.75^{cd}	9.06^{abc}	3.58^{ab}	39.51^{a}
Local check	50^{g}	122.33^{f}	163.33^{f}	3.11^{e}	13.4^{g}	2.93^{d}	109.54^{e}	7.2^{de}	2.16^{e}	29.81^{cd}
Moti	52^{f}	124^{ef}	162^{f}	4.23^{bc}	15.2^{ef}	3.46^{a}	114.23^{de}	8.92^{abc}	2.77^{cd}	29.45^{d}
Numan	53.33^{e}	125.33^{de}	152,33^{g}	3.66^{cde}	16.2^{de}	2.93^{d}	142.97^{a}	9.09^{abc}	2.71^{cd}	29.68^{cd}
Tumsa	56.33^{c}	139.66^{a}	182^{b}	4.6^{ab}	20.53^{a}	3.23^{b}	114.35^{d}	10.46^{a}	3.98^{a}	38.08^{a}
Walki	57^{c}	130^{bc}	181^{bc}	3.53^{de}	19.26^{ab}	3.03^{bcd}	90.75^{g}	10.22^{ab}	3.39^{b}	33.29^{b}
Mean	58.11	135.20	165.90	3.72	22.55	3.08	108.30	9.92	3.48	35.23
LDS	1.25	3.26	3.25	0.62	1.56	0.21	4.69	1.56	0.51	2.47
CV (%)	1.31	1.47	1.11	6.08	5.78	4	2.4	10.41	10.03	4.36

Means followed by different letters within columns are significantly different at 5% probability level, NS = not significant.

DF = days to flowering, DM = days to maturity, PH = plant height, NB = Number of branches per plant, NP = Number of pods per plant, NS = Number of seeds per pod, HSW= Hundred seed weight, BY = Biomass yield, GY = grain yield, HI = Harvest index.

Table 5. Mean grain yield and other agronomic traits of faba bean varieties at Anlemo Woreda Sanfe wasala kebele farmers training centre during 2021 growing season.

Variety	DF	DM	PH (cm)	NB	NP	NS	HSW (g)	BY (t ha$^{-1)}$	GY (t ha$^{-1)}$	HI
Ashabeke	55.00^{e}	121.66^{e}	165.667^{cd}	1.53^{cde}	16.73^{cde}	3.4^{ab}	120.97^{b}	10.16^{bc}	3.33^{bc}	32.83^{cde}
Didi'a	61^{a}	124.33^{d}	156.333^{e}	1.53^{cde}	13.4^{f}	3.13^{bc}	107.52^{d}	7.66^{d}	2.41^{de}	31.52^{e}
Dosha	57.66^{bcd}	125^{d}	163.667^{de}	1.2^{e}	18^{bcd}	3.13^{bc}	103.55^{e}	11.59^{a}	3.98^{a}	34.34^{bc}
Gabalicho	61^{a}	134.66^{a}	151^{g}	2.83^{a}	14.67^{ef}	2.66^{d}	114.12^{c}	6.25^{e}	2^{e}	31.74^{de}
Gora	59^{abc}	132^{b}	167.667^{c}	1.26^{e}	20^{ab}	3.06^{dc}	120.92^{b}	10.23^{bc}	3.34^{bc}	32.66^{cde}
Hachalu	59.66^{ab}	129.33^{c}	176.667^{b}	2.2^{b}	18.93^{abc}	3^{dc}	102.7^{e}	6.88^{de}	2.48^{d}	36.13^{b}
Local check	49^{g}	117.66^{g}	167^{cd}	1.66^{cd}	13.73^{ef}	3^{dc}	92.57^{f}	9.95^{bc}	3.33^{bc}	33.5^{cd}
Moti	52^{f}	118.33^{fg}	153.333^{fg}	1.33^{de}	15.33^{def}	3.73^{a}	102.13^{e}	9.2^{c}	3.04^{c}	33.04^{cde}
Numan	57^{cde}	120.66^{ef}	161.333^{e}	1.8^{c}	13.67^{f}	3.13^{bc}	136.97^{a}	9.83^{bc}	3.33^{bc}	33.88^{c}
Tumsa	56.66^{de}	135.66^{a}	182.667^{a}	1.4^{de}	21.33^{a}	3^{dc}	107..02^{d}	9.76^{bc}	3.87^{a}	39.65^{a}
Walki	58^{bcd}	129^{c}	176.667^{b}	1.8^{c}	18.47^{abc}	3^{dc}	80.72^{g}	10.91^{ab}	3.66^{ab}	33.55^{cd}
Mean	56.9	126.20	165.63	1.55	16.75	3.11	98.37	9.31	3.16	33.89
LDS	2.20	2.65	3.83	0.37	3.05	0.34	2.10	1.21	0.46	1.85
CV (%)	2.27	1.24	1.36	12.84	10.7	6.55	1.15	7.68	8.63	3.22

Means followed by different letters within columns are significantly different at 5% probability level, NS = not significant.
DF = days to flowering, DM = days to maturity, PH = plant height, NB = Number of branches per plant, NP = Number of pods per plant, NS = Number of seeds per pod, HSW= Hundred seed weight, BY = Biomass yield, GY = grain yield, HI = Harvest index.

Farmers Variety Evaluation and Selection at three locations

The evaluations mean score value for each variety ranged from 3.25 to 4.66 at main campus research site (Table 6). Tumisa (4.66) scored the highest value followed by Dosha (4.41) and Numan (4.41) and the lowest mean scored was by Didi'a (3.25) and Gabalicho (3.25).

At main campus research site, the best varieties namely Tumisa and Dosha were selected as top ranking in all groups as final selections or adapted varieties. The same variety (Tumisa) had better performance and found to be promising from the analysis of researchers' collected data in this site.

At lamuda research site, the evaluations mean score value for each variety ranged from 3.25 to 4.33 (Table 7). Dosha (4.33) and Tumisa (4.33) scored the highest values followed by variety Numan (4.25) and the lowest mean was scored by Didi'a (3.25).

The best varieties namely Dosha and Tumsa were selected as top ranking in all groups as final selections or adapted varieties by farmers at Lambuda research site.

The same varieties had better performance and found to be promising from the analysis of researchers' collected data in this site. According to farmers selection criteria variety Dosha scored high mean value (4.75) followed by Tumisa (4.66) followed by Numan (4.58) and least mean value was recorded from Didi'a (3.83) at Sanfe wasala Kebele (Table 8).

In this regard, best varieties namely Dosha and Tumisa were selected as top ranking in all groups as final selections or adapted varieties at this site.

In general, the best varieties namely Tumisa, Dosha and Numan were selected as top ranking in all districts as final selections or adapted varieties. In line to this finding Awol *et al.* (2016), Bekele (2016) and Yirga and Zinabu (2019) stated that Dosha and Tumisa were the 1st ranked variety by farmers' selection. It is obvious that farmers demonstrated the ability to select well adapted and preferred varieties, under their circumstances, using their own criteria.

They understand also as an opportunity to large number of improved faba bean varietal choices on their own resources and enhance all farmers' access to crop varieties and increase variety diversity. Besides, it allows varietal selection in targeted areas at cost-effective and also in less time, which helps for easy adoption and dissemination of released varieties in larger areas.

Table 6. Farmers' preference criteria on faba bean variety selection at Wachemo University main campus research site.

Variety	PES	OAP	STS	NB	NP	SN	SS	PH	DR	LS	GY	SY	Total	Mean	Rank
Ashabeke	4	3	4	3	3	3	4	4	3	3	3	3	40	3.33	7
Didi'a	4	4	3	3	3	3	3	3	4	3	3	3	39	3.25	8
Dosha	5	5	5	4	4	4	4	5	4	4	5	4	53	4.41	2
Gabalicho	3	3	3	5	4	2	3	3	4	3	3	3	39	3.25	8
Gora	5	4	3	3	4	4	4	4	4	4	3	4	46	3.83	4
Hachalu	5	4	5	4	5	4	4	4	4	4	4	4	51	4.25	3
Local	5	4	4	4	4	4	3	4	3	3	3	4	45	3.75	5
Moti	4	4	3	3	3	5	4	3	3	3	3	2	40	3.33	7
Numan	5	5	5	4	4	4	5	5	4	4	4	4	53	4.41	2
Tumisa	5	5	5	5	5	4	4	5	5	4	5	4	56	4.66	1
Walki	4	4	4	4	5	3	2	3	4	3	3	4	43	3.58	6

PES=Plant establishment, OAP=Overall performance, STS=stem strength, NB= number of branches; NP= Number of pods SN= number of seeds, SS =seed size; PH= plant height; DR= Disease resistance; Ls= Leaf shading; Gy= Grain Yield; SY= Straw yield; Rating 5= excellent, 4= Very good, 3= average, 2= poor and 1 = very poor.

Table 7. Farmers' preference criteria on faba bean variety selection at Lambuda research site

Variety	PES	OAP	STS	NB	NP	SN	SS	PH	DR	LS	GY	SY	Total	Mean	Rank
Ashabeke	4	4	4	4	4	4	4	4	4	5	3	3	47	3.91	3
Didi'a	3	3	4	3	3	3	3	4	3	3	4	3	39	3.25	7
Dosha	5	5	5	4	5	4	4	4	4	4	4	4	52	4.33	1
Gabalicho	3	4	4	4	3	3	3	3	4	4	3	2	40	3.33	6
Gora	3	4	4	3	4	4	4	4	4	4	4	4	46	3.83	4
Hachalu	5	5	5	4	4	4	4	5	4	4	4	4	52	4.33	1
Local	4	4	4	3	4	4	4	4	4	3	4	4	46	3.83	4
Moti	4	4	4	3	3	5	4	3	3	4	3	3	43	3.58	5
Numan	5	5	4	4	4	4	5	4	4	4	4	4	51	4.25	2
Tumisa	5	5	5	4	4	4	4	5	4	4	4	4	52	4.33	1
Walki	4	4	4	4	5	4	2	3	4	4	4	4	46	3.83	4

PES=Plant establishment, OAP=Overall performance, STS=stem strength, NB= number of branches; NP= Number of pods SN= number of seeds, SS =seed size; PH= plant height; DR= Disease resistance; Ls= Leaf shading; Gy= Grain Yield; SY= Straw yield; Rating 5= excellent, 4= Very good, 3= average, 2= poor and 1 = very poor.

Table 8. Farmers' preference criteria on faba bean variety selection at Anlemo woreda Sanfe wasala kebele farmers' training centre.

Variety	PES	OAP	STS	NB	NP	SN	SS	PH	DR	LS	GY	SY	Total	Mean	Rank
Ashabeke	5	5	5	4	4	4	5	4	4	4	4	3	51	4.25	5
Didi'a	4	4	4	4	4	4	3	4	4	4	3	4	46	3.83	9
Dosha	5	5	5	5	5	4	4	5	5	4	5	5	57	4.75	1
Gabalicho	3	4	4	4	3	3	4	4	4	4	3	3	43	3.58	9
Gora	5	4	4	4	4	4	4	4	4	4	4	4	49	4.08	7
Hachalu	5	5	5	4	4	4	4	5	4	5	4	4	53	4.41	4
Local	5	5	4	4	4	4	4	4	4	4	4	4	50	4.16	6
Moti	4	5	4	4	4	5	4	4	4	4	3	3	48	4	8
Numan	5	5	5	4	5	5	5	5	4	4	4	4	55	4.58	3
Tumisa	5	5	5	4	5	5	4	5	4	5	5	4	56	4.66	2
Walki	4	4	4	4	5	4	3	4	4	4	4	4	48	4	8

PES=Plant establishment, OAP=Overall performance, STS=stem strength, NB= number of branches; NP= Number of pods SN= number of seeds, SS =seed size; PH= plant height; DR= Disease resistance; Ls= Leaf shading; Gy= Grain Yield; SY= Straw yield; Rating 5= excellent, 4= Very good, 3= average, 2= poor and 1 = very poor

Conclusion and recommendation

In general, there were significant differences in grain yield and differences in most of the growth and agronomic parameters of faba bean varieties at each district. From the results of this study, faba bean varieties like Tumisa, Dosha and Hchalu showed a stable yield performance and other agronomic traits across all locations which put them prior rank. In addition to this,

according to the farmers' evaluation and selection variety Tumisa, Dosha and Numan were best performing with grain yield and yield components at each location. Therefore, based on both researchers and farmer's evaluation varieties Tumisa, Dosha, Hachalu and Numan were recommended for further popularization and wider production by farmers of the study area.

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