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Evaluation of Faba Bean (*Vicia faba* L.) Varieties for Yield Performance in Kaffa Zone, Southwestern Ethiopia

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ABSTRACT

This study aims to evaluate yield performance of faba bean (*Vicia faba* L.) varieties with data from field experiment that was conducted at Alarigeta testing site of Bonga Agricultural Research Center in the 2012 and 2013 cropping seasons using six improved faba bean varieties with the local check. The improved varieties included in the study were Cs-20-DK, Degaga, Tumsa, Hachalu, Dosha, and Walki. These varieties were assigned to the Randomized Complete Block Design with three replications. In this experiment, yield and yield related traits of the improved varieties were measured and evaluated against the performance of the local check. The combined analysis of the over year experiment showed significant (P<0.05) differences among varieties for most of the parameters studied such as grain yield, number of pods per plant, hundred seed weight, days to flowering and maturity. The varieties Tumsa and Hachalu were found to be high yielder with the value of 6.31 and 5.86 tons ha^{-1}, respectively. Selected farmers around the experimental site made the assessment on the performance of the evaluated varieties at flowering and physiological maturity stages. They evaluated and ranked these varieties using their own criteria. According to their perception on the performance of the varieties they also ranked Tumsa and Dosha at the first and second level, respectively. The results obtained from the statistically analysis combining the farmers' preference revealed that Tumsa, and Dosha were the best performing varieties in all measured traits as compared to others. Therefore, varieties Tumsa and Dosha could be used for popularization and wider production by the farmers in the study area and in the farming communities of similar agro-ecologies. Use of the appropriate technology packages and optimum crop management practices along with these varieties is also recommended in order to attain maximum productivity.

Introduction

Faba bean (*Vicia faba* L.), is an important pulse crop in terms of area coverage and volume of annual production in Ethiopia (Tamene and Tadese, 2013). It is a major staple food crop among pulses and it is mainly grown in the mid and high altitude areas of the country with an elevation ranging from 1800-3000 meters above sea level (Musa and Gemechu, 2006). The crop has a versatile use; it plays an important part in food security, maintenance of soil health and sustainability of different cropping systems (Sainte, 2011). The crop contributes to the smallholder farmers as a source of protein in both rural and urban areas (Osman et al., 2014) and is an important source of income for farmers. The crop is also used as a cover crop and animal feed in different areas of the world. The crop is characterized by the production of large amount of biomass that can be tilled back into the soil as green manure. The straw from the crop is also used as fuel in Sudan and Ethiopia (Tewodros et al., 2015). Due to its high protein content, the crop helps to make various traditional dishes in Ethiopia (Senayit and Asrat, 1994), contains a high amount of protein, 24-33% compared to 6-10% protein in major cereal crops (Winchi, 2006; IFPRI, 2010). Moreover, the crop is widely used as a good sources of starch, cellulose and minerals (Haciseferogullari et al., 2003). It also provides essential amino acids particularly lysines that are not present in sufficient quantity in staple cereal crops (Giller, 2001).Due to its nitrogen fixing capacity the crop is used in rotation with cereal crops like wheat and tef (Gorfu and Feyissa, 2006; IFPRI, 2010).

Faba bean is one of the oldest domesticated and third most important cool-season food legumes in the world (Torres et al., 2006) and is commonly produced as a winter annual in subtropical areas. It takes about four to five months for maturity depending on the growing conditions of the area (Macleod and Sweetingham, 1999; Mussa et al., 2008). The geographical origin of faba bean is not clearly known but in Central Asia and the Mediterranean regions have been proposed as possible centers of origin (Metayer, 2004). Historically, Ethiopia is seen as one of the centers of secondary diversity for faba bean (Torres et al., 2006) and the second largest faba bean producing country in the world next to China (Jarso and Keneni, 2006). Currently the crop is commonly grown in different areas of Ethiopia receiving annual rainfall of 700-1000mm (ICARDA, 2006). However, Amhara and Oromia regions have the highest contribution of faba bean production in Ethiopia (Yitayih and Azmeraw, 2017).The annual area coverage of the crop in Ethiopia is 443,966.09 hectares with the total production and productivity of 8.39 million tons and 1.91 tons ha^{-1}, respectively (CSA, 2016).

Kaffa zone is one of the administrative zones in the SNNPRS which has a huge potential for faba bean production. In addition, the area has got plenty of rainfall for a longer duration in a year. Thus, the crop is grown in the highland areas of the zone. Despite the potential of the zone the productivity of the crop in the area is 1.4 tons ha^{-1} which is below the national average yield of 1.9 ton ha^{-1} (FAOSTAT, 2014). This indicates that the productivity of the crop is still far below its potential due to lack of improved varieties and application of inadequate agronomic practices in the area. In fact, there is no research activity conducted in the area with regard to the adaptability of improved varieties of faba bean. Therefore, the aim of this study was to evaluate improved faba bean varieties for their adaptability and yielding performance to improve the existing low productivity of the crop in the study area.

Materials and methods

Description of the experimental site

The field experiment was conducted at Alarigata testing site of Bonga Agricultural Research Center. Alargata is located about 20 kilometers away from the zonal town, Bonga. The study area represents the highland agro-ecologies of Kaffa zone. It is situated at 07^{o} 17' N latitude and 36^{o} 22' E longitudes at an elevation of 2400 meter above sea

level. The average annual rainfall and the average maximum and minimum temperature of the area are 975mm and 24 and 13 ^{o}C, respectively.

Experimental materials

Six improved faba bean varieties including the local check were used in this study and evaluated for their yield performance in the 2012 and 2013 cropping seasons. The improved varieties were CS-20-DK (CS20DK), Degaga (R-8783), Tumsa (EH990513), Hachalu (EH00102-4-1), Dosha (COLL 155/00-3), and Walki (EH96049-2).

Agronomic practices

The experimental field was ploughed following the standard practices for faba bean production before sowing. Fertilizer (DAP) was applied at sowing. Weeding and other agronomic practices were carried out in all experimental plots as per the recommendations.

Experimental design and layout

The experiment was laid down in a randomized complete block design with three replications. Each experimental plots having six rows consisted of 2.4 m length (9.6 m^2) and four internal rows (6.4 m^2) were used as a net plot area. Spacing between plants and rows were 10 and 40 cm, respectively. The spacing between blocks and plots were 1 m. Plants from the internal rows of net plot area were used for data collection and analysis of the parameters under study.

Data collection

Agronomic data were recorded on both plot and plant bases to evaluate the performance of the experimental varieties. Ten plants from each plot were selected and pre-tagged for data collection. Number of pods per plant, number of seeds per pod and plant height (cm) was recorded from the pre-tagged sample plants of each plot at maturity. However, the phenological data *viz*. days to flowering and maturity were recorded on plot bases by counting the number of days from sowing to the time when 50% and 85% of the plants were flowered and fully matured, respectively. Hundred seed weight was determined by weighing samples of randomly drown 100 seeds of each plots using a digital balance. Grain yield (ton ha^{-1}) for the experimental varieties of each plot was also recorded and all the data of the measured traits were subjected to the statistical analysis.

Statistical analysis

The collected data were subjected to statistical analysis using proc ANOVA model procedures of SAS, version 9.2(SAS institute, 2007). Variations between the treatment means were compared using least significant difference (LSD) at 5% probability level ($P<0.05$). Besides, coefficient of variance (CV %) was calculated to reveal the relative measure of variation that existed within the data. 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 =1, lower preference=5 (Gay et al., 2016).

Results and discussion

The analysis of variance for the measured traits of the tested varieties showed there were significant differences ($P<0.05$) in the number of pods per plant, hundred seed weight, days to flowering, days to physiological maturity and grain yield. However, there was no significant difference ($P<0.05$) among the varieties in the number of seeds per pod and plant height. There was significant difference ($P<0.05$) among years in the number of pods per plant and seed number per pod, days to flowering and maturity. Hence, the parameters were varying among years. The observed differences among the varieties could be due to variation in the genetic makeup of these varieties. On the other hand, means of the interactive effects of variety by year was significant only for grain yield (Table1). The varieties Hachalu and Dosha were showed a yield reduction in the year 2013 as compared to other varieties. The number of seeds per pod and hundred

seeds weight were also decreased when we see the mean values of individual year data (Table 2). This difference indicating that the variation was years. Similar results were reported by Melle et al. (2015) and Teshome, (2017) that indicated genotypic difference in their phonological and agronomic traits.

Table 1. Mean square values of agronomic characters of faba bean varieties from combined analysis of variance over years.

SOV	GYD	PPT	SPP	HSW	PHT	DTF	DTM
Variety	2.70**	33.99*	0.04^{NS}	1363.78**	395.05^{NS}	12.94**	42.97**
Year	0.60^{NS}	375.60**	0.19*	6.10^{NS}	304.56^{NS}	360.21*	924.02**
Variety* year	0.85*	20.53^{NS}	0.04^{NS}	38.37^{NS}	6.35^{NS}	6.21^{NS}	5.19^{NS}
Error	0.35	12.47	0.04	18.55	259.33	3.24	6.21

SOV = Source of variation, GYD = Grain yield, PPT = Number of pods per plant, SPP = Number of seeds per pods, HSW = Hundred seed weight, DTF = Days to 50% flowering, DTM = Days to physiological maturity, PHT = Plant height, Variety*year = Variety by year interaction; *=significant at 5% probability level, **= significant at 1% probability level, NS = non-significant.

Table 2. Mean values of the measured parameters of faba bean varieties tested in 2012 and 2013 cropping season.

Varieties	Mean values													
	Year 2012							Year 2013						
	GYD	PPT	SPP	HSW	PHT	DTF	DTM	GYD	PPT	SPP	HSW	PHT	DTF	DTM
Cs-20-DK	4.63	12.40	2.60	56.77	175.6	54.3	142.3	5.38	21.00	2.50	54.97	181.9	60.7	151.7
Degaga	4.80	13.33	2.47	59.27	170.6	55.0	142.3	5.81	12.27	2.53	62.80	171.9	58.0	150.0
Tumsa	6.02	16.20	2.53	91.40	174.7	55.7	147.0	6.61	23.47	2.53	89.30	181.7	60.3	155.0
Hachalu	6.12	12.60	2.63	75.00	154.7	55.0	147.0	5.60	17.47	2.50	70.00	159.4	64.7	155.0
Dosha	6.14	15.07	2.83	82.50	173.9	54.7	142.3	5.05	20.80	2.47	79.60	180.3	61.0	151.7
Walki	5.38	12.60	2.80	59.20	164.5	57.7	143.0	5.84	18.33	2.50	63.60	169.1	63.3	153.3
Local check	3.97	8.73	2.43	42.40	174.3	54.3	137.0	4.44	19.47	2.37	51.60	181.6	59.7	150.0
Mean	5.29	12.99	2.62	66.65	169.8	55.2	143.0	5.53	18.97	2.49	67.41	175.1	61.2	152.4
LSD (5%)	0.63	5.60	0.35	8.06	29.7	2.6	4.7	1.22	7.62	0.28	7.68	26.4	3.4	3.0
CV (%)	6.64	24.23	7.53	6.79	9.84	2.61	1.83	12.39	22.58	6.40	6.40	8.47	3.09	1.10

GYD = Grain yield (ton ha^{-1}), PPT = Number of pods per plant, SPP = Number of seeds per pods, HSW = Hundred seed weight (gm), and PHT = Plant height (cm), DTF = Days to 50% flowering and DTM = Days to physiological maturity.

Number of pods per plant

Significant differences (P<0.01) were shown among varieties for the number of pods per plant. The highest numbers of pods per plant were recorded for the varieties Tumsa, Dosha and Cs-20-DK with the respective numbers 19.8, 17.9 and 16.7, respectively unlike the remaining varieties under study (Table 3). The highest number of pods per plant was recorded in 2013 as compared to 2012.The observed difference among years is might be due to the difference in weather condition.

Number of seeds per pod

Number of seeds per pod is one of yield determining factors in pulse crops. The difference in seed number among the tested varieties ranged from 2.4(local check) to 2.7 (Dosha and Walki) with the grand mean of 2.6 (Table3). The improved faba bean varieties produced more number of seeds per pod than the local check. However, there was no significant difference among the improved varieties in the number of seeds per pod. This result is similar with the report of previous studies (Ashenafi and Mekuria, 2015).

Thousand-seed weight

The faba bean varieties evaluated showed a significant difference ($P < 0.05$) in the hundred seed weight. Seed weight of these varieties ranged from 47.0 to 90.4g. Variety Tumsa produced the highest hundred seed weight (90.4g) whereas; the local check was recorded for the smallest hundred seed weight (47.0g) (Table 3). This is in line with the report of Ashenafi and Mekuria (2015); Teame et al. (2017) who reported the highest hundred seed weight of variety Tumsa among the varieties they tested. The observed differences in hundred seed weight might be due to inherent genetic differences among the varieties.

Grain yield

The yield difference ranged from 4.21 ton ha^{-1} to 6.31 ton ha^{-1} with the grand mean of 5.42 ton ha^{-1} (Table3). The highest grain yields were obtained from the varieties Tumsa (6.31 tons ha^{-1}) and Hachalu (5.86 ton ha^{-1}) while the remaining varieties were recorded for the lowest mean grain yield. Varieties Tumsa and Hachalu had gave the yield advantage of 33.28% and 28.16% over the local check, respectively. The obtained high yielding potential of these varieties may be due to their large number of pods per plant and highest seed weight. Correspondingly, the high yielding performances of these varieties were reported earlier by Teame et al. (2017).

Table 3. Combined mean values of grain yield and yield components of faba bean varieties at Alarigata testing site.

Varieties	Mean values						
	GYD (ton ha^{-1})	PPL	SPP	HSW (gm)	PHT (cm)	DTF	DTM
CS-20-DK	5.00	16.70	2.55	55.87	178.8	57.5	147.0
Degaga	5.31	12.80	2.50	61.03	171.3	56.5	146.2
Tumsa	6.31	19.83	2.53	90.35	178.2	58.0	151.0
Hachalu	5.86	15.03	2.57	72.50	157.1	59.8	151.0
Dosha	5.60	17.93	2.65	81.05	177.1	57.8	147.0
Walki	5.61	15.47	2.65	61.40	166.8	60.5	148.2
Local check	4.21	14.10	2.42	47.00	178.0	57.0	143.5
Means	5.42	15.98	2.55	67.03	172.5	58.2	147.7
LSD (0.05)	0.70	4.18	0.23	5.09	19.1	2.13	2.95
CV (%)	10.90	22.09	7.55	6.43	9.34	3.09	1.69

GYD = Grain yield (ton ha^{-1}), PPT = Number of pods per plant, SPP = Number of seeds per pods, HSW = Hundred seed weight (gm), and PHT = Plant height (cm), DTF = Days to 50% flowering and DTM = Days to physiological maturity.

Table 4. Ranking of farmers' preference for faba bean varieties in 2012 and 2013 cropping season at Alarigata testing site.

Varieties	Cs-20-DK	Degaga	Tumsa	Hachalu	Dosha	Walki	Local check
Grain yield	3	2	1	2	2	2	4
High no. of pods per plant	1	3	1	2	2	2	2
Seed size	3	2	1	1	1	3	3
Seed color	2	3	1	2	2	2	5
Disease resistance	2	3	2	2	2	2	3
Overall plant performance	2	3	2	2	1	3	4
Total score	13	16	8	11	10	14	21
Rank	4	6	1	3	2	5	7

Preference scale 1-5, higher preferences=1, lower preference=5.

Farmers' selection

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 grain yield, seed size, seed color, pod number, disease resistance and overall plant performance. Farmers selection is not only based on the growth performance of the varieties but also grain yield and market preferences (color). Overall, based on their selection criteria the most preferred varieties were Tumsa, and Dosha, while the local check was the least preferred one (Table 4).

Conclusion

Faba bean is the least expensive source of protein for the people in Ethiopia. It is widely cultivated in the farming communities of Kaffa zone. However, lack of improved variety is the major challenge for the farmers in the study area. Thus, six improved faba bean varieties along with the local check were evaluated for their yield potential at Alarigata testing site of Bonga Agricultural Research Center. Based on this study, there were variations among the varieties for most of the parameters studied in the location. However, the highest grain yield was obtained from Tumsa and Hachalu followed by Walki, Dosha and Degaga at Adiyo district while, the lowest grain yield was obtained from the local check. Moreover, farmers of the testing area used their own criteria to select the tested varieties. Therefore, based on yielding performance and farmers' preference of the varieties Tumsa and Dosha were recommended for further popularization and wider production by farmers of the study area and other areas of similar agro ecological settings of Kaffa zone.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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