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EVALUATION OF FABA BEAN (*Vicia faba* L.) VARIETIES AGAINST FABA BEAN GALL DISEASE IN NORTH SHEWA ZONE, ETHIOPIA

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ABSTRACT

Faba bean gall disease is a newly emerging and devastating disease of faba bean that threaten its production and productivity in Ethiopia. Thus, this study was conducted with the objective to evaluate the reactions of faba bean varieties against faba bean gall disease. A field experiment was conducted at Basona Werana and Ankober Districts, in 2014. Sixteen faba bean varieties along with local check were tested in RCBD design with three replications. Faba bean varieties varied significantly ($p \leq 0.05$) for both disease and yield parameters. The lowest disease severity, AUDPC and infection rates were recorded from variety Gachena (Lay Gorebela) and Gora and Gachena (Mush). Moreover, the highest (2737 and 3374%-days) AUDPC values were recorded from the variety local and Selale at Mush and Lay Gorebela. The highest yield was obtained from varieties Gora, Gebelcho, Degaga, Gachena and Walki (Mush) and from varieties Gora and Gachena (Lay Gorebela). Also, yield of faba bean correlated negatively and significantly with AUDPC and final severity at both locations, whereas, AUDPC and severity associated positively and significantly from each other. From this study it can be concluded that relatively resistant and high yielder varieties can be used in combination with other control measures. Therefore, in the future, researches on integration of resistance and high yielder varieties with other management options should be conducted.

Contribution/Originality: This study is one of the very few studies in Ethiopia which have investigated the response of Faba bean varieties for the newely emerged gall disease. The study assessed seventeen varieties by scientifically comparing them with very important agronomic and disease resistance related attribute and come up with valid conclusion.

1. INTRODUCTION

Faba bean (*Vicia faba* L.) is grown in many countries as a rain-fed and irrigated crop for human food and animal feed and plays important roles in the national economy and agricultural production in various ways. Faba bean is a leading protein crop in and covered over half a million ha and production of close to one million tonnes of grain and 1.2 million tonnes of straw [1]. Moreover, despite the availability of high yielding varieties, the average national yield of faba bean under small-holder farmers is not more than 1.8 t ha^{-1} [1]. Various biotic, abiotic and

anthropogenic factors have attributed to this low productivity of the crop. According to Samuel, et al. [2] diseases are the most important biotic factors limiting the production of faba bean in Ethiopia. Many diseases are affecting faba bean production and productivity, but only a few of them have economic significance.

Recently, faba bean gall has become a serious threat to faba bean production and productivity in some parts of the country causing a yield loss as high as 100% [3]. In Ethiopia, the disease was first reported as a faba bean "gall" in North Shoa (Degem, Bash Area of Menz Mama and Mojana Wedera district) in 2011 [3, 4]. A survey conducted in major faba bean-growing districts of North Shoa indicated that the disease was new and problematic in all faba bean-growing districts [5]. Moreover, according to the survey conducted in 2013, the disease has spread to the highland faba bean-growing areas of Amhara, Tigray, and Oromia regions [6]. This shows that the spread of the disease has been very fast and expanding from year to year in all faba bean growing areas of the country.

Now, a little effort has been made for the control of this disease including fungicide sprays and screening of germplasms. Furthermore, it is hypothesized that different faba bean varieties and fungicides had different effect on this disease. So far, little has been known about this disease and there are no varietal recommendations against faba bean gall in North shewa zone. So, if appropriate strategy is not devised to curb the progress of the disease and to manage it timely, obviously the disease would continue to devastate vast areas of faba bean producing regions shortly, constraining the national production of this economic crop. Thus, this study was conducted with the objective to evaluate the reaction of selected faba bean varieties against faba bean gall disease and its effect on yield and yield related components.

2. MATERIALS AND METHODS

2.1. Experimental Sites

The experiment was conducted on the farmers' fields that were considered as "hot-spot" for faba bean gall under rain- fed conditions at Basona Werana and Ankober Districts, North Shoa Zone Figure 1. The specific experimental sites were Mush Kebele or Farmers Association (in Basona Werana District) and Lay Gorebela Kebele or Farmers Association (in Ankober District), which are hot-spot areas for the disease and that are located 20 and 42 km north and north-east of Debre Birhan town, respectively. Mush Kebele is found at an altitude of 2975 m.a.s.l. and receives average annual rain fall of 897.8 mm with mean minimum and maximum temperatures of 6.1 and 19.67 ^{o}C, respectively. Ankober Kebele is found at an altitude of 3152 m a.s.l. The area receives mean annual rainfall of 1793 mm with average minimum and maximum temperatures of 13 and 27 ^{o}C, respectively.

2.2. Experimental Materials and Design

A total of 17 faba bean genotypes (16 improved faba bean varieties Table 1 along with one local variety of each location (Ankober and Mush) were planted in 2014 main cropping season. The experiment was laid out in a randomized complete block design (RCBD) with three replications and with a plot size of 1.6 m x 2 m. Four rows per a plot each accommodating 20 plants were used and an inter-row and intra-row spacing of 40 cm and 10 cm, respectively, were used. Gangways of 0.5 and 1 m were used between plots and replications, respectively.

Full dose of phosphorous (46 kg ha^{-1}) and nitrogen (18 kg ha^{-1}) fertilizer was applied once at planting (*i*.e. on June 24 and 25 at Mush and Ankober, respectively) in the form of di-ammonium phosphate (DAP) just below the seed with light covering of soil to avoid direct contact with the seed. All other non-experimental variables and agronomic operations were applied uniformly to the entire experimental areas and throughout the experimental time.

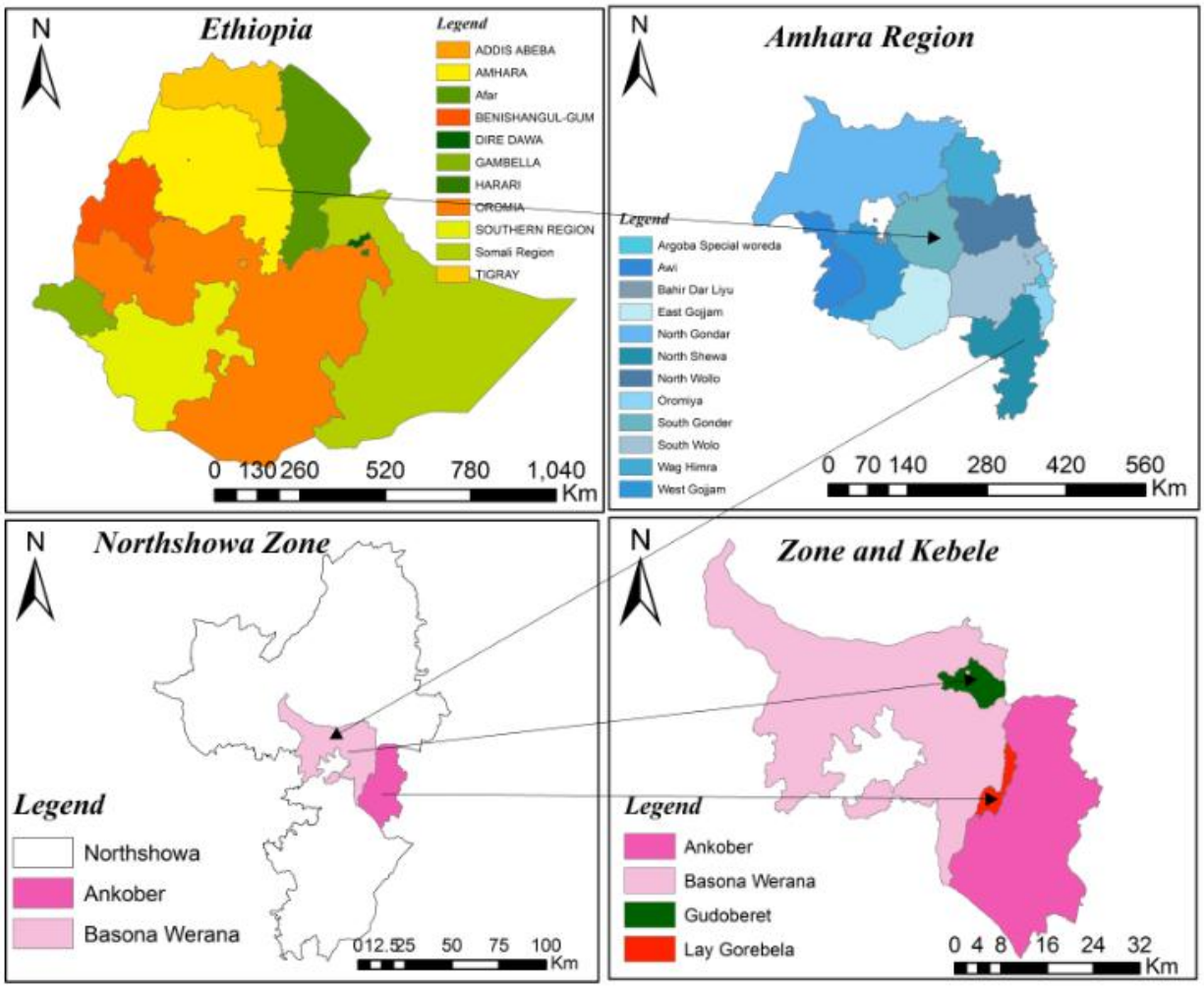

Figure-1. Map of the experimental sites.

2.3. Data Collected From Field Experiments

a. Disease Parameters

Days to disease onset: Measured as the date on which the disease was first noticed.

Disease severity: Disease severity was recorded on 20 randomly selected plants in the two central rows of each plot starting from the onset of the disease and repeated after every 10 day intervals. A 0-9 scale was used where 0 = no disease symptom observed, 1 = < 2% plant parts infected, 2 = 2 - 5% plant parts infected, 3 = 6 - 10% plant parts infected, 4 = 11 - 25% plant parts infected, 5 = 26 - 50% plant parts infected, 6 = 51 – 75% plant parts infected, 7 = 76 - 90% plant parts infected, 8 = 91 - 99% plant parts infected, 9 = 100% plant parts infected [7]. Disease severity scores were converted into a percentage severity index (PSI) for analysis [8].

$$PSI = \frac{Snr}{Npr \times Msc} x\ 100$$

In the formula, Snr is the sum of numerical ratings, Npr is number of plant rated, Msc is the maximum score of the scale. Means of the severity from each plot were used in data analysis.

Area under disease progress curve (AUDPC): AUDPC was calculated for each plot using the formula of Shaner and Finney [9] and was expressed in %-days.

$$\text{AUDPC} = \sum_{i=1}^{n-1} 0.5(X_{i+1} + X_i)(t_{i+1} - t_i)$$

Where X_i is the cumulative disease severity at the i^{th} observation, t_i is the time (days after sowing) at the i^{th} observation and n is the total number of observations.

Disease progress rate: Logistic, ln[Y/(1-Y)] [10] and Gompertz, -ln[-ln(Y)] [11] models were compared for the estimation of disease development from each treatment. The goodness of fit of the models was tested using the coefficient of determination (R2) and residuals (SE) [12].

b. Crop Parameters

Plant height (cm), number of pods per plant, number of seeds per pod,. 100 seed weight (gm) and total grain yield (t ha^{-1}) were recorded.

2.4. Data Analysis

The collected data were subjected to analysis of variance (ANOVA) to determine the treatment effects. All the disease reactions for each treatment were evaluated by averaging the data from the individual plants. The data on incidence and severity were subjected to square root transformation before analysis. Means that are significantly different were compared using Duncan Multiple Range Test (DMRT) at 5% probability of significance. Correlations of yield with disease and yield components were examined via correlation analysis using SAS software following the standard procedure [13].

Table-1. Faba bean varieties evaluated for their reaction against the newly emerged disease in the 2014 main cropping season.

No.	Faba bean varieties	Year of release	Altitude (m.a.s.l.)	Yield (Qt ha^{-1}) Research field	Description of the varieties
1	Adet-Hanna	2005	2224-2630	15-39.5	High yield, wide adaptation
2	Angacha-1	2009	2000-2800	30-40	High yield, wide adaptation
3	CS-20-DK	1977	2300-3000	20-40	High yield, wide adaptation
4	Dagm	2002	2600-3000	35	High yield, wide adaptation
5	Degaga	2002	1800-3000	32	High yield, diseases resistance, wide adaptation
6	Dosha	2009	2050-2800	28-62	High yield, wide adaptation, export type
7	Gachena	2008	2000-3000	17-30	High yield, wide adaptation
8	Gebelcho	2006	1900-2800	25-44	High yield, wide adaptation, export type
9	Gora	2013	-	44.1	High yield, wide adaptation, export type
10	Hachalu	2010	1900-2800	32-45	High yield, water-logging and black root rot resistance, wide adaptation, export type
11	Lalo	2002	2600-3000	36	High yield, wide adaptation
12	Moti	2006	1900-2800	28-51	High yield, wide adaptation, export type
13	Obse	2007	1900-2800	25-61	High yield, disease resistance
14	Selale	2002	2000-2800	23.3	Water-logging and black root rot resistance
15	Tumsa	2010	2050-2800	25-69	High yield, wide adaptation, export type
16	Walki	2008	1900-2800	24-52	High yield, water-logging and black root rot resistance, wide adaptation, export type
17	Local variety	Ns	Ns		Ns

Source: MoARD, Variety Registration Book, Issue numbers 5-13N; Ns: Not specified.

3. RESULTS AND DISCUSSION

3.1. Disease Onset

The symptom of faba bean gall disease was evident at 39 and 47 DAS at Mush and Ankober, respectively. The disease appeared on all varieties during the first assessment at both locations. The incidence of the disease was 100% after second (Mush) and third (Ankober) assessments.

3.2. Percentage Severity Index (PSI)

The analysis of variance (ANOVA) revealed that there was significant difference ($p \leq 0.05$) among varieties in percent severity index at both locations Table 2. At Lay Gorebela, when the disease developed naturally, the local variety instigated to show significantly higher (2.09%) level of PSI, whereas the variety Gachena showed lower (1.34%) level of PSI at 47 DAS. This finding corroborate the result of Getnet and Yehizbalem [14] who reported that different level of severity recorded on different faba bean varieties tested at different locations. Likewise, the highest (72.19%) level of PSI was recorded from the variety Selale, whereas, the lowest PSI was recorded from the variety Gachena (56.30%) at the final assessment (127 DAS). Accordingly, at this assessment date, the variety the Gachena reduced PSI by 22.01% as compared to Selale variety indicating the presence of different levels of resistance among faba bean varieties against faba bean gall disease. This current result agrees with Bond and Pope [15] who stated that on natural epidemics: the rate of disease development is affected by resistant levels of the crop.

Also, at Mush, initial PSI ranged from 1.95% (local variety) to 3.1% (variety Gora). Likewise, the consequent maximum i.e.78.09 and 76.22% severities were recorded from the variety Selale and local variety at the final assessment date (119 DAS). Also, at this assessment date the minimum 54.44 and 55.07% severities were recorded from the varieties Gachena and Gora, respectively. According to Belachew [16] significantly highest and lowest final gall severities were recorded from local and Gora varieties, respectively, under natural infection. In general, though epidemics of the faba bean gall disease occurred in both locations, it was more severe at Mush. This might be due to the presence of more favorable environmental conditions at Mush than at Ankober during the main crop growing season. Rhaïem, et al. [17] and Tivoli, et al. [18] illustrated that disease resistance level of some genotypes in the field varies from environment to environment.

3.3. Area under Disease Progress Curve (AUDPC)

Area under disease progress curves were significantly ($p \leq 0.05$) different among the faba bean varieties at both locations Table 3. At Lay Gorebela, the highest (2737.0%-days) AUDPC value was recorded from the variety Selale. The lowest (1981.9%-days) AUDPC value was recorded from the variety Gachena. Generally, the varieties Gachena reduced the AUDPC value by 26% over the variety Selale.

Likewise, the highest (3374.1%-days) AUDPC value was calculated on the local faba bean variety at Mush, whereas; the lowest i.e. 2260.3 and 2274.3%-days AUDPC values were calculated on the varieties Gora and Gachena, respectively Table 3. These Gora and Gachena faba bean varieties reduced the AUDPC value by 33.01 and 32.60%, respectively as compared to the local variety. In general, AUDPC values varied among the faba bean varieties depending on the resistance levels of the varieties and it is known that AUDPC is directly related to the yield loss. In agreement with this finding, Mastewal [19] also stated the presence of significant difference among faba bean varieties against this disease in East Gojjam.

3.4. Disease Progress Rate

The rate of disease progress was significantly ($P<0.05$) different among treatments at both locations Table 3 At Lay Gorebela, the highest (0.033, 0.032, and 0.032 gompit per day) disease progress rates were calculated for the faba bean varieties Selale, Angacha-1 and the local variety, respectively. The lowest (0.0265 gompit per day) progress rate was obtained from the variety Gachena Table 3. Likewise, at Mush, progress rates ranged from 0.02 (Gora) to 0.034 (Selale) gompit per day. Consequently, the disease progress rate of the variety Selale was faster by 1.61 and 1.57% times from the varieties Gora and Gachena, respectively.

Generally, variation in the disease progress rate of the faba bean gall was clearly observed due to the difference in resistance levels of the varieties. The disease was increasing more rapidly on the variety Selale, which also showed higher level of final disease severity than the other faba bean varieties at both locations. Lower disease progress rate were calculated for the varieties Gachena and Gora, which exhibited moderately resistance reaction.

This observation agrees with disease development rate that is affected by the resistant level of the crop which is high on susceptible and low on resistant ones [15].

3.5. Yield and Yield Components

3.5.1. Plant Height

The ANOVA revealed that varieties showed significant difference in their plant heights at both locations Table 4. At Lay Gorebela, plant heights ranged from 58.27 to 114.7 cm on the varieties Selale and CS-20-DK, respectively. This might be due to the presence of severe gall on this variety. Also, at Mush, the tallest (84.80 cm) plant height was recorded from the variety Gora. The shortest plant heights of 54.33 and 57.33 cm were recorded from the variety Selale and local variety, respectively.

Table-2. Severity of "*faba bean gall*" at Ankober and Mush in 2014 main cropping season.

Faba bean varieties	Lay Gorebela		Mush	
	Initial (47 DAS)	Final (127 DAS)	Initial (39 DAS)	Final (119 DAS)
Adet-Hana	1.58^{bcde}	62.40^{cde}	2.36^{bcde}	69.06^{cd}
Angacha-1	1.89^{abc}	68.89^{abc}	2.93^{abc}	71.61^{bc}
CS-20-DK	1.76^{abcde}	62.80^{cde}	2.40^{abcde}	65.02^{de}
Dagm	1.52^{cde}	61.96^{de}	3.01^{ab}	66.62^{cde}
Degaga	1.64^{bcde}	61.48^{de}	2.05^{de}	63.78^{de}
Dosha	1.58^{bcde}	61.30^{de}	2.69^{abcd}	62.74^{de}
Gachena	1.34^{e}	56.30^{e}	2.11^{de}	54.44^{f}
Gebelcho	1.83^{abcd}	$64.81b^{cd}$	2.46^{abcde}	64.15^{de}
Gora	1.46^{cde}	58.65^{de}	1.95^{e}	55.07^{f}
Hachalu	1.90^{abc}	62.80^{cde}	2.23^{cde}	67.51^{cde}
Lalo	1.59^{bcde}	64.44^{cd}	$2,08^{abc}$	67.20^{cde}
Moti	1.59^{bcde}	61.30^{de}	2.08^{de}	67.36^{cde}
Obse	1.40^{de}	63.50^{cd}	2.31^{bcde}	64.06^{de}
Selale	1.99^{ab}	72.19^{a}	2.68^{abcde}	78.09^{a}
Tumsa	1.68^{abcde}	60.93^{de}	2.33^{bcde}	63.156^{de}
Walki	2.01^{ab}	$61.00d^{e}$	2.04^{de}	62.41^{e}
Local	2.09^{a}	70.41^{ab}	3.1^{a}	76.22^{ab}
Mean	1.70	63.24	2.45	65.79
CV (%)	15.789	6.28	17.98	5.78

Note: DAS: Days after sowing, CV: Coefficient of variation.

Table-3. The AUDPC (%-days) values and progress rates of faba bean gall disease on different faba bean varieties.

Faba bean varieties	AUDPC (%-days)		Infection rate (r) per day	
	Lay Gorebela	Mush	Lay Gorebela	Mush
Adet-Hana	2196.9^{defg}	2965.6^{cd}	0.0288^{cdef}	$0.0277b^{c}$
Angacha-1	2655.9^{ab}	2872.4^{de}	0.0319^{ab}	0.0281^{b}
CS-20-DK	2166.6^{efg}	2664.6^{ef}	0.0280^{cdef}	0.0254^{bcd}
Dagm	2362.6^{cde}	3007.5^{cd}	0.0295^{bcde}	0.0272^{bcd}
Degaga	2190.0^{defg}	2733.9^{ef}	0.0285^{cdef}	0.0254^{bcd}
Dosha	2165.5^{efg}	2713.0^{ef}	0.0283^{def}	0.0256^{bcd}
Gachena	1961.9^{g}	2274.3^{g}	0.0265^{f}	0.0214^{e}
Gebelcho	2228.8^{def}	2811.1^{de}	0.0298^{bcd}	0.0247^{cd}
Gora	2016.5^{fg}	2260.3^{g}	0.0269^{ef}	0.0209^{e}
Hachalu	2117.9^{efg}	2798.9^{de}	0.0280^{def}	0.0274^{bcd}
Lalo	2421.7^{bcd}	3090.5^{bc}	0.0309^{abc}	0.0276^{bc}
Moti	2138.2^{efg}	2867.3^{de}	0.0280^{cdef}	0.0258^{bcd}
Obse	2233.9^{cdef}	2810.8^{de}	0.0299^{bcd}	0.0251^{cd}
Selale	2737.2^{a}	3302.3^{ab}	0.0330^{a}	0.0337^{a}
Tumsa	2099.1^{fg}	2693.7^{ef}	0.0237^{def}	0.0252^{cd}
Walki	2076.8^{fg}	2562.1^{e}	0.0268^{f}	0.0248^{cd}
Local	2483.4^{bc}	3374.1^{a}	0.0318^{ab}	0.0317^{a}
Mean	2250.17	2811.99	0.0290	0.0260
CV (%)	6.70	4.58	5.3900	6.5300

Note: CV: Coefficient of variation, AUDPC: Area under disease progress curve.

3.5.2. Number of Pods Per Plant and Seeds per Pod

Faba bean varieties exhibited significant ($p \leq 0.05$) variation in their pod numbers per plant. In the current study, the highest numbers pods per plant of 26.53 and 23.07 were recorded from the variety Dagm at Lay Gorebela and Mush, respectively. At this location, the lowest (8.27) number of pods per plant was obtained from the variety Gebelcho, which, in turn did not have significant difference from the varieties Adet Hana, Degaga, Gachena, Gora, Moti, Obse and Tumsa Table 4. Also, the lowest i.e. 11.53, 11.2, 11.13, 10.87 and 10.33 numbers of pods per plant were recorded from the varieties Obse, Moti, Gora, local and Gachena, respectively at Mush. However, these varieties had no significant difference from all the varieties other than the varieties Dagm and Selale in number of pods per plant Table 4.

On the other hand ANOVA revealed that there were no significant ($p > 0.05$) differences among varieties in the number of seeds per pod at both locations, however, the range for this parameter was large. Mastewal [19] also reported the presence of non significant variation among faba bean varieties tested on this parameter. Seed number per pod ranged from 2.03 to 2.68 at Lay Gorebela, whereas at Mush it ranged from 2.27 to 3.2.

Table-4. Effect of different faba bean varieties on plant height, pods per plant, seeds per pod in 2014.

Faba bean varieties	PH		PPP		SPP	
	Lay Gorebela	Mush	Lay Gorebela	Mush	Lay Gorebela	Mush
Adet-Hana	88.40^{ab}	61.40^{cd}	15.00^{defg}	12.47^{bc}	2.05	2.27
Angacha-1	93.73^{ab}	75.13^{abc}	15.35^{defg}	13.67^{bc}	2.09	2.67
CS-20-DK	114.40^{a}	77.93^{ab}	23.20^{abc}	14.00^{bc}	2.04	3.20
Dagm	98.87^{ab}	71.8^{abc}	26.53^{a}	23.07^{a}	2.17	2.60
Degaga	86.73^{ab}	80.60^{ab}	11.80^{efg}	16.13^{bc}	2.64	2.53
Dosha	109.87^{a}	76.53^{ab}	19.00^{bcde}	12.47^{bc}	2.04	2.67
Gachena	107.47^{ab}	75.67^{ab}	11.47^{fg}	10.33^{c}	2.14	2.60
Gebelcho	81.07^{bc}	79.40^{ab}	8.27^{g}	13.13^{bc}	2.25	2.60
Gora	111.40^{a}	84.80^{a}	13.93^{efg}	11.13^{c}	2.46	2.33
Hachalu	108.27^{ab}	83.87^{ab}	18.80^{bcdef}	15.27^{bc}	2.05	2.60
Lalo	101.73^{ab}	71.40^{bc}	23.07^{abc}	15.40^{bc}	2.43	2.70
Moti	95.40^{ab}	80.20^{ab}	12.27^{efg}	11.20^{c}	2.68	2.67
Obse	105.73^{ab}	83.20^{ab}	12.27^{efg}	11.53^{c}	2.35	2.73
Selale	58.27^{c}	54.33^{d}	24.20^{ab}	18.40^{ab}	2.30	2.47
Tumsa	107.20^{ab}	81.07^{ab}	13.20^{efg}	13.27^{bc}	2.15	2.27
Walki	109.07^{ab}	76.13^{ab}	21.87^{abcd}	15.13^{bc}	2.03	2.60
Local	93.60^{ab}	57.33^{d}	16.47^{cdef}	10.87^{c}	2.06	2.53
Mean	98.31	74.58	16.86	13.97	2.22	2.61
CV (%)	17.33	10.79	26.29	27.44	13.69	11.14

Note: CV: Coefficient of variation, LSD: Least significant difference, PH: Plant height, PPP: Pods per plant, SPP: Seeds per pod.

3.6. Grain Yield and Hundred Seed Weight

Faba bean varieties showed significant ($p \leq 0.05$) variation in their grain yield and hundred sed weight at both locations Table 5. From the beginning, it should be emphasized that the differences in grain yield among the varieties could be explained not only by differences in the levels of disease occurrence but also in the inherent potential yields of the varieties. The highest (4.41 t ha^{-1}) grain yield was gained from variety Gora, whereas the lowest (2.26 t ha^{-1}) grain yield was from variety Selale at Lay Gorebela. Also, the highest yields of 3.77, 3.74, 3.70, 3.65 and 3.59 t ha^{-1} were obtained from the varieties Gora, Gebelcho, Degaga, Gachena and Walki, respectively, at Mush. The lowest grain yields of 1.71 and 1.91 t ha^{-1} were obtained from the local variety and the variety Selale, respectively. Mastewal [19] confirmed that lowest grain yield was obtained from local faba bean variety compared to other varieties tested against faba bean gall disease. Furthermore, the ranking of the varieties for yield may change, should the varieties be exposed to higher disease severity. This is mainly due to varying levels of tolerance that is expected in different faba bean varieties.

At Lay Gorebela, the lowest grain weight of 29.1 g was recorded from the variety Selale. On the contrary, the variety Gora had a hundred seed weight of 84.50 g. and did not show significant differences from the varieties Gachena, Obse and Tumsa in hundred seed weigh. Similarly, the lowest i.e. 31.07, 33.4, 34.83, and 35.07 g hundred seed weight were recorded from varieties Dagm, Lalo, Selale and local, respectively, at Mush. On the other hand, the highest (76.77 g) grain weight was recorded for the variety Gora.

3.7. Association of Disease Parameters with Yield

Correlation analysis showed that faba ba bean gall severity had moderate and high negative correlation (r = -0.38 and r = -0.62) with yields at Lay Gorebela and Mush, respectively Table 6. Also, grain yield showed significant and negative correlations (r = -0.39 and r = -0.63) with AUDPC values at Lay Gorebela and Mush, respectively. Sahar, et al. [20] also reported that the higher AUDPC values were accompanied by lower yields. On the other hand, the correlations observed between disease parameters (severities and AUDPC values) were positive and highly significant ($p \leq 0.01$).This might indicated the terminal disease severity and AUDPC were very important in determining the extent of losses in yield and yield components and the observed levels of the disease had a considerable adverse effect on grain yield of the crop.

Table-5. Yields and hundred seed weights of faba bean varieties tested at Lay Gorebela and Mush in the 2014 main cropping season.

Faba bean varieties	Grain yield (tons ha^{-1})		HSW (g)	
	Lay Gorebela	Mush	Lay Gorebela	Mush
Adet-Hana	2.35^{ef}	2.11^{cd}	47.67^{de}	51.43^{e}
Angacha-1	2.65^{def}	2.73^{bc}	44.87^{de}	43.07^{g}
CS-20-DK	3.14b^{cdef}	3.17^{ab}	52.53^{d}	46.00^{fg}
Dagm	3.2b^{cdef}	2.06^{cd}	30.73^{fg}	31.07^{h}
Degaga	2.71^{cdef}	3.70^{a}	50.20^{de}	46.37^{fg}
Dosha	3.61^{abcd}	3.29^{ab}	63.87^{c}	58.33^{d}
Gachena	4.02^{ab}	3.65^{a}	79.40^{ab}	70.43^{b}
Gebelcho	2.82^{cdef}	3.74^{a}	67.63^{c}	67.93^{c}
Gora	4.41^{a}	3.77^{a}	84.50^{a}	76.77^{a}
Hachalu	3.89^{abc}	3.37^{ab}	51.93^{de}	48.23^{ef}
Lalo	3.28^{abcdef}	3.07^{ab}	30.27^{fg}	33.40^{h}
Moti	2.94^{bcdef}	3.31^{ab}	71.03^{bc}	68.83^{c}
Obse	3.52^{abcde}	3.47^{ab}	74.83^{abc}	67.70^{c}
Selale	2.26^{f}	1.91^{d}	29.10^{g}	34.83^{h}
Tumsa	3.58^{abcd}	3.37^{ab}	79.07^{ab}	65.60^{c}
Walki	3.64^{abcd}	3.59^{a}	71.53^{bc}	67.93^{c}
Local	2.37^{ef}	1.71^{d}	41.10^{ef}	35.07^{h}
Mean	2.24	3.06	57.07	50.98
CV (%)	22.55	15.97	11.87	5.25

Note: CV: Coefficient of variation, LSD: Least significant difference, HSW: Hundred seed weight.

4. CONCLUSION AND RECOMMENDATION

In conclusion, the present study revealed the existence of variability among faba bean varieties against faba bean gall disease and grain yield at both locations. The lowest PSI, AUDPC and infection rate were recorded from variety Gachena (at Lay Gorebela) and varieties Gora and Gachena (at Mush). Regarding grain yield, the highest grain yield was obtained from varieties Gora, Gebelcho, Degaga, Gachena and Walki (at Mush) and from varieties Gora and Gachena (at Ankober). Conversely, the lowest grain yield was harvested from variety Selale (at Lay Gorebela) and varieties Selale and local (at Mush). Moreover, yield of faba bean correlated negatively and significantly with AUDPC and final severity at both locations, whereas, AUDPC and severity associated positively and significantly from each other. From this study it can be concluded that relatively resistant and high yielder varieties can be used in combination with other control measures. Therefore, in the future, researches on integration of resistance and high yielder varieties with other management options should be conducted.

Table-6. Correlation coefficients (r) for disease parameters and crop yields in 2014 main cropping season.

A) Lay Gorebela

Parameters	PH	PPP	SPP	HSW	YLD	PSI
PH	------					
PPP	0.183ns	------				
SPP	0.050ns	0.126ns	------			
HSW	0.347*	0.492**	0.081ns	------		
Yld	0.344*	0.030ns	0.065ns	0.376**	------	
PSI	-0.336*	-0.071ns	-0.215ns	-0.480**	-0.381**	------
AUDPC	-0.494**	-0.310*	-0.164ns	-0.661**	-0.390**	0.703**

B) Mush

Parameters	PH	PPP	SPP	HSW	YLD	PSI
PH	------					
PPP	0.001ns	------				
SPP	0.108ns	0.060ns	------			
HSW	0.460**	0.477**	0.103ns	------		
YLD	0.788**	0.212ns	0.115ns	0.632**	------	
PSI	-0.623**	-0.143ns	-0.135ns	-0.673**	-0.622**	------
AUDPC	-0.603**	-0.184ns	-0.115ns	-0.726**	-0.629**	0.810**

PH: Plant height, PPP: Pod per plant, SPP: Seed per pod, HSW: Hundred seed weight, YLD: Yield, PSI: Present severity index, AUDPC: Area under disease progress curve,*: refers to mean square values significant at α=0.05, **: refers to mean square values significant at α=0.01, ns: refers to mean square values not significant at α=0.05.

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