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Host plant response of faba bean varieties to chocolate leaf (*Botrytis fabae*) spot at Debub Ari District of South Omo, Southwestern Ethiopia

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Abstract: Botrytis fabae, which causes faba bean chocolate spot is key issues which reduces faba bean production and productivity in Ethiopia. Various better varieties were released in the country Ethiopia but those varieties were not tested for chocolate leaf spot in the thematic areas of South Omo, Southwestern Ethiopia. Therefore, this experiment was concerned to evaluate the host plant response of varieties to disease at Gedir and Deli farmer associations of district during the 2020 and 2021 main cropping seasons. Field experiment revealed that the mean percent severity ranges from 12.22 to 41.85% and variation in the area under the disease progress curve ranged from 384.26 to 731.12 units day-1 and for two locations, the disease progression rate ranged between 0.0115 and 0.04 units per day among tested faba bean varieties. Tested varieties revealed different reaction types in which, 6.7% resistant, 76.9% moderately resistant, and 15.4% susceptible responses. Across fields and seasons, the Numan variety exhibited reliable resistance response against chocolate leaf spot and it also resulted best yields. Thus it is better to use the Numan variety with appropriate management options in production to reduce the disease epidemics in faba bean-producing areas of South Omo, Southwestern Ethiopia.

Keywords: Botrytis fabae, Chocolate leaf spot, percent severity, varieties, Yield.

1. Introduction

Faba bean (*Vicia faba* L.) is a major pulse crop grown in various countries in the world and Ethiopia produces it second after China [1-2]. Globally, its production accounts 4.4 million and average productivity 2.2 tha-1[3]. Currently, the crop covered 0.43 million hectare of land and provided 2.03 t ha-1 of grain yields in the country [4]. In Southwestern Ethiopia 1.8 ton and South Omo 1.03 [5]. However, in the thematic areas of South Omo, the crop productivity is below the regional average [5]. This is due to different factors of crop production such as the condition of soil fertility, repeated water stress, insect pests and diseases are considered as the main factors in Africa [6].

Chocolate spot, which starts as small, dark red patches on leaves that expand, coalesce, and eventually cause severe premature defoliation. It reduces yield by 94.6%, especially in Ethiopia's

western highlands [6]. Relative humidity (≥70%, warm temperature (10-23°C) and wet weather conditions are favorable for the progression of chocolate spot disease intensity [7]. The use of clean seeds, proper management of plant debris, changing one crop by another crop across the season, and use of safe seed containers are management options that reduce the damage caused by chocolate leaf spot [8]. Use of the host resistance option is also the best additional method to inhibit progression of the chocolate leaf spot [9].

The scope of production of faba bean in South Omo is characterized by use of farmers' own saved seeds that assisted as source of initial inoculum for onset, disease development and spread of diseases. Direct buying of infected seeds from local market is also the major cause for disease epidemics in the thematic areas of South Omo. Also, most improved varieties, which stayed for long times on farmer hands, were reported susceptible to chocolate leaf spot [8]. Thus, the absence of the improved disease resistance faba bean varieties is the major problem that results in a decrement of crop yields [8]. Breeding faba bean varieties that are impervious to chocolate leaf spot plays a significant role in the livelihood of the people. Thus, there is an urgent need to evaluate and identify varieties resistant to chocolate leaf spot and integrate with other disease control practices to develop sustainable integrated strategy for Chocolate leaf spot management. Therefore, the studies were 1.To evaluate the resistance response of varieties against the disease 2. To identify promising varieties for seed yield.

2. Materials and Methods

2.1. Area Description

The first and second field experiments were implemented at Debub Ari district farmers' fields, which is located at 36°30'-37°73'E and 05°67'- 6°19'N and its altitude ranges from <500 -3500 m.a.s.l. and especially an altitude of the trial site in this district at Gedir kebele 2206 and Deli kebele 2400 m.a.s.l.

2.2. Experimental materials

The treatments involved in the experiments consisted of thirteen faba bean varieties.

Degaga, Gora, Dosha, Gebelcho, Hachalu, Walki, Moti, Dodk, Tumsa, Obse, Numan , Ashebeka and local was used(Table-1). Each plot was 2m x 2 m by size consisting of five rows with 40 cm space among rows and 15cm between plants. Three replications of the tests were done using a randomized complete block design.

Table 1. During the 2020 and 2021 growing season, a few agro morphological parameters of faba bean varieties were investigated for chocolate leaf spot reaction at Debub Ari District of South Omo, Southwestern Ethiopia.

Faba bean Varieties	Year of releases	Date of Maturity	Area of Production	Yield (qt/ha)
Degaga	2002	116 -135	1800 -3000	20 - 37
Moti	2006	116 -135	1900 -2800	20 - 35
Obse	2007	103 -166	1900 -3000	21 - 35
Dosha	2009	120 -130	1900 -2800	21 - 30
Tumsa	2010	120 -130	1900 -2800	21 - 35
Gora	2013	126 -168	1900 -2800	20 - 40
Hachalu	2010	122 -156	1900 -2800	20 - 38

Gebelcho	2006	103 -167	1800 -3000	20 - 30
Walki	2007	133 -146	1800 -2800	20 - 42
Ddk	1977	145 -160	2300 -3000	20 - 35
Numan	2015	135 -143	1800 -3000	26 - 43
Ashebeka	2015	145 -149	1900 -2800	20 - 38
Local	-	-	-	-

(Source: Ethiopia Agricultural Research Institute, 2018).

2.3. Assessments of diseases

Data like PSI, Area under disease progress curve (AUDPC), disease progress rate (DPR) was recorded. Chocolate leaf spot severity was rated by using a 1-9 severity scoring scale where, 1 - no lesions or covering up to 1% of leaf surface; 3-lesions covering 1-2 % of leaf surface; 5 - lesions common (3-5 mm in diameter), covering 2-5% of leaf surface; 7 - lesions that cover 5-10 % of leaf surface; 9 - extensive lesions, covering more than 10% of the leaf surface [10]. Randomly 5 plants per plot were selected and tagged to collect every disease parameter. The disease was scored at weekly intervals starting from the first onset of chocolate spot symptom and continued until the final podding stage [11-12]. Disease epidemics data were rated using 1-9 rating scale and then changed in to percentage severity index using the following formula.

$$\text{PSI} = \frac{\text{Sum of numerical ratings} \times 100}{\text{Number of plants scored} \times \text{maximum score on a scale}}$$

The percentage severity index was used to determine the area under the disease progress curve using the following formula [13].

$$\text{AUDPC} = \sum_{i=1}^{n} \left(\frac{xi + xi + 1}{2}\right)(ti + 1 - ti) \qquad (1)$$

Where:- Xi - the cumulative disease severity expressed as a proportion at the i^{th} observation

ti - time of the i^{th} assessment, n-the total number of observation.

2.4. Growth and yield data collection

Plant height, number of pods per plant, seeds per pod, 100 seed weight and grain yield.

2.5. Data analysis

Data like percent severity, area under disease progress curve, apparent infection rate and yield and related traits data were subjected to analysis of variance (ANOVA) using the SAS GLM procedure. The means were separated using least significant difference at $p< 0.05$ probability level. Analysis relationships were used to examine relations between and among disease and grain yield and yield-related parameters. The homogeneity of variance of varieties across two locations were tested by the F-max test and results of the F-test for almost all parameters were found non-significant. Thus, combined analyses were employed.

3. Results and Discussion

3.1. Percent severity of the chocolate spot

Mean percent severity of chocolate spot on faba bean varieties ascertained different stages of damage (Table-2). Field experiment revealed that the highest disease severity were scored from local and Dodk varieties while the lowest disease severity from Numan variety in both locations. Haile et al. [6] reported that different faba bean varieties showed various reaction responses to chocolate leaf spots in variable locations. This result in line with the finding of Daygne et al.[14] that reported the highest and lowest terminal chocolate spot severity on local variety this due to accumulation of secondary inoculum because variety susceptibility and Mekuria and Ashenaf [15] reported that lower mean severity was recorded from improved variety. Furthermore, Yitayih and Azmeraw,[16] reported that the disease results in heavy premature defoliation. From current study, Numan variety reduced 70.27% of chocolate leaf epidemics in comparison with the local variety.

Table 2. Mean Percent severity and AUDPC of chocolate leaf spot on faba bean yields in Gedir and Deli farmers Associations' of Debeb Ari at main cropping season.

Varieties	PSI	AUDPC unit-day
Numan	12.22^{d}	384.26^{c}
Walki	31.48^{c}	650.40^{ab}
Ashebeka	26.29^{c}	521.10^{bc}
Gebelcho	30.00^{c}	609.24^{ab}
Moti	28.52^{c}	574.30^{ab}
Tumsa	29.23^{c}	594.06^{ab}
Dosha	33.70^{bc}	681.32^{ab}
Gora	29.26^{c}	585.93^{ab}
Local	41.11^{ab}	731.13^{a}
Hachalu	30.00^{c}	612.93^{ab}
Degaga	33.70^{bc}	705.09^{a}
Dodk	41.85^{a}	727.53^{a}
Obse	29.26^{c}	620.86^{ab}
CV (%)	14.87	16.52
LSD(0.05)	7.64	171.31

PSI-percent severity index, AUDPC-Area under disease progress curve, CV-coefficient variation, LSD-least significant difference.

3.2. Area under disease progress curve (AUDPC)

AUDPC is an appropriate summary of plant disease epidemics that integrates into initial intensity, the rate parameter, and the duration of epidemics. AUDPC is also indicator of epidemics [17]. Analysis variance depicted that the lowest AUDPC from Numan variety but the non-significant difference was ascertained between Ashebeka while the highest AUDPC from Local and Dodk but statistically non-significant with all rest varieties except Numan variety (Table-2, Figure-1). Wakoya et al.[2] reported that among varieties significantly different AUDPC values observed.

Numan variety reduced 47.44% AUDPC-day in comparison with Local variety and 47.17% AUDPC-day in comparison Dodk variety.

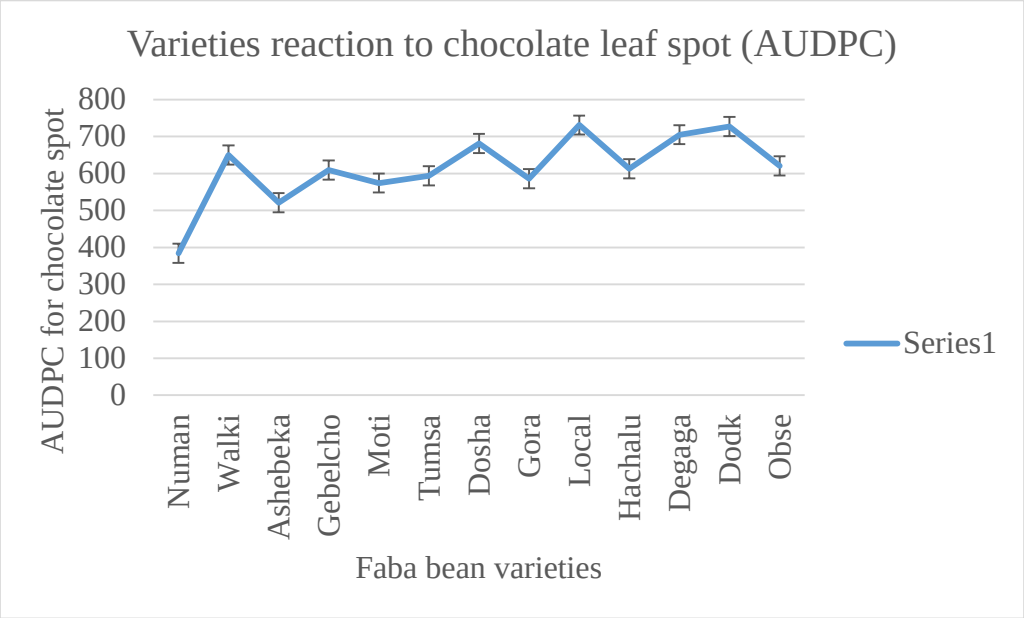

Figure 1. Combined mean of AUDPC on 12 improved faba bean varieties and a local check under field condition in 2020 and 2021 cropping seasons at Gedir and Deli Farmers Associations of thematic area.

3.3. Disease progress rate (r)

Disease development showed different rates of progress between faba bean varieties at both experimental locations (Table-3). The highest average mean disease progress rate was recorded from Tumsa and Moti varieties while the lowest progression were from Numan and Obse. Variety Numan reduced 37.8% units in comparison with local varieties and Dodk variety reduced 53.06% which showed as moderately susceptible reaction group between tested faba bean varieties. This variation among tested faba bean varieties might be attributed from genetic variability of varieties and the condition of environmental factors in the study area Gudero et al.[22].

Table 3. Disease progress rate(r) of chocolate leaf spot on faba bean yields in Gedir and Deli Farmers Associations of Debeb Ari District in 2020 and 2021 respectively at main cropping season.

Varieties	Disease parameters in Gedir and Deli farmer Associations in 2020 and 2021 respectively in main cropping season				
	Gedir 2020		Deli 2021		Average DPR
	DPR(r)	SE rate	DPR(r)	SE rate	DPR(r)
Numan	0.010	0.009	0.013	0.014	0.0115
Walki	0.036	0.015	0.016	0.014	0.026
Ashebeka	0.015	0.014	0.022	0.017	0.0185
Gebelcho	0.007	0.016	0.019	0.014	0.013
Moti	0.037	0.016	0.021	0.012	0.029
Tumsa	0.063	0.020	0.017	0.013	0.04
Dosha	0.028	0.022	0.017	0.016	0.0225
Gora	0.035	0.017	0.015	0.014	0.025

Local	0.023	0.022	0.014	0.014	0.0185
Hachalu	0.042	0.018	0.012	0.011	0.027
Degaga	0.015	0.015	0.016	0.015	0.0155
Dodk	0.036	0.02	0.013	0.012	0.0245
Obse	0.006	0.014	0.018	0.013	0.012

DPR-disease progress rate, SE rate- standard error of rate.

3.4. Reaction of tested varieties against chocolate spot under field conditions

Tested varieties showed different reactions to chocolate leaf spot (Table-4).Among tested faba bean varieties 76.2% were classified as moderately resistant, 15.4% moderately susceptible and 7.6% resistant reaction to chocolate leaf spot. The results suggested that this differential reaction to Chocolate leaf spot was due to the faba bean varieties. The genetic heterogeneity seen across the studied varieties could explain the variance in response seen among varieties for chocolate leaf spot, suggesting that varieties could be exploited to genetically enhance resistance to chocolate leaf spot. Depending upon the reaction criterion, Numan variety exhibited resistant reaction while Local and Dodk varieties were revealed a moderately susceptible reaction and Walki,Ashebeka,Gebelcho, moti,Tumsa,Dosha,Gora,Hachalu,Degaga and Obse were classified as moderately resistant reaction. Zebire and Tadesse [18] reported that different tested faba bean varieties showed different reaction categories.

Table 4. The reaction of faba bean Varieties against chocolate leaf spot under field conditions at Gedir and Deli Farmers Associations of Debub Ari district, South Omo during 2020 and 2021 cropping season.

Varieties	Disease parameters in Gedir and Deli farmer associations in 2020 and 2021 respectively in main cropping season.			
	PSI Gedir	PSI Deli	PSI av. mean	Reaction type
Numan	11.11d	13.33d	12.22	Resistant
Walki	27.40c	35.55abc	31.47	Moderately resistant
Ashebeka	24.44c	28.14c	26.29	Moderately resistant
Gebelcho	27.40c	32.59abc	29.99	Moderately resistant
Moti	28.88c	28.14c	28.51	Moderately resistant
Tumsa	30.37bc	28.14c	29.25	Moderately resistant
Dosha	31.85bc	35.55abc	33.70	Moderately resistant
Gora	24.44c	34.07abc	29.25	Moderately resistant
Local	40.74ab	41.48a	41.11	Moderately susceptible
Hachalu	25.92c	34.07abc	29.99	Moderately resistant
Degaga	30.37bc	37.03abc	33.70	Moderately resistant
Dodk	43.70a	40.00ab	41.85	Moderately susceptible
Obse	28.88c	29.63bc	29.25	Moderately resistant

Tested varieties categorized in to different reaction classes, where 0 upto 2% is highly resistant (HR), > 2 to 15% is resistant (R), > 15 to 40% is moderately resistant (MR), > 40 to 60% is moderately susceptible (MS) and > 60 to 80% is susceptible (S) >80 to 100% is highly susceptible (HS) based on mean percent severity values. Abo-Hegazy et al. [19]

3.5. Yield and Yield components of faba bean varieties

Pant height, number of pod per plant, seeds per pods and hundred seed weight were showed statistically significant differences (table-5). The highest plant was recorded from variety Numan

but non-significant varieties Ashebeka, Gebelcho,Moti, Tumsa and Hachalu. Highest number of pods per plant was recorded from varieties Numan,Walki, and Moti but non-significant difference was observed wirh Gebelcho,Tumsa,Dosha and Gora varieties while lowest number of pods per plant were from Dodk and local varieties. Hithest hundred seed weight from Numan variety while lowest from Dodk variety. Gudero et al., [22]. reported that different yield components responded differently to the development of chocolate leaf spots.

The maximum yield was recorded from the variety Numan and the lowest yield from the Obse variety (Table-4). Numan variety increased 67.47 % yield in comparison with Obese and 38.29% in comparison with local variety. This inconsistent yield finding could be related to genetic variation among tested cultivars and responses to chocolate spot epidemics. Mesele et al. [20] and Wakoya [21], reported that among different faba bean varieties vary result were observed.

Table 5. Combined Mean result of yield and yield components of Faba bean at Gedir and deli kebeles of Debubi Ari Woreda at main cropping season.

Varieties	PH(in cm)	PPP	SPP	HSW(gram)	GY(kg/ha)
Numan	73.26^{a}	6.30^{a}	3.26^{a}	80.88^{a}	3136.5^{a}
Walki	60.7^{cde}	6.40^{a}	2.90^{bc}	54.82^{e}	2713.4^{b}
Ashebeka	69.2^{ab}	5.4^{bcd}	3.16^{ab}	72.51^{b}	2882.7^{b}
Gebelcho	67.6^{abc}	5.8^{abc}	3.10^{ab}	73.25^{b}	2405.5^{cd}
Moti	68.1^{abc}	6.28^{a}	2.90^{bc}	69.19^{bc}	2327.4c^{d}
Tumsa	71.0^{ab}	6.06^{ab}	2.59^{cde}	65.31^{cd}	2360.2^{cd}
Dosha	64.2^{bcde}	6.06^{ab}	2.56^{cde}	65.90^{cd}	2229.6^{d}
Gora	59.9^{cde}	6.10^{ab}	2.73^{cd}	67.29^{cd}	2421.3^{c}
Local	57.12^{ef}	4.70^{d}	2.60^{cde}	54.94^{e}	1935.5^{e}
Hachalu	66.6^{abcd}	6.03^{ab}	2.50^{de}	63.12^{d}	2372.7^{cd}
Degaga	58.83^{def}	5.3^{bcd}	2.73^{cd}	54.86^{e}	1980.5^{e}
Dodk	56.3^{ef}	4.70^{d}	2.33^{e}	49.78^{f}	1531.4^{f}
Obse	56.3^{ef}	4.98^{cd}	2.46^{de}	69.46^{bc}	1020.7^{g}
CV (%)	7.89	8.78	7.42	4.30	4.77
LSD(0.05	8.43	0.84	0.345	4.69	181.47

PH= Plant height, PSI CLS= percent severity index for chocolate leaf spot, PPP= pods per plant, SPP =seeds per pods, HSW= hundred seed weight in gram, CV= coefficient of variation, LSD-Least significant difference.

3.6. Association of yield and disease parameters

Negative non-significant correlation between yields and disease parameters which indicates disease exhibited significant role in yield reduction (Table-6). Zebire and Tadesse 2017 reported similar ideas. And also, yield and yield related components were positively and significantly correlated which contributed to yield increments. This results in line with Gudero et al.[22] who reported positive correlation between yield and yield components of faba bean.

Table 6. Correlation coefficients of disease and yield parameters of faba bean varieties at Deli and Gedir farmers Associations Debub Ari during 2020 and 2021 main cropping season.

Variables	PSI	AUDPC	PH	PPP	SPP	HSW	GY
PSI	1.0						
AUDPC	0.89***	1.0					
PH	0.09	-0.11	1.0				
PPP	-0.33**	-0.23*	-0.1583	1.0			
SPP	-0.09	-0.10	0.3260**	-0.098	1.0		
HSW	-0.32**	-0.3114**	0.2455*	0.1234	0.28	1.0	
GY	-0.03	-0.17	0.74***	0.1290	0.46**	0.29*	1.0

PSI-Percent severity index, AUDPC-Area under disease progress curve, PH- plant height in cm, PPP- pods per plant, SPP-Seeds per pods, HSW-Hundred seed weight, GY-grain yields.

4. Conclusion

Over-all, chocolate spot caused by botrytis fabae is a major disease of the crop that requires a better attention in the study areas of South Omo Zone. The variety Numan looks to have better resistance against the epidemics of chocolate spot disease and provided high yield advantage as related to the other tested varieties. In addition, it showed consistent chocolate spot resistance reaction and yield potential across location and seasons. Therefore, it could be suggested that using variety Numan in addition with other management techniques is the best option for controlling the chocolate spot disease in South Omo, Southwestern Ethiopia.

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