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Review Article

Epidemiology of Chocolate Spot (*Botrytis fabae* sard.) and Faba Bean (*Vicia faba* L.) Resistance Potential for Disease Control in Ethiopia: A Review

Fikiru Wakoya Walde*

Department of Plant Sciences, College of Agriculture and Natural Resources, Wollega University, P. O. Box 38 Shambu, Ethiopia

ABSTRACT

Faba bean (*Vicia faba* L.) is an important pulse crop produced all over the world, however, its production is reducing especially due to chocolate spots (*Botrytis fabae* Sard.) which is a highly dominant and damaging disease in Ethiopia. The objective of this review is; to point out the opportunities and challenges of disease epidemics and the resistance potential of faba bean crops in Ethiopia. This disease, causing a yield reduction up to 34 to 67% varies on the tolerances and the susceptibility of the cultivar as well as environmental variables. Its occurrence differs among districts, years, growth stages, agronomic practices, and climatic conditions. Under favorable conditions, chocolate spot disease increases as the plant's growth stage and the quantity as well as the potential of inoculum transported to the crop canopy and the time of arrival of inoculum related to the stage of the crop development and weather condition. The main selection criterion and epidemiological components of resistance are infection efficiency, the extent of symptoms, and the latent period. Some efforts have been made to integrate host plant resistance, epidemiological knowledge, chemical and cultural practices to manage the disease.

Keywords: Faba bean; *Botrytis fabae*; Genotypes; Epidemiology, Resistance

INTRODUCTION

Ethiopia is probably one of the primary centers of diversification for faba bean crop and it is produced in many highlands and semi-high land regions with altitudes ranging from 1800-3000 meters above sea level. In the 2016 cropping season, the total area under cultivation is estimated to be 443,966.09 ha of land from which thousands of tons are produced. However, the production has reduced from 4.8 million ha in 1961 to 2.4 in 2008 with 4.8 to 4.4 tons per hectare reduction in production. This reduction is due to the susceptibility of the crop to biotic and abiotic factors. Chocolate spot (*Botrytis fabae*), Ascochyta blight (*Ascochyta fabae*), and faba bean rust (*Uromyces viciae-fabae*) are identified as the major diseases affecting faba bean in the country.

Of the diseases, chocolate spot can cause yield losses to reach 60–80% and can also cause a total crop failure under severe epidemic on susceptible cultivars [1]. This is because of weather conditions (rainfall, temperature 15-22°C, and Rh 70%), environmental variability highlands up to 3000 m.a.s.l. pathogen virulence, cultivar susceptibility, high inoculum density, age of the plant, and certain cropping practices that favor disease development [2]. In 2007 reported that some studies have been done on resistance genes of plants, for instance, immunization of plants with pathogens activates a variety of plant defense responses, for example, the activation of genes encoding pathogenesis-related proteins. Recent molecular research on R-proteins and downstream signal transduction linkages has provided sensational insights, which will enhance the use of R-genes for disease control [3]. In Ethiopia, several research both surveys and experiments are done yet fragmented results reported from else. From these works picking the important technologies for the sustainable management of crops and increase the crop is very important. This review is hopefully crucial for giving future direction policymakers the government to develop strategic disease management in the country; otherwise, the production of the crop is decreasing from time to time due to chocolate spot disease with supplementary factors. Therefore, the objectives of this review are; to point out the opportunities and challenges of disease epidemics and the resistance potential of faba bean crops in Ethiopia.

LITERATURE REVIEW

Origin, production and distribution of faba bean

Several literatures are suggested that basically, the origin of faba bean is given to the Mediterranean, Central Asian and South American countries and be certain of a native to North Africa and southwest Asia, however, today produced over all the worlds. Singh et al. [4]

Correspondence to: Fikiru Wakoya Walde, Department of Plant Sciences, College of Agriculture and Natural Resources, Wollega University, Ethiopia, Tel: +251910887812; E-mail: b.wakwoya@gmail.com

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assumed that Afghanistan and Ethiopia are the second centers of diversity. Currently, China is the leading country producing faba bean in production of 1.64 million tons, followed by Ethiopia 0.92 million tons and Australia 0.34 million tons. Ethiopia is the second-largest faba bean producer in the world about 921,761.5tons total annual production especially, the Oromia region has contributed to the highest production about 483,201.66tonnes (52.4%) in the country followed by the Amhara region 283,691.26 ton (31%) of the area per year.

Biology and disease development of chocolate spot

Chocolate Spot is caused by two fungi: *Botrytis fabae* and *Botrytis cinerea Pers.* and can be residue or stubble-borne or seed-borne. Chocolate spot is the disease of most concern in faba beans grown in the world. Disease development is highly dependent on weather conditions and the fungus succeeds in moderately warm (15 to 25°C) and humid conditions. Higher plant density increases susceptibility, due to higher humidity within the canopy. The severity of the disease also depends on when the infection starts, with early disease development in the season or during flowering, which may cause more damage and result in large losses. Mid- to late-season infections, which are more often observed, may cause little or no yield loss. Conidia are spread to neighboring plants and fields by wind and rain, where they cause new infections (water is essential for their germination). Botrytis can overwinter as sclerotia in the soil, in crop debris, and on seed. Spores produced by the fungus are spread by wind and rain splash within and between crops [5].

Moisture on the plant surface is important for spore germination and infection. The disease builds up rapidly under moderately warm, moist conditions. Once the disease becomes established, it spreads quickly in the crop and within four to five days of infection, spores can be produced on infected tissue, initiating secondary infection and further spread of the disease [5]. Terefe et al. [6] stated that the conidial size had been reduced in length from 24.86-19.54 sporulation ($\times 10^3$/ml)^2 at temperature increases from 22-24°C and the same ranges of temperature the width of the conidia had been reduced from 16.32-11.54 sporulation ($\times 10^3$/ml)^2. According to the authors, the temperature has significantly affected the biology of the fungus *Botrytis fabae* species.

Epidemics of chocolate spot disease in Ethiopia

The weather condition such as temperate suitability for disease development described by Kora et al., [7] stated that warm temperature (15- 22°C) and humid weather (above 90% RH) conditions are preferred for chocolate spot disease epidemics and similar reports by Eshetu et al. [8] are presented that have been done in Bale highlands of Southeastern Ethiopia chocolate spot disease affected by the higher total annual rainfall (878 mm-1170 mm) as well as the temperatures (5-32°C) of the area has created a favorable environmental condition for the diseases, Sillero et al. [9] chocolate spot disease epidemics affected by genotype and environment with their interactions. Furthermore, it is wide-ranging among altitude ranges, cropping systems, and supplementary cultural practices. Modifying the microclimate and intercropping which is causing physical barriers by interrupting spores supported by wind from neighboring infected faba bean plants, thereby reducing the amount of effective inoculum available to infect new tissues in favor of disease prevalence and decreasing active spore population by trapping. Eshetu et al. [8] again reported that about 90.4% and 37.5% disease incidence and PSI respectively, are the highest mean value planted in July, however, the lowest epidemics were reported in September.

Several researches were conducted in different regions of Ethiopian country results reported from some faba bean genotypes by different scholars shown that the chocolate spot disease mainly *Botrytis fabae* epidemics vary from region to region. These results (Table 1) might be because of different weather conditions at different geographical locations of the country and the genotypes of the crop. The ranges of the results are high, for instance, disease severity (14.85-49.6%), percent severity index (20-45%), and area under disease progress curve (300-2535.3% days).

Resistance potential of faba bean genotypes in Ethiopia

All genotypes of existing faba bean are an incomplete resistance that, at least in some cases, may have a multi-gene basis, which should facilitate obtaining a durable resistance yet, a long-time report indicated that the breeding programs have a possible option use to identify sources of resistance to chocolate spot disease. A system of screenings for the stability of resistance to *B. fabae* is crucial for the success of a breeding program. Field trials are inclusive approaches, options, and powerful tools to identify sources of resistance as they reflect the natural conditions.

Beyene et al. [10] reported on the performance of the parents and F1 progenies of faba bean for disease resistance, the chocolate spot severity of the parental lines ranged from 3.8% for the resistant variety (ILB-4726) to 32.2% for the susceptible faba bean variety (Kasa). The disease severity for the F1 genotypes ranged from 2.2–25.7%. All F1 genotypes from crosses of the resistance parent lines; R 9 R (ILB 4726, ILB 938, and BPL 710) had the lowest disease severity of 2.2–4.1% and the lowest rAUDPC values ranging from 0.20 to 0.28 [11-15].

Sahile et al. [16] reported that because of the hazards of pesticides on public health and environmental balance, a relatively recent direction of pest control management was introduced. For instance, encouraged resistance is a spectacular modern approach with a wide-ranging in plant disease control and it could be induced in plants by applying chemical elicitors. According to the authors, application of Shikimic and Salicylic Acids with fungicide on health plant caused changes in osmotic pressure has no significant rise in proline content of faba bean leaf extract whereas, its application on infected plants caused a significant increase as well as pathogen alone, fungicide plus pathogen, as well as pathogen alone, induced a marked decrease in total soluble sugar. Moreover, application of shikimic acid, salicylic acid, and their combination rises in the total soluble sugars (TSS) of healthy faba bean leaf extract and decrease in TSS of infected plants, a significant increase in citric acid content and this effect is progressively increased in infected plants treated with shikimic acid, salicylic acid alone or their combination, as well as changes in keto-acids, in total soluble nitrogen, in ions content and keto-acids.

Temesgen et al. [17] reported that on the yield stability of faba bean crops the quantity of variance contributed by the interaction of genotype and environment is larger than that contributed by genotype and this is leading to the presence of differences in genotypic responses across the test environments and indicating, in turn, a large difference in genotypic performances and their rank

Table 1: Epidemics of Chocolate spot (*Botrytis fabae*) disease on some faba bean (*Vicia faba*) genotypes in different geographical locations of Ethiopia.

Faba bean genotypes	DS[a]	DSI[b]	AUDPC[c]	R[d]	Authors	Location
Gebelcho	14.848	-	516.6	-	Tekalign et al., [10]	EIARe, Ethiopia
	-	42.6	1850	0.185	Adugna & Lemessa [11]	Southwest Ethiopia
	-	24	399	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	25.5	32.22	2041.7	-	Wolde & Mitiku [13]	Southeastern Ethiopia
	33.95	-	-	-	Degife & Kiya [14]	Southern Ethiopia
	16.493	-	629.5	-	Tekalign et al., [10]	EIAR5, Ethiopia
	-	44	2005	0.186	Adugna & Lemessa [11]	Southwest Ethiopia
Moti	-	22	480	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	22.28	32.47	1988.9	-	Wolde & Mitiku [13]	Southeastern Ethiopia
	34	-	-	-	Wakoya [15]	Western Ethiopia
	24.69	-	-	-	Degife & Kiya [14]	Southern Ethiopia
	17.707	-	584.3	-	Tekalign et al., [10]	EIAR, Ethiopia
Dosha	-	23	400	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	39	-	-	-	Wakoya [15]	Western Ethiopia
	41.98	-	-	-	Degife & Kiya [14]	Southern Ethiopia
CS-20-DK	23.468	-	680.9	-	Tekalign et al., [10]	EIAR, Ethiopia
	-	24.1	1275	0.181	Adugna & Lemessa [11]	Southwest Ethiopia
	-	23	396	-	Yitayih & Azmeraw, [12]	Northern Ethiopia
	-	39.88	-	-	Sahile et al., [16]	Ethiopia
	37	-	-	-	Wakoya [15]	Western Ethiopia
	25.93	-	-	-	Degife & Kiya [14]	Southern Ethiopia
Nc-58	24.554	-	662.5	-	Tekalign et al., [10]	EIAR, Ethiopia
	-	22	480	-	Yitayih & Azmeraw, [12]	Northern Ethiopia
	-	42	1880	0.189	Adugna & Lemessa [11]	Southwest Ethiopia
Bulga-70	24.557	-	649.8	-	Tekalign et al., [10]	EIAR, Ethiopia
	-	32.8	1620	0.151	Adugna & Lemessa [11]	Southwest Ethiopia
	-	25	556	-	Yitayih & Azmeraw, [12]	Northern Ethiopia
	-	-	-	-	Wakoya [15]	Western Ethiopia
Kasa	32.251	-	698.9	-	Tekalign et al., [10])	EIAR, Ethiopia
	-	38.9	1810	0.189	Adugna & Lemessa [11]	Southwest Ethiopia
	-	24.5	-	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	38	-	-	-	Wakoya [15]	Western Ethiopia
	32.72	-	-	-	Degife & Kiya [14]	Southern Ethiopia
Degaga	-	25.5	1420	0.118	Adugna & Lemessa [11]	Southwest Ethiopia
	-	21	340	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	28.64	37.78	2535.3	-	Wolde & Mitiku [13]	Southeastern Ethiopia
	28.5	-	-	-	Wakoya [15]	Western Ethiopia
Gora	29.63	-	-	-	Degife & Kiya [14]	Southern Ethiopia
	29	-	-	-	Wakoya [15]	Western Ethiopia
	25.93	-	-	-	Degife & Kiya [14]	Southern Ethiopia
Hachalu	-	44.4	1880	0.192	Adugna & Lemessa [11]	Southwest Ethiopia
	28.05	37.53	2502.6	-	Wolde & Mitiku [13]	Southeastern Ethiopia
	33	-	-	-	Wakoya [15]	Western Ethiopia
	32.41	-	300	-	Degife & Kiya [14]	Southern Ethiopia
Obse	-	20	-	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	36	-	-	-	Wakoya [15]	Western Ethiopia
	29.63	-	-	-	Degife & Kiya [14]	Southern Ethiopia

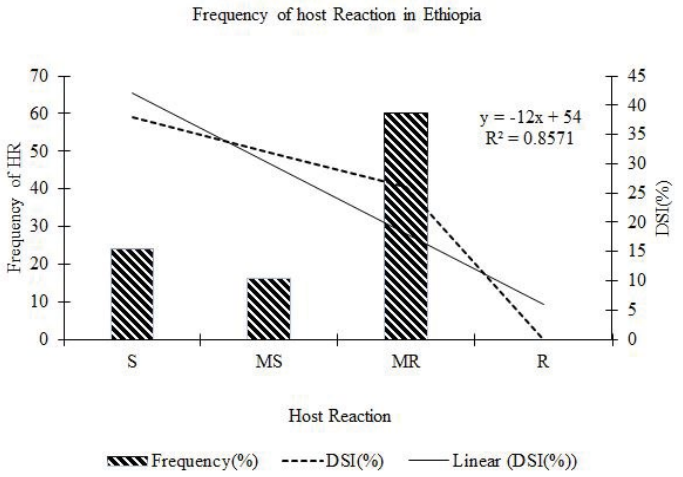
Tumsa	-	45	2011	0.171	Adugna & Lemessa [11]	Southwest Ethiopia
	-	22	350	-	Yitayih & Azmeraw [12]	Northern Ethiopia
	15.95	25.31	1405	-	Wolde & Mitiku [13]	Southeastern Ethiopia
	37	-	-	-	Wakoya [15]	Western Ethiopia
	33.95	-	-	-	Degife & Kiya [14]	Southern Ethiopia
Wolki	-	42	1850	0.165	Adugna & Lemessa [11]	Southwest Ethiopia
	16.7	25.19	1413.6	-	Wolde & Mitiku [13]	Southeastern Ethiopia
Holeta-02	29	-	-	-	Wakoya [15]	Western Ethiopia
Fb Didia	30	-	-	-	Wakoya [15]	Western Ethiopia
Tesfa	35	-	-	-	Wakoya [15]	Western Ethiopia
	-	33.3	1620	0.187	Adugna & Lemessa [11]	Southwest Ethiopia
	-	24	430	-	Yitayih & Azmeraw [12]	Northern Ethiopia
Mesay	49.6	-	-	-	Wakoya [15]	Western Ethiopia
	-	43	2995	0.181	Adugna & Lemessa [11]	Southwest Ethiopia
	-	22	485	-	Yitayih & Azmeraw [12]	Northern Ethiopia
Shallo	17.04	27.65	1680.3	-	Wolde & Mitiku [13]	Southeastern Ethiopia
Mosisa	21.27	31.36	1958.3	-	Wolde & Mitiku [13]	Southeastern Ethiopia
Adet-Hana	-	25	495	-	Yitayih & Azmeraw [12]	Northern Ethiopia
Kuse	-	42.6	1850	0.167	Adugna & Lemessa [11]	Southwest Ethiopia

orders across the environments, however, Sillero et al. [9] reports that chocolate spot disease epidemics more or less affected by genotype about 13%, environment about 41% and their interaction about 22% for the multi-location field trials. The variation of the phenotypic expression across environments is a problem often encountered in resistance screenings, whose explanations may include different pathogen races, that is a specific virulence in the local pathogen populations matching specific resistance genes in the plant material; particular sensitivities of the different accessions to the inclusive disease levels and weather condition, soil properties or agricultural practices [9].

Certain resistant germplasm has been reported but most of it has yet to be introduced into the agricultural market, however, total resistance has not been reported and only incomplete resistance is being used. In other words, the major constraint for faba bean breeding for chocolate spot resistance is the lack of good sources of resistance. Aïcha Bouhassan et al. [18] described the integration of different resistances might verify to be a sensible approach and according to Thomas et al. [19] report, it would be useful to have some markers to contribute the selection; wyerone acid phytoalexin synthesis and peroxidase activity have been proposed as markers for resistance. In Spain the molecular markers have not been associated so far with chocolate spot resistance; despite a mapping study is still in progress [9].

Varies results obtained by different researchers (Table 1) shown that the disease-host reaction varies from location to location. Accordingly, for instance, Moti and Dosha varieties had MR against the disease which supported by the authors refer gushing in the below table, while Kasa, Bulga-70, and NC-58 varieties are susceptible to chocolate spot disease. Several authors agreed that Tumsa and Wolki varieties had resisted to the disease. The genotypes with the collateral environment have a big factor because the reaction of the other varieties is varying from location to location.

In fact, several improved varieties were releasing from national and regional research organization in Ethiopia yet, most of are



S=Susceptible, MS=Moderate Susceptible, MR=Moderate Resistance, R=Resistance DSI=Disease Severity Index, HR=Host Reaction.

Figure 1: Frequency of host reaction against chocolate spot (*Botrytis fabae*) disease in Ethiopia.

affecting by Chocolate spot disease. As the summary of faba bean host reaction frequency to chocolate spot disease (Figure 1), in Ethiopia about 60% of the frequency of the disease index of the varieties are moderately resistance, followed by susceptible (24%) and moderately susceptible (16%), while nothing disease resistance had been recorded for this review.

DISCUSSION AND CONCLUSION

Ethiopia is probably one of the primary centers of diversification for faba bean crop and it is produced in many highlands and semi-high land regions with altitudes ranging from 1800-3000 meters above sea level. Despite its importance, the production has declined significantly and useful genetic variation has been lost. This is might could be environmental variability, pathogen virulence, cultivar susceptibility, high inoculum density, age of the plant, and certain cropping practices that favor disease development. In addition to genetic erosion of faba bean genotypes, a chocolate

spot disease which is fungal pathogen species caused by *Botrytis fabae* had contributed to the reduction of faba bean production in Ethiopia. Based on the key stress the useful genetic variations which identified should be used to develop cultivars with multiple resistances, to attain stable yields. Many types of research were conducted in different regions of the Ethiopian country, but the results reported by different intellectuals shown that the chocolate spot mainly *Botrytis fabae* disease development and distribution vary from region to region. The disease-host reaction varies from ranges of susceptible genotypes to resistance genotypes; however, it has no constant resistance potential because one genotype shown resistance on one location becomes susceptible to another location. Anyhow, for this review consideration should be given for Shallo and Wolki varieties. Consequently, the epidemiological characteristics of the disease and on another side the study of the disease resistance potential of the crop is a very key and very important point for the future works to overcome the problems and fill the demands of faba bean production in Ethiopia.

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