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IMPACT OF CHOCOLATE SPOT (*Botrytis fabae* SARD) ON PRODUCTION OF FABA BEAN (*Vicia faba* L.) AND ITS MANAGEMENT OF IN ETHIOPIA: A REVIEW

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ABSTRACT

Faba bean (*Vicia faba* L.) is a crucial protein source leguminous crop and produced globally. Chocolate spot is the most serious necrotrophic fungal disease caused by Botrytis fabae Sard that hampering Faba bean production in Ethiopia and all over the planet. This review paper aims to show the study's findings, especially on management aspects which have been conducted in Ethiopia and worldwide It is a highly prevalent and destructive disease that invades Vicia spp. especially Vicia faba. The pathogen is present in nearly all Faba bean cultivation areas, causing yield loss up to 61% on susceptible and 34% on tolerant Faba bean genotypes in the central highlands of Ethiopia. However, it has been reported as high as 60-90% on susceptible varieties globally other than Ethiopia. The fungus can spread via seeds, wind, and rain splash and can survive on plant debris or in the soil. It is aggressive at medium temperature (15-23°C) and high relative humidity (70-100%). Chocolate spot is importantly managed by cultural strategies viz deep plowing, early sowing, and mixed cropping. Moreover, host plant resistance, use of Obse, Tumsa, and Degaga varieties reduce the epidemics of the disease. At to effective bioagents, Bacillus, Pseudomonas and trichoderma spices can be used. Chlorothalonil, benomyl +mancozeb, Dithane M45, Galben mancozeb, and copper oxychloride Fungicides were also effective to manage it. Therefore, integrated disease management, effective, economically feasible, and environmentally sound is highly valuable and suggested to manage a chocolate spot in Ethiopia.

Keywords: *Botrytis fabae*; chocolate spot; disease epidemics; faba bean; integrated disease management.

1. INTRODUCTION

Faba bean (*Vicia faba* L.) is assigned to the central Asian, Mediterranean, and South American centers of diversity and believe to be native to North Africa and Southwest Asia [1]. It is an important pulse crop and occupies nearly 30.09 million hectares of land worldwide. It is an annual legume with one or more rigid, hollow, and erect stems. Ethiopia is considered as; the secondary center of diversity and also one of the nine major agro geographical production regions of Faba bean. The annual national production of legume crops in Ethiopia was cover 14% it's compared to cereals crops [2]. In Ethiopia, the average yield of Faba bean crop is about 2.53 t ha^{-1} which is less than yield potential (8 t ha^{-1}) [3].

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Faba bean serves as a source of food and feed and is a valuable and cheap source of protein. It is produced in the world as the source of protein. The protein fraction could be used for animal feed and the carbohydrate-rich fraction for biofuel production, as proposed for other legumes [4]. It makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen [5]. It is also an important source of income for farmers and generates foreign currency for the country. The plant is grown mainly for its green pods and dried seeds, which are rich in a protein (18.5 to 37.8%) that can substitute for animal protein in humans [6].

There are many biotic and abiotic factors that hamper Faba bean production in Ethiopia. Climate change (variability), edaphic factors, water stress, and colds are among the major abiotic constraints of faba bean production. Moreover, climate variability due to increased temperature and erratic precipitation over time has increased the susceptibility of faba bean which also favored disease development. As a result of climate change different fungal pathogens evolved, seriously affecting the production of faba bean [7].

More than seventeen pathogens have been reported so far on Faba bean from different parts of Ethiopia [8]. Chocolate spot (*Botrytis fabae* Sard.) is the major fungal disease hampering Faba bean production in Ethiopia. Chocolate leaf spot is caused by both *Botrytis cinerea* Pers. ex Pers. And *Botrytis fabae* Sard. *Botrytis cinerea* is a parasite and saprophyte on a wide range of host plants, whereas *B. fabae* is specialized for the invasion and colonization of *Vicia spp*. especially *V. faba* [9]. It is a highly prevalent and destructive disease, causing yield loss of up to 61% on susceptible and 34% on tolerant Faba bean genotypes in the central highlands.

But we can manage this economically important disease in a manner which comprised by using different methods from these late sowing of Faba bean, mixed cropping of Faba bean with cereal crops, fungicides application, and crop rotation was found better to reduce the disease and increase the grain yield [6]. Therefore, to enhance productivity and production of faba bean, it needs to control chocolate disease in various methods and this paper is written to review achievements that have been conducted regarding the economic importance, biology, ecology, and management of chocolate spot in Ethiopia the following aims.

2. METHODOLOGY

This paper is written as a review article. The data included in it is collected from secondary data sources that were conducted previously in Ethiopia and globally. Hence, various journal articles, proceedings, books, and reports were used to review and organize it. Tables and figures were used as reviewing techniques to make the review briefer.

3. RESULTS AND DISCUSSION

3.1 Economic Importance of Chocolate Spot

Chocolate spot caused by (*Botrytis fabae*) attacks all of the above-ground parts of the broad bean plant and causes losses by reducing seed yield and affected seed quality due to the prevailing environmental conditions [6]. *Botrytis fabae* infects only a few closely related plant species. Chocolate spot is the most prevalent and important disease in the major faba bean growing regions of Ethiopia as well as elsewhere in the world. It can cause a halo spot, develop into leaf blight in *Trifolium dasyurum* and lead to a disease on pulses such as field pea, lentils (*Lens Culinarys* M.), vetch (*Vicia sativa* L.), and chickpea and carbon bean (*Vicia narbonensis* L.) [10].

Botrytis fabae is one of the economically important diseases that damage the foliage, limit photosynthetic activity, and reduce Faba bean production. In the Maghreb region (Libya, Tunisia, Algeria, Morocco), losses due to chocolate spot diseases can reach 60–80% on susceptible genotypes. The chocolate spot was caused yield losses of faba bean that varying from 34% on a tolerant genotype up to 61% on a susceptible genotype in Ethiopia [11]. In Negash areas, Tigray, in 2000 seed yield loss of 62% was due to this disease. Unsprayed plots had significantly lower grain yields (1.9 t/ha in 2004 and 2.3 t/ha in 2005) compared to sprayed plots. In unprotected crops, the disease can reduce yields by 30-50 percent under conditions favorable for disease development [12].

Yet complete crop failure due to the disease is commonly encountered when a long-lasting favorable environmental condition for disease development prevails in an area [9]. As a result of climate change different fungal pathogens evolved in new ways and faba bean production is seriously affected [13]. Thus, climate change and associated changes in disease scenarios will demand changes in crop and disease management strategies. Yield losses as high as 90% and total crop failure in severe epidemics of *Botrytis fabae* have been reported from areas where extended periods of wet weather conditions prevail [14].

3.2 Biology of Chocolate spot

The chocolate spot of faba bean is caused by the fungal pathogen known as *Botrytis fabae* Sard. This

pathogen is classified in the Eukaryota, Kingdom Fungi, phylum Ascomycota, subphylum Pezizomycotina, class Leotiomycotina, order Helotiales, family Sclerotiniceae, and belongs to the genus Botrytinia [15]. Chocolate leaf spot is also caused by *Botrytis cinerea* Pers. ex Pers. A teleomorph of *B. fabae*, *Botryotinia fabae*, was described by [16]. *Botrytis cinerea* is a parasite and saprophyte on a wide range of host plants, whereas *B. fabae* is specialized for the invasion and colonization of *Vicia spp*. especially *V. faba*. The existence of races of *B. faba* has been proposed based on reaction to differentials in Mediterranean countries. More works have to be done to understand variability in *B. fabae*. The pathogen is the necrotrophic fungus *Botrytis fabae* Sard, which is present in nearly all faba bean cultivation areas [17].

In-plant disease assays on faba bean and lentil, *B. fabae* was more aggressive than *B. cinerea* and we observed variation in susceptibility among a small set of cultivars for both plant hosts. Using light microscopy, we observed a spreading, generalized necrosis response in faba bean toward *B. fabae*. In contrast, the plant response to *B. cinerea* was localized to epidermal cells underlying germinated spores and appressoria [18]. *B. cinerea* has been characterized as a necrotrophy that kills host cells by activating programmed cell death and the hypersensitive response [19]. According to Robrert et al. (2020), the colony diameter increases 1–2 days after inoculation at the center of the plate was used to measure growth rate (n = 5) and the isolate was grown in the dark at room temperature (20°C).

Furthermore, a recent paper describes *Botrytis fabiopsis* that causes chocolate spot disease in faba beans in China and is closely related but distinct from *B. fabae*. There are a limited number of *B. fabae* gene sequences in the Gen Bank database and these have enabled the phylogenetic classification of *B. fabae* with other *Botrytis* and *Sclerotinia species* [20].

The symptoms of infection by *Botrytis fabae* on faba bean vary from minor necrosis to extensive destruction of tissue and leaves, stems, flowers and pods can be infected, with flowers and pods being the most susceptible parts [15]. The absence of cottony white mycelium and the presence of gray sporulation differentiate Botrytis gray mold from Sclerotinia [21]. Even in fields with severe Botrytis, sporulation is often very difficult to find by the late morning or afternoon, especially on dry, windy days. Plants should always be evaluated for *Botrytis* early in the morning or several hours after rainfall events [21]. It appears as reddish-brown spots on leaves and under favorable conditions on stems, flowers and pods. Subsequently, these spots grow larger and can even merge into a black mass.

The disease results in heavy premature defoliation and under warm moist conditions crop lodging may occur. Plant growth and most physiological activities are adversely affected leading to a drastic reduction in yield [5]. At the aggressive stage, lesions begin to sporulate and the spots increase and coalesce turning into rust-colored necrotic lesions. The lesions become much darker and get covered in the fluffy grey-white mycelium of irregular form on all the plant organs. During this stage, large areas of leaf tissue of faba bean may die, leading to defoliation [15]. It is characterized by spot lesions on leaves that start as rust-colored to dark-brown spots which become surrounded by an orange-brown ring. Lesions can expand to a diameter of 5-10 mm and have a tobacco-colored center. Light and dark concentric ridges often develop during lesion expansion [22].

3.3 Ecology and Epidemics of Chocolate Spot

The fungus can be carried on seeds and also survive on plant debris or in the soil. Sowing infected seeds will introduce the disease into clean areas. Masses of spores are produced on infected plants and are then spread onto other plants by wind and rain splash to begin new infections. The diseases often begin on dead leaves and then spread to growing plants [15]. Severe outbreaks are most common in the Nile delta, near rivers in China, rainy coastal areas of the Mediterranean, and the more oceanic climate of western France and western UK [23]. The prevalence of chocolate spot in the main faba bean growing areas of Ethiopia is about 94.6% [24].

It attacks faba beans under very different agro-ecological conditions in Ethiopia, from the low rainfall north-eastern zone to the high rainfall northwestern zone of Ethiopia [5]. Terefe et al. [25] reported that temperature strongly influenced the growth and sporulation of *B. fabae* and infection and development of chocolate spot in faba bean varieties. The optimum temperature required for (growth, sporulation, invasion, and infection) disease development is 22°C. When humidity is high, the non-aggressive stage changes to the aggressive stage [15].

Sillero et al. [26] reported the interactions of temperature with some *Uromyces viciae-fabae*: *Vicia faba* gene combinations. They also showed that host-pathogen pairs responded differently to varying temperatures. It is well known that temperature governs the rate of reproduction of fungi and the physiological conditions of the host and has a marked

effect on the incidence of diseases. Temperature also affects the growth and aggressiveness of pathogens and the expression of disease symptoms in the plants [27]. Moreover, it has been demonstrated that inoculum density and host physiology have been closely related to temperature and disease development. Thus, plants and pathogens require optimum temperature ranges to grow and carry out their physiological activities. Temperature ranging from 18 to 27°C for faba bean growth and between 15 and 23°C for *B. fabae* development [28] are reported. The severity of chocolate spot is favored between 92-100% relative humidity and 15-20°C temperature [25].

Humid (≥70% relative humidity, especially in the mornings), warm (10-23°C), and rainy (frequent rain) weather conditions are favorable for the growth of chocolate spot epidemics. With this environment, the epidemic grows with the apparent infection rates ranging from 0.142 to 0.164 disease units per day, which means several chocolate spot generations within a single growing season. This is an indication of the rapid and dangerous spread of the disease. If the pathogen falls short of the above-listed weather variables, it will be forced to have a short infection period, and this is significant in the spread of an epidemic [9].

Chocolate spot of faba bean (*Botrtytis fabae*) occurred almost everywhere faba bean is grown [29]. The pathogen infects the leaf tissue, petioles, stems, and seeds. It survives as sclerotia in infected plant debris for more than a year. Sclerotia of *B. fabae* stay alive for about two years under Holetta conditions on the surface of the ground and die in four months when buried 20cm deep [30]. The fungus *B.fabae* was recovered from infected plant debris stored in Nitosol after 12 months, but not from that stored in Vertisol [31]. Soil type and depth at which infected plant residues are located affect the biology of the fungus, and this might have a practical implication on disease management [9].

3.4 Management of Chocolate spot

3.4.1 Cultural methods of control

Planting faba bean in a mixture with field pea in a ratio of 1:2 drastically reduces the epidemic development of chocolate spot in faba bean. Studies carried out at several locations in the northwest part of the country by Adet Agricultural Research Center confirmed the advantages of mixing faba bean and field pea in different proportions in reducing chocolate spot severity. However, mixed cropping culture might not be feasible in large-scale production of faba bean. The value of growth of faba bean in mixture with field pea regarding the reduction of chocolate spot infection in faba bean is continuous [6].

Deep plowing of the fields with high chocolate spot infection immediately after harvest reduces the risk of disease development. Substantial delay and shortening of chocolate spot epidemic and thereby reduction of attack can be achieved by late sowing of faba bean as the conditions suitable for the development of the disease do not exist for a sufficiently long period but, seed yield harvest from the late sown crop is considerably less than that of the early sown crop. Integrated disease control for faba bean studies conducted on farmers' fields under different environmental conditions showed that newly released varieties with resistance to chocolate spot responded less to fungicidal applications [9].

Substantial delay and shortening of chocolate spot epidemic and thereby reduction of attack can be achieved by late sowing of faba bean as the conditions suitable for the development of the disease do not exist for a sufficiently long period. However, seed yield harvest from the late sown crop is considerably less than that of the early sown crop. A research report done by Gorfu [28] revealed that deep plowing of the fields with high chocolate spot infection immediately after harvest reduces the risk of disease development. In addition, early sowing and use of improved varieties avoid the occurrence of chocolate spot disease at epidemic proportions [9].

3.4.2 Host resistance

A critical decision in crop production is the selection of the cultivar(s) to be grown. Some cultivars are resistant to particular pathogens and are inherently less damaged than other genetically related plants growing in the same location. Resistant cultivars have provided one of the most successful approaches to the control of pathogens [32]. Enormous differences exist among local and exotic genotypes concerning resistance or tolerance which could be exploited to breed chocolate spot resistant faba bean varieties [9].

Research done by Mesele [33] by using 13 faba bean revealed that in all assessment dates between 35 and 98 DAP chocolate spot severity was significantly lower (< 23%) on CS20DK and Degaga followed by Tesfa and Bulga-70%. Meanwhile, the resistant genotypes EH00012-4, EH01046-1, EH00053-1, and EH01021-1 should be further evaluated for their possible use in the future for faba bean improvement program. Similarly, Faba bean collections have been

screened for response to chocolate spot, and evaluation methods improved [34].

The International Centre for Agriculture Research in Dry Areas (ICARDA) has incorporated resistance into local germplasm, so new genotypes have been introduced in Australia, Egypt, and Ethiopia, among other countries [13]. So far, several chocolate spot-resistant genotypes have been reported. Source of resistance for chocolate spot (BPL-1179-A-1, BPL-1802-1, and BPL-1179-2) have been identified from introductions of ICARDA to Ethiopia. From the landrace collections, several varieties, namely CS20DK, NC-58, Bulga 70 (coll111/77), Wayu (Wayu 89-5), Selale, Lalo, Dagm, and Adet Hana have been nationally or regionally released for different recommendation domains [33]. This indicated that there is an opportunity to find resistant varieties in the future which help in the increment of faba bean production in Ethiopia as well as it will be incorporated in integrated disease management strategies.

On the other hand, Yitayih and Azmeraw [35] reported that the disease incidence was lower on varieties Obse and Moti in Ethiopia. The severity of chocolate spot was lower on varieties Obse, Tumsa, and Degaga. Varieties Obse, Degaga, and Tumsa significantly reduced the severity of chocolate spot disease by 8.89, 6.85, and 5.91%, respectively, over Bulga 70 and Adet-Hana. Varieties Obse, Degaga, and Tumsa significantly reduced the AUDPC of chocolate spot disease by the amount of 229.63, 214.81, and 187.96% over variety Bulga 70, respectively. The highest yield (t/ha) was obtained from variety Degaga (1.55) and Tumsa (1.30). Thus, to conclude and recommend that variety Degaga and Tumsa are moderately tolerant or less susceptible to chocolate spot disease than other varieties with a better yield [35].

Moreover, according to the result of Dagne et al. [36], the highest mean final disease severity at (118 DAP) 38.29% was recorded on the main plots of the local variety and the lowest mean final disease severity 32.75% was on the main plots of the variety Mosisa. The maximum Area Under the disease progress curves (AUDPC) was calculated on the unsprayed plots of local variety and Walki, which were 1817%-days and 1716.42%- days, respectively. On unsprayed plots of variety, local chocolate spot development was increasing at a rate of 0.03 units per day.

3.4.3 Biological control

Many fungi and bacteria are known to be very effective against soil-borne diseases. Research has shown that foliar diseases can also be managed effectively through microorganisms. Among these, *Bacillus spp*. is very important. *Bacilli* generally have simple nutritional requirements, can colonize dry surfaces for a long period, rapidly utilize many of the available nutrients, and can sustain many of the environmental hazards. Several potent strains from different species of *Bacillus* have been tested on a wide variety of plant species for the ability to control several diseases and some have been commercialized already. Among the different bacteria, *Bacillus* and *Pseudomonas* have been reported to have the greatest potential to control *Botrytis* diseases [37].

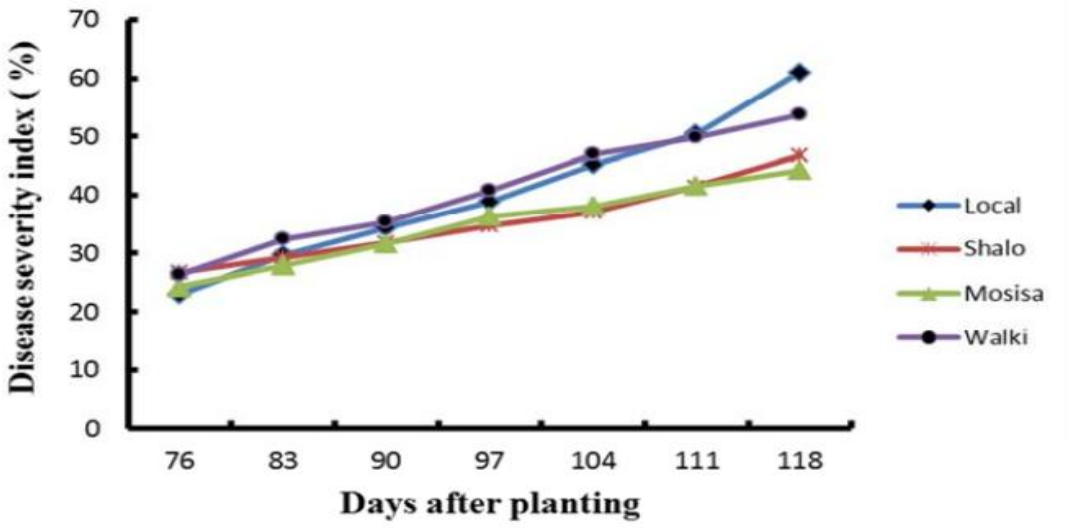

Fig. 1. Disease progress curve of the chocolate spot on four faba bean varieties (Source: Misgana, [9])

Three biological agents namely, Plant – Guard [*T. harzianum* (30 million organisms/cm3)], BioZeid 2.5% W.P. [(*Trichoderma album*) 10 million spore/gram] and Bio Arc 6.0% WP [(*Bacilusmegaterium*) 25 million cell/gram] were effective at the rate of 250, 200 and 100 ml or g/100 Lt water against this disease, respectively [38]. There is promise in using biological control agents to control chocolate spot diseases; nevertheless, this strategy has not been fully exploited. Isolate of *Trichoderma ovalisporum* and *Trichoderma longibrachiatum* as effective antagonists of *B. fabae* for the first time [13].

In Ethiopia, the study revealed that the biological control agents for a chocolate spot of faba bean and *Bacilli* are natural residents of faba bean leaves. Thirty isolates of *Bacillus spp*. were tested for their effects on *B. fabae* by dual culture technique on potato dextrose agar. Sixteen isolates produced 5 mm or higher inhibition zone and out of these, two isolates were the most effective having inhibition zone of 8 and 7 mm [9]. Isolates reduced the growth of the pathogen colony in dual culture by 23 - 64%. Four Isolates proved most effective in retarding disease development on two susceptible and one tolerant cultivar and can be further explored for commercial use for the management of chocolate spot disease of faba bean [5].

Bacillus subtillis which is a gram-positive and obligate bacteria had a role as a biological control against *B.fabae*. What they do was that they grow the causative pathogen alone and together with the antagonist bacteria on the growth media finally found that the *bacillus* has the greatest potential to control chocolate spot disease of faba bean so, finally, they conclude that *B. subtilis* can be further recommended as a component of integrated management of chocolate spot disease of faba bean; additionally, they recommended that further study has to be done to explore the mode of action by *bacillus subtilis* against *fabae*. From this trial, they get 62.96% growth reduction of *B.fabae*. Also from this trial, they found that *B.subtilis* was efficient in controlling chocolate spot disease [9].

3.4.4 Chocolate spot management by fungicides

Several fungicides, both systemic and protectant were tested for control of a chocolate spot in the past [39]. From these, chlorothalonil, benomyl +mancozeb were effective against the chocolate spot. Chlorothalonil completely protected faba bean plants from infection when applied at weekly intervals, but extended intervals of more than 15 days were less effective. Faba bean producers can realize the benefit of early sowing, increased yield, by planting improved varieties at the beginning of the growing season and spraying the crop with chlorothalonil at a rate of 2.5 kg a.i. per hectare of once or twice after disease infection has reached 30% severity level [28]. The experiment that was done by using three to four sprays was applied, mancozeb at a rate of 0.7 kg per hectare proved more effective than chlorothalonil. According to the concept of integrated disease management, chemical treatment should only be applied as a supplement to combat chocolate spot risk [9].

Fungicide application significantly reduced chocolate spot severity, AUDPC, and disease progression rate. The highest chocolate spot PSI, AUDPC, and disease progression rate was recorded from the local unsprayed plot at both sites; whereas the lowest chocolate spot PSI (3.7%) was recorded from walki treated with fungozeb. Maximum grain yield was recorded from plots treated with fungozeb fungicide at both locations [40]. Samuel et al. [5] reported that the cereal mixed cropping and fungicide application consistently reduced chocolate spot severity and increased the yield correspondingly. El-Sayed et al. [41] also reported that Dithane M45, Galben manozeb and copper oxychloride chemicals reduced the growth of *B. fabae* under in vitro conditions.

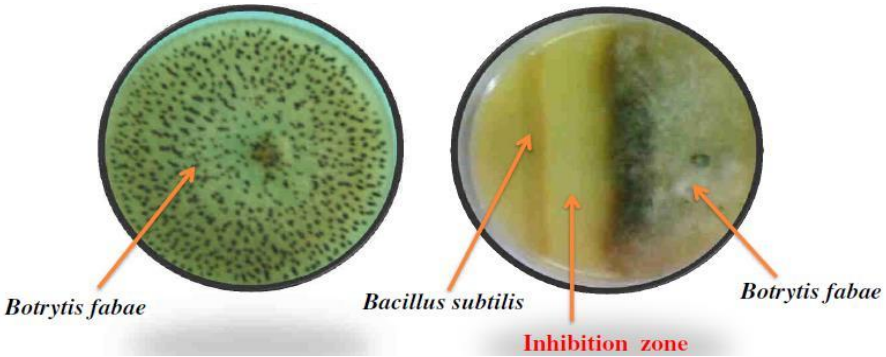

Fig. 2. Antagonistic efficiency of *Bacillus subtilis* against *B. fabae* (Source: Misgana, [9])

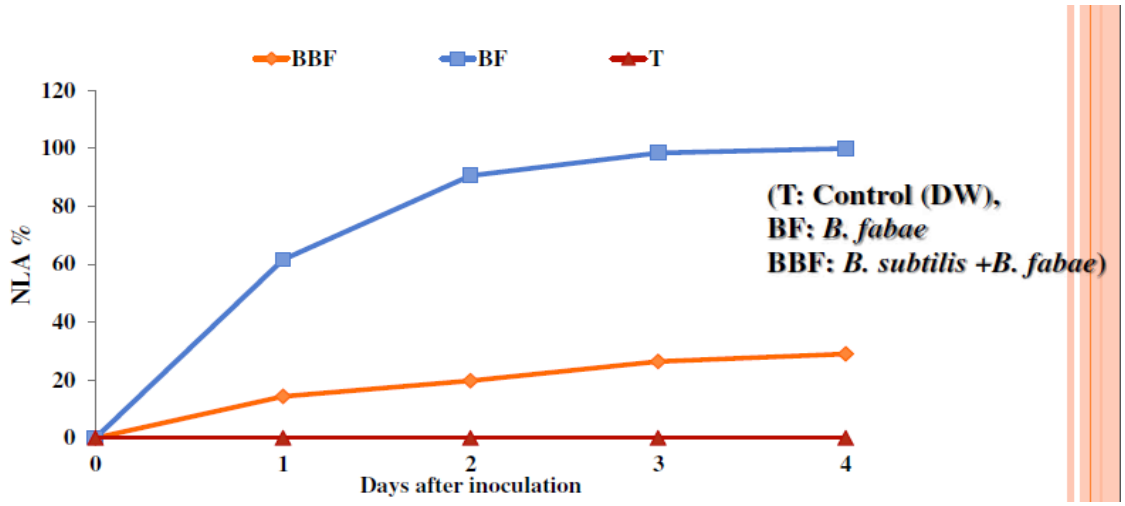

Fig. 3. Effect of *Bacillus subtilis* on chocolate spot disease on the detached leaf (Source: Misgana, [9])

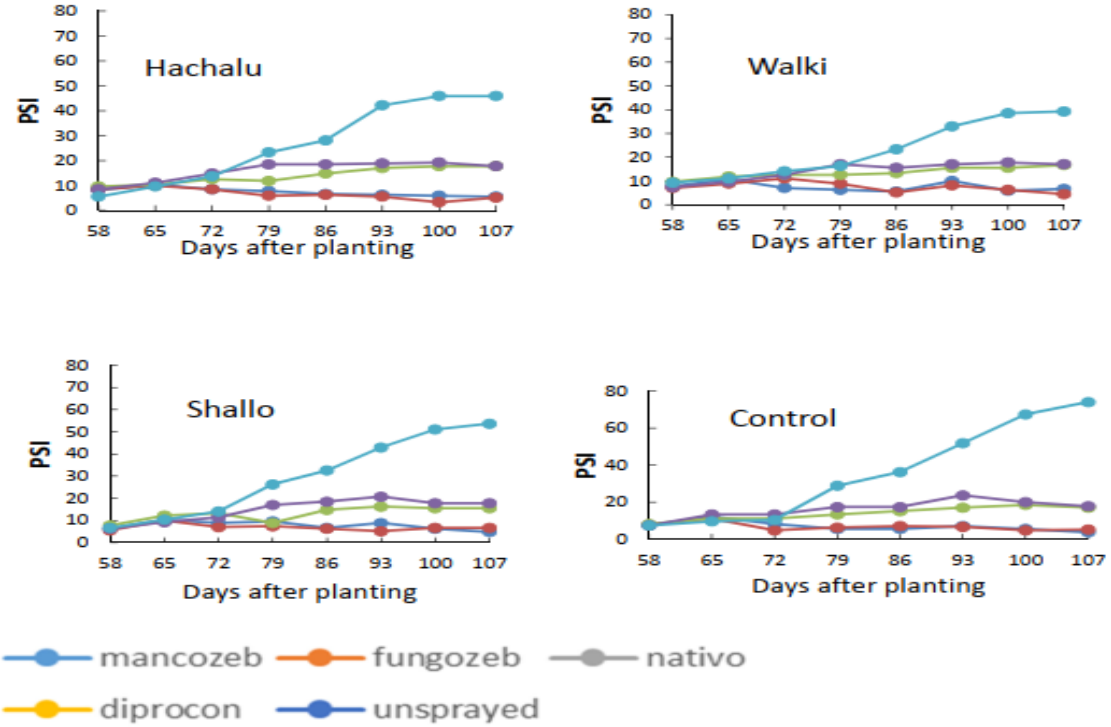

Fig. 4. Faba bean chocolate spot percentage severity index at different days of recording on four varieties sprayed with four fungicides (Source: Misgana, [9])

3.4.5 Integrated disease management

Using an individual management practice alone may not reduce the level of disease to an acceptable level, whereas the additive effect of several practices will be done. Recently a shift in scientific thinking and practice in the management of faba bean diseases has been seen and greater emphasis was on identifying, evaluating, and integrating location-specific components of integrated disease management [32]. The main emphasis in research and development to combat food legume diseases is on the host resistance and chemical control where ever applicable, and quite often these components of disease management were practiced in isolation from each other [9]. Estayih [11] reported that the use of improved cultivars and fungicide protection (Chlorothalonil at a rate of 2.5kg ha once or twice after disease infection reaches 30%) as integrated disease management, had the synergetic effect to avoid epidemics of chocolate spot and increase seed yield of faba bean.

An integrated approach is key to the successful management of chocolate spot in faba bean. Mixed cropping of faba bean with cereal crops and mancozeb spray reduced the disease and increased the grain yield, as well as the seed weight over sole and mixed cropping with field pea [13]. Similarly, Agegnehu and Fessehaie [42] also found that cereal mixing with faba bean has advantages over faba bean mixing with field pea. The chocolate spot was significantly reduced when faba bean was intercropped with cereals, but not when intercropped with legumes. Suppressive effects can be ascribed to a combination of host biomass reduction, altered microclimate, and physical barriers to spore dispersal. Also, the creation of a physical barrier in the form of non-host plants prevents some of the dispersed spores from being deposited on the host tissue by interception [43].

Integrated disease control for faba bean studies conducted on farmers' fields under different environmental conditions showed that newly released varieties with resistance to chocolate spot responded less to fungicidal applications. These findings led to the development of improved disease control packages. The use of new, resistant varieties has reduced the use of chemicals drastically. In addition, early sowing, use of improved varieties, and fungicide protection avoid the occurrence of chocolate spot disease at epidemic proportions than using the two options individually [28].

Ermias and Tagegn [44] did some research to identify the best combination of sowing dates and different frequencies of fungicide (Mancozeb) application for the management of chocolate spot disease of faba bean. According to their research output, the mean maximum chocolate spot severity of 51.89% was recorded from the first sowing date plot that received no fungicide treatment whereas, the least severity of 28.67% (based on a 1-9 scale) was recorded from the last sowing date plot which received four times fungicide spray (Table 1). The highest yield was obtained from the sowing date integrated with four frequencies of fungicide application (3903.6 kg/ha). They concluded that adjusted sowing dates with resistant variety and judicious use of fungicide can be used as a good option for chocolate spot management.

Table 1. Effect of sowing date and fungicide spray frequency on the severity of chocolate spot disease and yield of faba bean

Treatments	Chocolate spot	Yield (Kg/ha)
S1C0	51.89	2960.3
S1C1	44.44	2895.8
S1C2	39.78	3009.2
S1C3	40.78	3527.2
S1C4	38.00	3903.6
S2C0	51.89	2498.1
S2C1	40.78	2864.7
S2C2	39.78	2904.0
S2C3	36.11	3051.0
S2C4	33.33	3320.6
S3C0	46.33	1927.1
S3C1	40.78	3110.7
S3C2	33.33	3039.1
S3C3	32.44	2255.5
S3C4	30.56	2930.8
S4C0	38.00	1275.1
S4C1	33.33	1810.1
S4C2	29.67	1504.8
S4C3	29.67	1558.5
S4C4	28.67	1606.1
CV	9.36	26.15
LSD ($p<0.05$)	0.53	1121

Note: S1, S2, S3 and S4 = Sowing date 1, 2, 3 and 4. C0, C1, C2, C3 and C4 = Chemical spray frequencies from 0 times spray to 4 times spray. S1C0 = interaction of Sowing date 1- and 0-times chemical spray, S1C1 = interaction of Sowing date 1 with 1 times chemical spray, S4C4 = interaction of Sowing date 4 with 4 times chemical spray and for all it goes likewise. (Source: Ermias and Tagegn, [44])

4. CONCLUSION AND RECOMMENDATIONS

Generally, the chocolate spot is caused by *Botrytis fabae* which infects only a few closely related plant species and attacks all of the above-ground parts of the broad bean plant and causes losses by reducing seed yield and affected seed quality. Losses due to chocolate spot diseases can reach 60– 80% on susceptible and 34 % on resistant faba bean genotypes, respectively. *B. fabae* is specialized for the invasion and colonization of *Vicia spp*. especially *V. faba and now day*, *Botrytis fabiopsis* that causes chocolate spot disease in faba beans and *Botrytis cinerea* is a parasite and saprophyte on a wide range of host plants.

The fungus can be carried on seeds and also survive on plant debris or in the soil and it is spread onto other plants by wind and rain splash to begin new infections. Temperature and ≥70% relative humidity strongly influenced growth and sporulation of *B. fabae* and infection and development of chocolate spot in faba bean varieties. Deep plowing of the fields with high chocolate spot infection immediately after harvest, late sowing, and planting faba bean with field pea production methods reduce the risk of disease development. The use of resistant cultivars has provided the most successful strategy to control the pathogen. Varieties Obse, Degaga, and Tumsa significantly reduce the epidemics of the disease.

On the other hand, *Bacillus spp.*, *Pseudomonas spp*, *Trichoderma ovalisporum* and *Trichoderma longibrachiatum* have been reported to have the greatest potential to control *Botrytis fabea*. Managing the disease with chlorothalonil, benomyl +mancozeb, fangozeb, Dithane M45, Galben manozeb and copper oxychloride fungicides is very effective to reduce the disease. An integrated approach of all available practices is the key to the successful management of chocolate spot in faba bean. In this regard, mixed cropping of faba bean with cereal crops and mancozeb spray reduced the disease and increased the grain yield. Moreover, adjusted sowing dates with resistant variety and judicious use of fungicide were effective, economically feasible, and environmentally sound to manage chocolate spot. Therefore, to manage chocolate spot, I suggested that integrated disease management is better to be applied by farmers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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