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Review Article

Overview of Epidemiology, Biology and Integrated Management of Chocolate Spot (*Botrytis fabae*) of Faba Bean in Ethiopia

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Abstract: Chocolate spot is a serious disease that cause yield reduction on Faba bean crop, thus, effective management is essential. The objective of this review work was to review available to manage chocolate spot of faba bean with host resistance and fungicides. There are many biotic and abiotic factors which hampers Faba bean production in Ethiopia. From biotic factors chocolate spot (Botrytis fabae Sard.) is the major fungal disease hampering Faba bean production in Ethiopia.). It is a highly prevalent and destructive disease, causing yield loss up to 61% on a susceptible and 34% on tolerant Faba bean genotypes in the central highlands. But we can manage this economically important disease in 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 were found better to reduce the disease and increased the grain yield. Therefore, use all available diseases management methods in combination that is IDM (Integrated Disease management) is better to reduce disease severity of chocolate spot.

Keywords: Chocolate Spot, Faba Bean, Integrated Disease Management, Management Method

1. Introduction

Grain legumes play an important role in improving livelihood, nutritional security of farmers and populations in less developed countries as well as sustainability of agriculture in dry areas worldwide [1]. In Ethiopia, faba bean is grown in the highlands (1780–3000 m.a.s.l.) with 700–1000 mm annual rainfall [2]. The area of faba bean production in Ethiopia has increased by 18.21% from 2010 cropping season to 2016; Faba bean (*Vicia faba* L.) also called as broad bean, horse bean and field bean, is one of the earliest domesticated food legumes in the world, probably in the late Neolithic period [3]. It is assigned to the Central Asian, Mediterranean, and South American centers of Diversity and believes to be a native to North Africa and southwest Asia and extensively cultivated elsewhere and the secondary centers of diversity are postulated in Afghanistan and Ethiopia [4]. It ranks sixth in production among the legumes grown in the world. China has been the main producing country, followed by Ethiopia, Egypt, Italy, and Morocco [5]. Ethiopia is considered as; the secondary center of diversity and also one of the nine major agro geographical production regions of Faba bean. The primary producers of pulses are small scale farmers with small and dispersed plots under rained conditions, with substantially lower yields compared to the improved Faba bean varieties and international yields.

The annual national production of legume crops in Ethiopia was cover 14% it's compare from cereals crops [6]. 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}) [7]. Faba bean serves as a source of food and feed and is a valuable and cheap source of protein. It makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen [8]. 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 [9]. In the highlands of Ethiopia, faba bean is one of the most important food crops widely produced used for a source of cash to the farmers, foreign currency to the country and restoration of soil fertility by fixing atmospheric nitrogen and is a suitable rotation crop for cereals [10].

Faba bean makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen and reduce the dependence on external fertilizer inputs and also an important source of income for farmers and generates foreign currency for the country [11]. Integration of faba bean varieties with different reaction to chocolate spot with foliar sprays protected the faba bean varieties from high chocolate spot epidemics, increased yield, yield components and maximized marginal benefit compared to a single control approach [12]. As result of climate change different fungal pathogen evolved in new ways and faba bean production is seriously affected [13, 14]. 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 [4]. Chocolate spot is a major limiting factor in the main faba bean growing regions of Ethiopia and yield losses vary from 34 to 61% [14, 15]. Many methods of control are possible such as the use of resistant genotypes, chemicals (fungicides), and biological, induced resistant and modified cultural practices. In fact, the amount of losses in seed yield due to a disease determines the importance of that disease Management options for chocolate spot disease in Ethiopia include the use of resistant cultivars, chemical control (Mancozeb), copper oxychloride and copper hydroxide fungicide application consistently reduced chocolate spot severity and increased the yield correspondingly. Mancozeb, copper hydroxide and copper oxychloride chemicals reduced the growth of *B. fabae* under in vitro conditions.

Despite its huge importance, the productivity of Faba bean in Ethiopia is far below its potential due to a number of factors, the biological limitations include inherently low grain yielding potential of the indigenous cultivars and susceptibility to biotic and abiotic stresses [10]. Among the biotic stresses, chocolate spot (*Botrytis fabae*), rust (*Uromyces vicia fabae*), and black root rot (*Fusarium solani*) highly contribute to the low productivity of the crop. The pathogen is the necrotrophic fungus *Botrytis fabae* Sard, which is present in nearly all faba bean cultivation areas [16]. *Botrytis fabae* is one of economically important diseases that damage the foliage, limit photosynthetic activity, and reduce Faba bean production [17]. In the Maghreb region (Libya, Tunisia, Algeria, Morocco), losses due to chocolate spot diseases can reach 60– 80% on susceptible genotypes [18].

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 [12]. as well as complete crop failure due to long lasting favorable environmental condition for the diseases [19]. Many different chocolate spot diseases control methods are possible such as the use of resistant genotypes, chemical fungicides, biological, and cultural practices. A chemical is recommended for use when the cost of its application equals to or is less than the returns gained when the damage is below threshold level or within the tolerant limit [3, 20] reported that faba bean varieties and fungicide application consistently reduced chocolate spot severity and increased the yield correspondingly. A research conducted by [21] reported that there were lack of improved varieties and poor seed system in Ethiopia. On this review focused on understanding of Epidemiology and biology of Chocolate Spot *(Botrytis fabae) and management method on* Faba Bean is important for in terms of both quality and quantity of Faba Bean production and reduction of infestation chocolate spot disease.

2. Origin and Distribution of Faba Bean

Faba bean is assigned to the Central Asian, Mediterranean, and South American centers of Diversity and believe to be a native to North Africa and southwest Asia, and extensively cultivated elsewhere and the secondary centers of diversity are postulated in Afghanistan and Ethiopia [4].

2.1. Production Status and Importance of Faba Bean

It ranks sixth in production among the legumes grown in the world. China has been the main producing country, followed by Ethiopia, Egypt, Italy, and Morocco [10]. In Ethiopia, the average yield of faba bean is 2.53 t ha^{-1} and occupies large area (about 427,696.8 ha) of production among other pulses which accounts 3.4% of total production [7]. In Ethiopia, the productivity of faba bean is far below its potential due to a number of factors, the biological limitations include inherently low grain yielding potential of the indigenous cultivars and susceptibility to biotic and abiotic stresses [10]. Cultivated faba bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries. It can be used as a vegetable either green or dried, fresh or canned and common breakfast food in the Middle East, Mediterranean region, China and Ethiopia [22]. It also considered as a meat extender or substitute and as a skim-milk substitute and sometimes grown for green manure [22]. One of the best bio factory of nitrogen by fixing 130 to 160 kg N/ha [23] used for restoration of soil fertility by fixing atmospheric nitrogen and is a suitable rotation crop for cereals [10]. In Ethiopia, the most popular dishes of faba bean are ‘Shero’ (a sauce for ‘Enjera’) and ‘Siljo’, a national dish made from faba bean flour, ‘Nifro’ (boiled), ‘Ashuke’ (roasted and soaked) and ‘Endushdush’ (sprouted and roasted), ‘Enjera’ (flat bread used as staple food in Ethiopia) by mixing it with other cereals like wheat, barley or sorghum, Ful (dish of cooked and mashed faba beans prepared with oil, chopped onion garlic and tomato [21].

2.2. Chocolate Spot of Faba Bean

The Botrytis diseases are probably the most common and most widely distributed diseases of vegetables, ornamentals, fruits, and some field crops throughout the world. The Botrytis diseases appear primarily as blossom blights under humid conditions, the fungus produces a noticeable gray-mold fruiting layer on the affected tissues that is characteristic of Botrytis diseases [24]. Some of the most serious diseases caused by Botrytis include gray mold of strawberry, grapes and of many vegetables as well as chocolate spot of faba bean [25].

2.2.1. Causative Agent of Chocolate spot of Faba Bean

Chocolate spot of faba bean is caused by the fungal pathogen known as Botrytis fabae. 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 [21]. Chocolate leaf spot is caused by both Botrytis cinerea Pers. ex Pers. and Botrytis fabae Sard. A teleomorph of B. fabae is Botryotinia fabae. 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 [19].

2.2.2. Biology and Ecology of Chocolate spot of Faba Bean

The fungus can be carried on seeds and also survive on plant debris or in the soil. Sowing infected Seed 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 [21].

2.2.3. Geographical Distribution and Epidemiology of Chocolate Spot of Faba Bean

Chocolate spot disease is one of the most important causes of instability for faba bean (Vicia faba L.) crop yields across the world. 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 [26]. 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 [27]. [28] reported that, temperature strongly influenced growth and sporulation of B. fabae and infection and development of chocolate spot in faba bean varieties. The optimum temperature required for the (growth, sporulation, invasion and infection) disease development is 22°C. When humidity is high, the non-aggressive stage changes to the aggressive stage [29]. 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 [19].

2.2.4. Host Range of Chocolate Spot of Faba Bean

Chocolate spot of faba bean (Botrtytis fabae) occurred almost everywhere faba bean is grown [30]. 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 [31]. Botrytis fabae infects only a few closely related plant species. It can cause a halo spot, develop in to 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 chick pea and narbon bean (Vicia narbonensis L.) [32].

2.2.5. Signs and Symptoms of Chocolate spot of Faba Bean

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 [21]. The absence of cottony white mycelium and the presence of gray sporulation differentiates Botrytis gray mold from Sclerotinia [33]. 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 [33]. 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 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 drastic reduction in yield [34]. At aggressive stage lesion begin to sporulate and the spots increase and coalesces turning into rust colored necrotic lesions. The lesions become much darker and get covered in 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 [21]. 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 [35].

2.2.6. Importance of Chocolate Spot of Faba Bean

The Botrytis fabae is one of economically important diseases that damage the foliage, limit photosynthetic activity, and reduce faba bean production [17]. In the Maghreb region (Libya, Tunisia, Algeria, Morocco), losses due to chocolate spot diseases can reach 60– 80% on susceptible genotypes [18]. 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 [12] as well as complete crop failure due to long lasting favorable environmental condition for the diseases [19]. Unsprayed plots had significantly lower grain yields (1.9 t/ha in 2004 and 2.3 t/ha in 2005) compared to sprayed plots. Complete crop loss can occur when the environmental condition become conducive [19].

3. Management of Chocolate Spot of Faba Bean

3.1. Cultural Methods of Diseases Control

In addition, planting of Faba bean in mixture with field pea

in a ratio of 1:2 drastically reduces 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 growing of faba bean in mixture with field pea regarding reduction of chocolate spot infection in faba bean is continuous. Deep ploughing 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 of time but, seed yield harvest from the late sown crop is considerably less than that of 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 [19].

3.2. 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 pathogen [36].

3.3. Biological

A number of 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. has been found to be very important. Bacilli generally have simple nutritional requirements, are able to colonizes dry surfaces for long period of time, they 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 ability to control several diseases and some have been commercialized already. Among the different bacteria, Bacillus and Pseudomonas have been reported to have greatest potential to control Botrytis diseases [37].

3.4. Integrated Disease Management

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 [36]. 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 to each other [19]. [12], 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 an integrated disease management, had synergetic effect to avoid epidemics of chocolate spot and increase seed yield of faba bean. Similarly, [38], reported that, a fungicide (Mancozeb at rate of 2.5kg/ha) was integrated with sowing date and resistant faba bean variety "Shalo" the highest yield was harvested from plot treated with early sowing and four times fungicide spray.

4. Conclusion

The faba bean (*Vicia faba*) is belonging to tribe *Vicieae*. It is a legume capable of fixing nitrogen in association with root nodule bacteria and it is the most efficient nitrogen fixer of the pulse crops to increasing soil fertility and gran yield. But, there are many biotic and a biotic factors which hampers faba bean production in Ethiopia. Chocolate spot is significantly reduced faba bean production. On these review concerned about epidemiology of Chocolate spot and use of different management option. To understanding the epidemiology of Chocolate spot is important for controlling of Chocolate spot through use of different management methods such as cultural, chemical, use resistance varieties, biological control and integrated disease management (IDM) to reduced yield loss and increase productions of Faba bean. To understanding interaction of environmental factors with the epidemiology of Chocolate spot, the activities of biological control agent, cropping system and effectiveness of fungicides is important for controlling the disease. Generally, we can control Chocolate spot by using different methods to delays and shortening of chocolate spot epidemic by late sowing of faba bean, mixed cropping of faba bean with cereal crops and Mancozeb spray reduced the disease and increased the grain yield. Therefore, knowing epidemiology of Chocolate spot and use all available control measure in combination to better reduced severity of Chocolate spot disease.

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