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Review Article

Challenges, Opprtunities and Management of Faba Bean Chocolate Spot (*Botrytis Fabae* Sard.) Disease in Ethiopia: Review

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Abstract

Faba bean (Vicia faba L.) is a vital pulse crop globally, with significant importance in Ethiopia. However, its production is threatened by various biotic stresses, particularly chocolate spot disease caused by Botrytis fabae Sard., which is one of the most damaging and prevalent diseases in the country. This review aims to assess the opportunities and challenges related to the management of chocolate spot epidemics and to explore the resistance potential of faba bean cultivars in Ethiopia. Chocolate spot disease can cause substantial yield losses, ranging from 34% to 67%, and its severity is influenced by cultivar susceptibility, environmental conditions, and agronomic practices. The disease's incidence varies across districts, years, growth stages, and climatic conditions, with more severe outbreaks occurring under favorable conditions such as high humidity and moderate temperatures. The disease tends to exacerbate as the plant progresses through its growth stages, especially when inoculum accumulation and its timing in relation to crop development align with conducive weather conditions. Key epidemiological components in the resistance of faba beans to chocolate spot include infection efficiency, the extent of visible symptoms, and the latent period of the pathogen. Effective management of this disease is crucial for maintaining faba bean production, and several strategies can help mitigate its impact. Late sowing, mixed cropping with cereal crops, the application of fungicides, and crop rotation have been identified as effective practices for reducing disease incidence and enhancing grain yield. Furthermore, an Integrated Disease Management (IDM) approach, combining these methods, provides a comprehensive solution to control chocolate spot and reduce its severity. This review underscores the importance of integrating multiple disease management strategies to safeguard faba bean production in Ethiopia, ensuring sustainable cultivation of this critical crop.

Keywords

Faba Bean, Botrytis Fabae, Genotypes, Epidemiology, Resistance

1. Introduction

1.1. Background and Justification

Faba bean (Vicia faba L.) is one of the oldest cultivated food legumes, with a history of over 5,000 years of cultivation, underscoring its significant agricultural and historical importance [63]. The crop is grown in approximately 60 countries worldwide, ranking fourth in global legume production, behind garden peas, chickpeas, and lentils [65]. In 2017,

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global production reached an impressive 4,840,090 tons, with China, Ethiopia, Australia, the United Kingdom, and Germany being the leading producers [13]. Notably, China leads both in faba bean area coverage and production, while Ethiopia closely follows as one of the major contributors to global production [26]. This highlights the crop's importance to both national and global agricultural systems.

In Ethiopia, faba bean has become a critical crop after being introduced from the Middle East through Egypt [7, 27]. It plays a vital role in the socio-economic structure of rural communities, offering both food and feed, and acting as a significant protein source for both human and livestock consumption [74]. Additionally, faba bean contributes to soil fertility through nitrogen fixation, supporting sustainable farming practices, and its cultivation is integral to crop rotation systems that enhance long-term soil health [27]. As a source of income, faba bean also plays a role in Ethiopia's economy, contributing to both domestic livelihoods and the nation’s foreign currency earnings [1, 71]. The crop's importance is further emphasized by the growing demand for faba bean as a food product in both local and international markets.

However, despite the crop's significance, its yield in Ethiopia remains below its potential due to several challenges, particularly biotic and abiotic stressors [3, 52]. Among these stressors, diseases are the primary limiting factor to increased productivity, with chocolate spot disease (*Botrytis fabae*) being the most destructive [4]. Chocolate spot disease has been responsible for severe yield reductions of up to 67% in unprotected faba bean crops [11]. This disease is especially prevalent in Ethiopia, where environmental conditions such as high rainfall and elevation exacerbate its impact, with reported yield losses ranging from 34% to 61% in affected regions [20, 50]. These losses have substantial economic consequences for smallholder farmers who depend on faba bean for food and income.

To combat chocolate spot and reduce its impact, various management strategies have been employed globally, including in Ethiopia. The use of chemical fungicides, such as mancozeb and fungozeb, alongside cultural practices like crop residue management and adjusting planting dates, has been effective in mitigating disease incidence [72, 45]. Furthermore, breeding efforts have led to the development of resistant and tolerant faba bean varieties, while biological control agents such as *Trichoderma harzianum* and *Bacillus subtilis* have shown promise as sustainable alternatives to chemical control [31, 22].

The integration of these management strategies has demonstrated significant potential in improving faba bean productivity, controlling disease outbreaks, and boosting farm profitability [1]. A comprehensive approach that incorporates genetic resistance, sound agronomic practices, and biological control methods is essential for ensuring the sustainability of faba bean production in Ethiopia and other regions. The continued development and adoption of these strategies will play a crucial role in enhancing food security and improving rural livelihoods in Ethiopia and beyond. In conclusion, while faba bean holds substantial agricultural and economic importance globally, its potential is hindered by diseases like chocolate spot. However, effective disease management strategies have the capacity to significantly improve yield and ensure the crop’s continued contribution to global food security.

1.2. Methodology

The methodology involved a comprehensive review of existing literature to gather detailed information on chocolate spot disease of faba bean (*Botrytis fabae*), including its causal agent, distribution, and patterns of disease incidence and severity in Ethiopia. The study examined the symptoms, survival mechanisms, and spread of the pathogen, as well as the environmental factors influencing disease development. Data on yield losses attributed to the disease were compiled from various sources. Additionally, disease management strategies, including cultural, chemical, and biological control methods, were reviewed to understand their effectiveness in managing the disease and reducing its impact on faba bean production in Ethiopia.

2. Literature Review

2.1. Origin, Taxonomy, Biology, Ecology and Production of Faba Bean

2.1.1. Origin and Taxonomy

The geographic origin of faba bean (*Vicia faba* L.) is primarily attributed to the Near East, where it is believed to have been domesticated in the 6th millennium BC [16]. Other key centers of diversity include the Mediterranean basin, South America, and Central Asia [39, 35], with Afghanistan and Ethiopia also recognized as secondary centers of diversity for the crop [75]. However, [58] reported that the exact origin of faba bean remains uncertain. Taxonomically, faba bean belongs to the kingdom Plantae, division Spermatophyte, class Dicotyledonae, order Fabales, family Fabaceae, genus *Vicia*, and species *Vicia faba* [64].

2.1.2. Biology and Ecological Adaptation of Faba Bean

Faba bean (*Vicia faba*) belongs to the tribe Vicieae and is an annual herbaceous plant with coarse, hollow stems that can grow between 0.3 to 2 meters in height [47, 63]. It features large, pinnate leaves composed of two to six leaflets. The plant produces white flowers with purple markings, which cluster in groups of one to five, with one to four pods developing from each cluster. Each pod contains three to twelve seeds. Under optimal growing conditions, the pods typically mature for harvest in four to five months [47].

Faba bean thrives under cool, moist conditions and can tolerate frost, making it well-suited for cooler climates. However, hot and dry weather is detrimental to the crop [5]. The plant prefers altitudes ranging from 1800 to 3000 meters above sea level (m.a.s.l.) [5, 24]. Ideal rainfall for faba bean cultivation ranges from 650 to 1100 mm annually, while temperatures between 13-18 ℃ are optimal for growth [58, 7]. The crop does not tolerate standing water and requires moisture during the first 9 to 12 weeks after establishment [60]. Moderate amounts of water are generally sufficient for faba bean growth [63].

Faba bean prefers medium-textured soils and is best suited to those with a pH ranging from 6.5 to 8.0 [49]. Unlike many other legumes, it is more tolerant of acidic soils and can grow in a variety of soil types, although it thrives best in loam soils [58]. [5] also noted that faba bean grows well on fertile, well-drained soils with adequate organic matter reserves and a pH range of 6.0-7.0. The crop is slow to emerge, taking around 20 to 25 days after planting [58], and the time from seeding to harvest typically ranges from 90 to 120 days, depending on cultivar and climatic conditions [10].

2.1.3. Faba Bean Production and Productivity in Ethiopia

Faba beans are a major crop in various countries, including China, Ethiopia, Egypt, the Mediterranean region, and Latin America [74]. China is the leading global producer, with an average annual production of 11,779,800 tons [58]. In Ethiopia, faba bean ranks first in terms of area coverage and total national production among cultivated grain legumes [15]. Additionally, Ethiopia is the fourth-largest exporter of faba beans, following France, Australia, and the United Kingdom [25].

However, despite its prominence, the productivity per unit of land in Ethiopia remains below its potential, although improvements in yield have been observed over time [41, 43]. According to [15], faba beans covered 443,966.09 hectares, accounting for 3.56% of the total cultivated land, with a production of 8,486,545.69 quintals, representing 3.18% of total grain legume production. Despite this increase [43] indicated that the production potential in Ethiopia ranges from 2.8 to 6.2 tons per hectare in research fields, and 2.3 to 3.9 tons per hectare on farmers' fields.

Although productivity is improving, Ethiopia's yield remains low compared to the global average of 3.7 tons per hectare in major producing countries [26]. Faba bean is grown across the country, with significant production concentrated in the Amhara and Oromia regions [43].

Importance and use of faba bean

Legume crops are second only to cereals in agricultural importance as a source of human food and animal feed. Among food legumes, faba bean plays a vital role in the diets of developing countries and is crucial for ensuring food and nutritional security, particularly for impoverished producers and consumers [24]. In Ethiopia, faba bean is deeply integrated into daily life, featuring in traditional dishes such as snacks (Eshet, Kolo, Nifro, Gunkul), main dishes (Shiro wet, Kik wet, Ful), and occasional dishes (e.g., Gulban, traditionally eaten from Good Friday to Easter Sunday), while also serving as animal fodder [74].

Faba bean is valued for its high nutritional content, long shelf life, and low cost compared to animal products. It plays a significant role in providing protein, energy, and micronutrients to populations in developing regions [8, 63]. The crop is an essential source of dietary protein, particularly when combined with other foods, supporting human nutrition [12].

In addition to its nutritional benefits, faba bean provides farmers with a valuable income source and contributes to foreign currency earnings [1]. Its nitrogen-fixing properties also help reduce fertilizer costs for subsequent cereal crops, such as wheat, teff, and barley, when used in crop rotation [63]. This makes faba bean an integral component of sustainable farming systems, supporting both economic and environmental sustainability for smallholder farmers.

2.1.4. Challenges and Opportunities

In recent decades, Ethiopian faba bean breeders have made significant progress by exploring diverse germplasms, resulting in the development and release of improved varieties, along with effective crop management and protection techniques. Collaborative efforts across disciplines have led to technological advancements that enhance productivity and generate valuable scientific data. However, challenges remain, such as mismatched selection processes, emerging threats like faba bean gall, pea weevil, and broomrape, as well as limited sources of resistance. Traditional breeding has been the main focus of research but has not fully utilized the genetic potential for production. While molecular breeding holds promise, it has received less attention compared to cereals. Looking forward, favorable policy environments, improved phenotyping technologies, and collaborations with universities and development organizations offer optimism. Addressing soil acidity and expanding markets could further enhance the genetic progress of faba bean and field pea through molecular breeding [30].

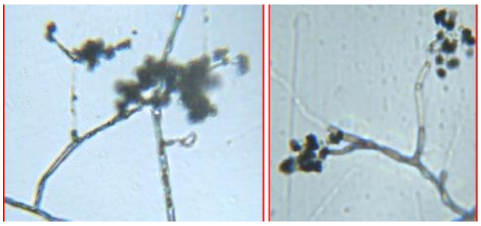
2.2. Origin, Taxonomy, Epidemiology and Management of Chocolate Spot Disease

2.2.1. Origin and Taxonomy of Chocolate Spot (*Botrytis Fabae*)

The history of chocolate spot disease (*Botrytis fabae*), first described by Berkley in Britain between 1849 and 1875, although its association with the disease was not recognized at that time [27]. It was later scientifically identified by the Mexican-born Galician microbiologist Sardina in 1929, when faba bean crops were attacked by the disease in various areas of Spain. Taxonomically, chocolate spot belongs to the kingdom Fungi, phylum Ascomycota, class Leotiomycotina, order Helotiales, family Sclerotiniceae, and genus *Botrytis*. The disease is caused by *Botrytis cinerea* and *Botrytis fabae*, with *Botrytis fabae* being the most significant, as it causes serious plant damage, unlike *B. cinerea* [18].

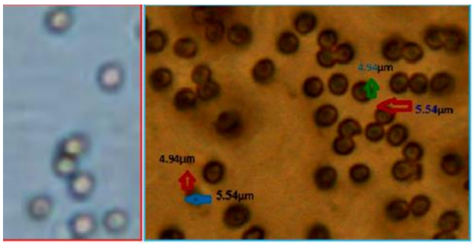
2.2.2. Biology of Chocolate Spot Disease of Faba Bean

The fungus *Botrytis fabae* has both sexual and asexual reproductive systems. Asexual reproduction occurs through the production of conidia, which are formed by conidiophores and can be seen with the naked eye on senescent leaves of infected plants [59]. Under a microscope, the conidiophore structure of *Botrytis fabae* can be observed, as shown in Figure 1. The conidia, which range from 6-18 µm by 4-11 µm in size, are the primary means of asexual reproduction for this pathogen [8]. reported the conidia size as 5.54 µm by 4.94 µm when detected under a microscope (Figure 2) [27].



Source: [27]

Figure 1. *Conidiophore of Botritis fabae observed under microscope.*



Source: [27]

Figure 2. *Conidia of Botritis fabae with measured diameter at 400x magnification.*

2.2.3. Distribution, Ecology and Epidemiology of Chocolate Spot Disease

a) Chocolate spot diseases distribution and its hosts

Chocolate spot disease (*Botrytis fabae*) is widely distributed across the globe, with reports from countries including Tunisia, Algeria, Morocco, Libya, Ethiopia, England, Spain, Norway, Germany, Russia, Japan, China, Canada, the Americas, and Australia. The disease primarily affects the leaves of faba bean but can also infect stems and flowers under severe conditions. While faba bean is the main host for *B. fabae*, minor hosts include soybean (*Glycine max*), lentil (*Lens culinaris*), common bean (*Phaseolus vulgaris*), and pea (*Pisum sativum*) [8].

b) Distribution and status of chocolate spot disease of faba bean in Ethiopia

Botrytis fabae, the causative agent of chocolate spot disease, is widespread in faba bean-growing regions throughout Ethiopia [27]. The incidence and severity of this disease, however, vary spatially across the country [28]. In Ethiopia, chocolate spot is the most damaging disease for faba bean, causing yield losses of up to 68% in susceptible cultivars. Despite the availability of high-yielding varieties capable of exceeding 2 tons/ha, smallholder farmers typically achieve an average yield of only 1.8 tons/ha [50]. Surveys in the Amhara Region in 2004 and 2005 showed widespread disease presence, with incidence rates ranging from 47% to 100% and severity indices from 17% to 49% [52]. The disease is particularly prevalent in agro-ecological zones above 2500 meters a.s.l., including the upper midland and lower highland areas, posing a significant challenge across all faba bean-growing regions in Ethiopia.

c) Ecology and epidemiology of the disease

Chocolate spot disease of faba bean (Vicia faba) is a widespread and destructive disease caused by the pathogen Botrytis fabae. This disease is prevalent in nearly all regions where faba beans are cultivated globally and is capable of causing significant yield losses, with unprotected crops suffering losses as high as 67% [56]. The disease manifests as reddish to chocolate brown spots on the upper and lower surfaces of faba bean leaves, petals, and pods. Initially, these spots appear as non-aggressive, slightly flattened lesions on the lower leaves. However, if mild, wet conditions persist, the disease becomes aggressive, rapidly progressing up the plant canopy, resulting in large patches of blighted leaves. As the disease progresses, plants lose flowers and pods, defoliate, and the stems turn reddish-brown and weakened, often leading to lodging [27].

The spread of B. fabae is facilitated by high humidity and temperatures between 15-20℃. Disease severity is closely related to environmental factors such as inoculum density, waterlogging, high plant density, and host physiology [56]. Studies have shown that relative humidity greater than 70%, along with temperatures ranging from 15 to 22℃, promote disease development. Additionally, pathogen virulence, plant age, cultivar susceptibility, and certain cropping practices can exacerbate the spread of the disease [27]. In Ethiopia, the humid conditions in the faba bean-growing highlands provide a favorable environment for the development of chocolate spot disease, contributing to its prevalence and severity.

A survey conducted in central Ethiopia revealed that chocolate spot had an incidence rate of 68%, and the disease progressed rapidly, with infection rates ranging from 0.142 to 0.164 disease units per day [50, 45]. This suggests that multiple generations of the disease can develop within a single growing season, leading to rapid and extensive crop damage. The pathogen survives as sclerotia in the soil, crop debris, and on infected seeds. When favorable environmental conditions occur, the sclerotia germinate, forming conidiophores that produce asexual spores (conidia), which are spread by wind and rain splash, contributing to the rapid spread of the disease across fields [8].

In regions with prolonged wet conditions, chocolate spot can reach epidemic proportions, causing substantial yield losses. The spots on the leaves and stems enlarge, eventually developing a grey, dead center with a red-brown margin, and spores form on the dead tissue [27]. The high susceptibility of faba bean to this disease in certain agro-ecological zones of Ethiopia highlights the need for effective disease management strategies to mitigate the impact of chocolate spot and improve crop productivity.

2.2.4. Economic Importance of Chocolate Spot Disease in Ethiopia

Chocolate spot is a major and economically damaging disease affecting faba bean crops globally, severely limiting photosynthetic activity and reducing productivity [52]. Severe epidemics can result in total crop failure, with yield losses reported as high as 90% in Australia, 59% in the UK, and over 50% in China [8]. In Ethiopia, chocolate spot is a key limiting factor in major faba bean-growing regions, causing yield losses between 34.1% and 68% [20, 55]. Under extreme epidemic conditions, losses can exceed 50%, leading to significant economic impacts [56]. Factors such as planting date, weed management, cropping systems, and previous crops influence disease occurrence and development, with varying severity depending on farming practices, field location, and the growing season [52]. Effective management of the disease is critical to mitigate its impact on faba bean production.

2.2.5. Managements of Chocolate Spot Disease

Cultural practices such as optimal sowing dates and plant population management play a crucial role in reducing the risk of chocolate spot disease in faba beans. Additionally, employing host plant resistance (HPR) through the development and use of resistant varieties can significantly mitigate disease severity. Biological control methods, including the use of antagonistic organisms, also offer promising results in managing the pathogen. Fungicide applications can be effective in reducing the disease, but they should be used judiciously. An integrated disease management (IDM) approach combining these strategies can help avoid high disease pressure and ensure better faba bean productivity [45].

a) Cultural control

Delaying the sowing of faba beans can help in reducing the intensity and duration of chocolate spot epidemics. late sowing can delay the disease onset, minimizing its impact [45]. Additionally, deep plowing of fields with high chocolate spot infection after harvest reduces the pathogen's survival and subsequent spread. Planting faba beans in a mixture with field pea at a 1:2 ratio has been shown to significantly reduce the development of chocolate spot epidemics [53]. However, this practice may not be feasible for large-scale faba bean production. Crop rotation, the burning of crop residues, and intercropping with crops like maize have also been proven effective in reducing chocolate spot severity. For instance, [34] demonstrated that faba bean-maize intercropping reduced the disease's severity by up to 28.5% compared to sole faba bean planting. These cultural practices are crucial components of integrated disease management strategies aimed at controlling chocolate spot.

b) Use of resistance varieties

Host resistance to *Botrytis fabae*, the pathogen responsible for chocolate spot disease, plays a vital role in controlling the disease and ensuring faba bean production [32]. Early sources of resistance were identified through the introduction of ICARDA germplasm to Ethiopia, which provided critical genetic material for breeding [47]. Studies such as those by [42] demonstrated significantly lower chocolate spot severity in faba bean varieties like CS20DK, Degaga, Tesfa, and Bulga. ICARDA's work has facilitated the global introduction of new resistant genotypes [45]. Post-ICARDA, resistant varieties like BPL-1179-A-1 and BPL-1802-1 were developed [42]. Furthermore, nationally released varieties like CS20DK, NC-58, and Bulga 70 have proven resilient against the disease [42]. Yield-boosting varieties such as Walki, Dosha, and Hachalu have also shown promise in terms of productivity [73]. Field evaluations consistently highlight the superior performance of varieties like Walki [70, 40]. Varieties like Moti, Gora, and Walki consistently perform well across various locations [19]. These findings underscore the importance of host resistance in managing chocolate spot and its role in enhancing faba bean productivity.

Table 1. *Information on improved faba bean varieties released nationally at federal research centers.*

No	Variety	Pedigree	Year of release	Research field ton/ha	Farmers' field ton/ha	1000 seed Weight	Altitude
1	CS20DK	CS20DK	1977	2.0-4.0	1.5-3.0	476	2300-3000
2	NC58	NC58	1978	2.0-4.0	1.5-3.5	449	1900-2300
3	KUSE2-27-33	Kuse2-27-33	1979	2.0-3.5	1.5-2.5	393	2300-3000

No	Variety	Pedigree	Year of release	Research field ton/ha	Farmers' field ton/ha	1000 seed Weight	Altitude
4	Kasa	Kasa	1980	4.5-5.5	2.5-4.0	428	1900-2300
5	Bulga 70	Coll 111/77	1994	2.0-4.5	1.5-3.5	440	2300-3000
6	Mesay	74TA12050 x 74TA236	1995	2.5-5.0	2.0-3.5	428	1800-2300
7	Tesfa	74TA26026-1-2	1995	2.0-4.0	1.5-3.5	441	1800-2300
8	Holetta-2	BPL 1802-2	2001	2.0-5.0	1.5-3.5	506	2300-3000
9	Degaga	R878-3	2002	2.5-5.0	2.0-4.5	517	1800-3000
10	Selale*	Selale Kasim 91-13	2002	2.2-3.3	1.0-2.3	346	2100-2700
11	Wayu*	Wayu 89-5	2002	1.8-3.2	1.0-2.3	312	2100-2700
12	Moti	ILB4432 x Kuse 2-27-33	2006	2.8-5.1	2.3-3.5	781	1800-3000
13	Gebelcho	ILB4726 x Tesfa	2006	2.5-4.4	2.0-3.0	797	1800-3000
14	Obse	CS20DKxILB 4427	2007	2.5-6.1	2.1-3.5	821	1800-3000
15	Dosha	Coll 155/00-3	2008	2.8-6.2	2.3-3.9	704	1800-3000
16	Wolki*	Bulga70x ILB 4615	2008	2.4-5.2	2.0-4.2	676	1800-2800
17	Tumsa	Tesfa x ILB 4726	2010	2.5-6.9	2.0-3.8	737	2050-2800
18	Hachalu*	ILB2717x CS20DK	2010	3.2-4.5	2.4-3.5	890	1900-2800
19	Gora	EH91020-8-2x BPL44-1	2012	3.0-5.0	2.0-4.0	980	1800-2800
20	Didi'a*	ILB 2717 x R878-3	2014	3.5-4.6	2.0-4.4	700	1800-2800
21	Ashebeka*	N861085xBPL1297-1	2015	3.0-5.0	2.8-4.7	885	1900-2800
22	Numan	EH99037-5xILB-1563	2016	2.2-3.8	3.6-5.1	1069	1800-3000

Source: [44]; *Released for vertisol areas/waterlogging problem areas, 1-18 and 19-22 released at Holetta and Kulumsa agricultural research centers, respectively

c) Biological control

Biological control agents show great potential in managing chocolate spot disease. identified *Trichoderma ovalisporum* and *Trichoderma longibrachiatum* as effective natural antagonists of *B. fabae* on faba bean leaves in Ethiopia [54]. evaluated six bioagents, including *Trichoderma harzianum*, *T. viride*, *Bacillus subtilis*, *Pseudomonas putida*, *Pseudomonas fluorescens*, and *Ampelomyces quisqualis*, and found that *T. harzianum* exhibited the highest efficacy, inhibiting 79.2% of fungal growth [22]. In contrast, *Bacillus subtilis*, *T. viride*, and *A. quisqualis* showed moderate inhibition, while *P. fluorescens* and *P. putida* were least effective. highlighted bio-priming as an innovative, integrated approach for disease control, offering an alternative to chemical fungicides amidst growing regulatory restrictions [27].

d) Use of fungicides

Several chemical fungicides, including systemic and protective types, have been evaluated for managing chocolate spot disease. tested four fungicides—mancozeb, fungozeb, nativo, and diprocon—and found fungozeb and mancozeb most effective in reducing symptoms [72]. studied Folpan, Mancozeb, and Mancolaxyl, with Mancozeb foliar spray proving effective, increasing yield by up to 22% [1]. Additionally, [5] highlighted the efficacy of Mancozeb at 3 kg/ha. [45] found Dithane M45, Galben mancozeb, and copper oxychloride effective against chocolate spot in vitro. Fungicides are widely used globally, with recommendations based on cost-effectiveness and damage thresholds [56].

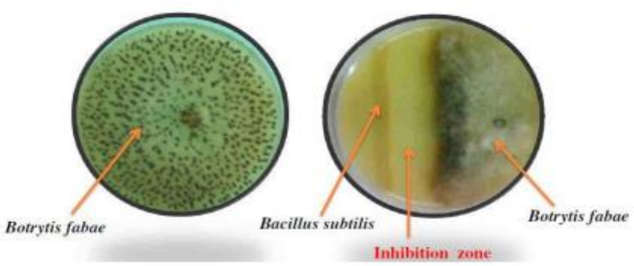


Figure 3. Antagonistic efficiency of Bacillus subtilis against B. fabae (Source: [45]).

e) Integrated disease management

Integrated Disease Management (IDM) is essential for controlling chocolate spot in faba bean, combining cultural practices, resistant host plants, fungicide applications, and biocontrol agents. Emphasize that a single management practice is insufficient, but a combination provides effective control [17]. Support this integrated approach, noting that it not only manages disease but also boosts crop productivity, contributing to food self-sufficiency [54]. Research by [72] highlights that fungicide treatments, such as fungozeb, increase yields, with the highest yield of 4.0 ton/ha in Walki. Mixed cropping with cereals and Mancozeb spray reduces disease incidence and increases grain yield and seed weight, as noted by [53]. Further studies by [3, 30], support the benefits of cereal intercropping with faba bean. [45] by demonstrates that IDM reduces chemical dependence through resistant varieties and practices, and that optimal sowing dates and fungicide use significantly control the disease. These strategies increase crop resilience while reducing chemical usage.

3. Conclusions and Recommendations

The management of faba bean chocolate spot (*Botrytis fabae* Sard.) disease in Ethiopia presents a significant challenge to smallholder farmers and the country's agricultural productivity. The disease, which affects both the foliage and overall plant health, leads to severe yield losses, with some reports indicating up to 68% reduction in yield under high disease pressure. Factors such as high humidity, improper crop rotation, and lack of resistant varieties exacerbate the problem, making the disease a persistent threat across various agro-ecological zones. However, there are numerous opportunities to improve chocolate spot management. Integrated Disease Management (IDM), which combines cultural practices, host plant resistance, biological control, and judicious use of fungicides, has shown promise in reducing disease severity and improving yield. The use of resistant faba bean varieties, biological agents like Trichoderma spp., and improved agronomic practices such as late sowing and mixed cropping, offer practical and sustainable solutions.

Looking ahead, continued research into new resistant varieties, effective biological control agents, and refined IDM strategies is essential. Collaboration between farmers, researchers, and extension services is key to successfully managing chocolate spot and increasing faba bean productivity in Ethiopia. By overcoming current challenges, there is potential to enhance food security, improve livelihoods, and boost the economy through increased faba bean production.

Abbreviations

IDM	Integrated Disease Management
ICARDA	International Center of Agricultural Research in the Dry Areas
CSA	Central Statistical Agency
EIAR	Ethiopian Institute of Agricultural Research

Conflicts of Interest

The authors declare no conflicts of interest.

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