



Science

INTEGRATED MANAGEMENT OF CHOCOLATE SPOT (*BOTRYTIS FABAE*) DISEASE OF FABA BEAN (*VICIA FABAE L.*) IN ETHIOPIA: A REVIEW

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Abstract

The primary producers of pulses are small-scale farmers with small and dispersed plots under rain-fed conditions with substantially lower yields of less than 0.9 t/ha as compared to the improved faba bean varieties and international yields. 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 comprises all available diseases management methods in combination that is IPM (Integrated Pest management). So, the objective of this review work was to review available integrated pest management option for management of chocolate spot disease of faba bean in Ethiopia. We can control the disease by using different methods from these late sowing of faba bean, mixed cropping of faba bean with cereal crops and mancozeb spray reduced the disease and increased the grain yield and seed weight over sole and mixed cropping with field pea; also cereal mixing with faba bean has advantages over faba bean mixing with field pea. Suppressive effects can be ascribed to a combination of host biomass reduction, altered microclimate and physical barriers to spore dispersal. Also 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. In Ethiopia, study has revealed that the biological control agents for chocolate spot of faba bean and Bacilli are natural residents of faba bean leaves. Additionally recommendation have been given that, further study has to be done to explore the mode of action by bacillus subtilis against fabae.

Keywords: Faba Bean; *Botrytis Fabae* Sard; Chocolate Spot; *Bacillus Subtilis* and IPM.

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1. Introduction

The faba bean (*Vicia faba* L.) in Ethiopia locally known as "Bakela" has been grown in the highlands of Ethiopia between 1800 and 3000 m above sea level. For many decades and the country is now considered as one of the centers of secondary diversity for the crop [3]. The crop occupies the largest areas among legumes and the total area under cultivation is estimated to be about 443,107.88 ha from which 8,389,438.97 quintals of grain yield is harvested [6]. The primary producers of pulses are small-scale farmers with small and dispersed plots under rain-fed conditions with substantially lower yields of less than 0.9 t/ha as compared to the improved faba bean varieties and international yields. 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 [14, 24]. 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 [14]. [24] Reported even higher losses of 67.5% in the unsprayed faba bean plots in northwest Ethiopia.

The production of the crop is enormously declining as the local faba bean cultivars are entirely attacked by chocolate spot and other diseases in southwest Ethiopia [23]. But we can manage this economically important diseases in manner which comprises all available diseases management methods in combination that is integrated management of diseases (IDM) which is synonymous to IPM(Integrated Pest management). So, the objectives of this work were to review available integrated pest management option for management of chocolate spot disease of faba bean and to point out the gaps in this area.

2. Literature Review

2.1. Faba Bean

The faba bean (*Vicia faba*) is belonging to tribe Viciaeae. Herbs with pinnate leaves and grows upright, ranging from 1-1.5 meters tall. It is an annual legume with one or more strong, hollow and erect stems. Faba bean has a strong taproot, compound leaves, and large, white flowers with dark purple marking. A flower cluster may produce 1-4 pods. The pods are large (up to 10 cm long and 1-2 cm wide) and green, turning dark at maturity.

Three to four oblong/oval seeds are contained within each pod. Flowering occurs in 45-60 days and requires 87-176 days to mature [1].According to [19] faba bean (*Vicia faba*) is classified into two subspecies *paucijuga* and *eu-faba*. Three varieties are recognized within *eu-faba*, the large seeded var. major, the intermediate var. equina, and the small seeded var. minor. Although *Vicia faba* was originated in the Mediterranean-Near East region, it is a temperate crop in its adaptation and has similar requirement with other pulse crops in the tribe *Viciaeae*. 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 [1].

However, this crop is one of the earliest domesticated food legumes and is now cultivated on large areas in many countries due to its high nutritive value in terms of energy and protein contents (24-30%). China leads in production, followed by Ethiopia, Egypt, Italy and Morocco. The crop occupies the largest area among the pulses in Ethiopia. Even though Ethiopia is the

world's second largest producer of faba bean, its share is only 6.96% of world production and 40.5% of Africa due to numerous diseases and other a biotic factor that affect the faba bean production and productivity. Therefore, increasing the crop production through using appropriate diseases management is one of the most important targets of agricultural policy in Ethiopia.

2.2. Economic Importance of the Disease

Chocolate leaf spot is caused by both *Botrytis cinerea* Pers. ex Pers. and *Botrytis fabae* Sard. A teleomorph of *B. fabae*, *Botryotinia fabae*, was described by [26]. *B. 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 on the basis of reaction to differentials in Mediterranean countries. More works have to be done to understand variability in *B. fabae*. Chocolate spot, caused by *Botrytis fabae*, is one of the major diseases of faba bean nationwide [5, 13]. [9] Recorded yield loss of up to 61% for susceptible genotypes and 34% for tolerant genotypes. 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 [15]. In Negash areas, Tigray, in 2000 seed yield loss of 62% was due to this disease.

2.3. Ecology and Epidemiology

The pathogen infects the leaf tissue, petioles, stems and seeds [11]. It survives as sclerotia in infected plant debris for more than a year. According to [11] 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. The fungus *B.fabae* was recovered from infected plant debris stored in Nitosol after 12 months, But not from that stored in Vertisol [13]. Apparently, soil type and depth at which infected plant residues are located have an effect on the biology of the fungus, and this might have practical implication on disease management.

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

3. Control of the Disease

3.1. Integrated Pest Management (IPM) or Integrated Disease Management (IDM)

The main emphasis in research and development to combat food legume diseases is on host resistance and chemical control where ever applicable, and quite often these components of disease management were practiced in isolation to each other. 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 (IDM). Integrated Pest management has been defined in many ways. One widely used definition was formulated by the United States Department of Agriculture in 1996, stating that IPM is “a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks” or integrated pest management is a process we can use to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere in urban, agricultural, and wild land or natural areas.

The word “pests”, in this definition, includes diseases and weeds as well as animals. The list of management tools often also includes genetics, i.e., resistant cultivars, and some definitions specify lack of impact on non-target organisms or mention maximizing the benefits as well as minimizing the risks. Further key aspects of IPM are the understanding of the biology of the pest, in order to model and predict outbreaks, and the concept of thresholds of damage, at which it becomes economically worthwhile to apply control methods. An individual management practice may not reduce the level of disease to an acceptable level, whereas the additive effect of several practices will be done. An integrated approach is the key to successful management of chocolate spot in faba bean. In general IDM has followed the principles of IPM [19]. The location specific IDM of faba bean is primarily based on host plant resistance (HPR) or genetic resistance; additionally other components of diseases management.

In some environments, IDM may require a single component used alone (usually HPR) or in combination with one other component (such as fungicide seed treatment) to adequately combat diseases of faba bean. The components of IDM employed in the production of faba bean are listed as follows:

- Cultural (agronomic) practices (sowing dates, plant population etc.).
- Host plant resistance (HPR),
- Biological control
- Chemical sprays (fungicides, pesticides),
- Disease modeling (prediction) for avoidance of high risk or disease pressure,

The combination of genetic resistance, hygiene and monitoring of crops for threshold levels of infestation, allows the most economic and effective controls with the result that economic yields can be maximized.

Table1: Progress in integrated chocolate spot management of faba bean

Crop	Disease	Component of IDM/IPM			
		HPR	AP	CC	BC
Faba bean	Chocolate spot	***	*	**	
					X

Note:*, **, ***=low, medium and High potential respectively; X=Not common

Source: Jellis et al., 1998

3.1.1. Cultural Control

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 [10]. However, seed yield harvest from the late sown crop is considerably less than that of early sown crop.

Research report done by [16] revealed that, deep plowing of the fields with high chocolate spot infection immediately after harvest reduce the risk of disease development. In addition, early sowing, use of improved cultivars varieties and fungicide (chlorothalonil at a rate of 2.5kg a.i. per hectare once or twice after disease infection reached 30%) avoid the occurrence of chocolate spot disease at epidemic proportions. Another research done by [4, 12] depicted that, 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 [1]. 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 [17].

3.1.2. Use of Resistance/Tolerant Varieties or Host Resistance

Enormous differences exist among local and exotic genotypes with respect to resistance or tolerance [8, 13, 16, and 27] which could be exploited to breed chocolate spot resistant faba bean varieties.

Research done by [23] 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%. Also research done by Gebrehiwot, (2011) revealed that faba bean genotypes varied greatly in their resistance. Meanwhile, the resistant genotypes EH00012-4, EH01046-1, EH00053-1 and EH01021-1 should be further evaluated for their possible use in future for faba bean improvement program. Similarly Faba bean collections have been screened for response to chocolate spot and evaluation methods improved [5]. 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 [25]. 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 [23]. From the landrace collections, a number of 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 [23]. This indicated that there is an opportunity to find resistant varieties in the future which help in increment of faba bean production in Ethiopia as well as it will be incorporated in integrated disease management strategies.

3.1.3. Biological Control

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 [25]. In Ethiopia, study revealed that the biological control agents for 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.

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 management of chocolate spot disease of faba bean [24].

Also study which was conducted by Kharrat Mohamed confirmed that *Bacillus subtilis* which is gram positive and obligate bacteria had role as 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 the found that the *bacillus* have greatest potential to control chocolate spot disease of faba bean so, finally they conclude that *B. subtili* can be further recommended as 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*.

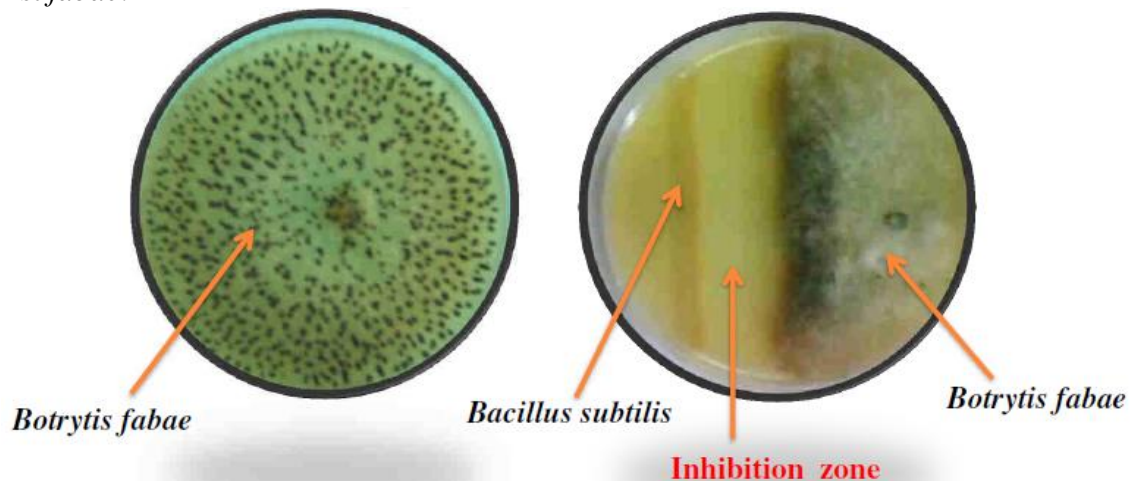


Figure1: Antagonistic efficiency of *Bacillus subtilis* against *B.fabae*. From this trial they get 62.96% growth reduction of *B.fabae* (Kharrat .M, 2015).

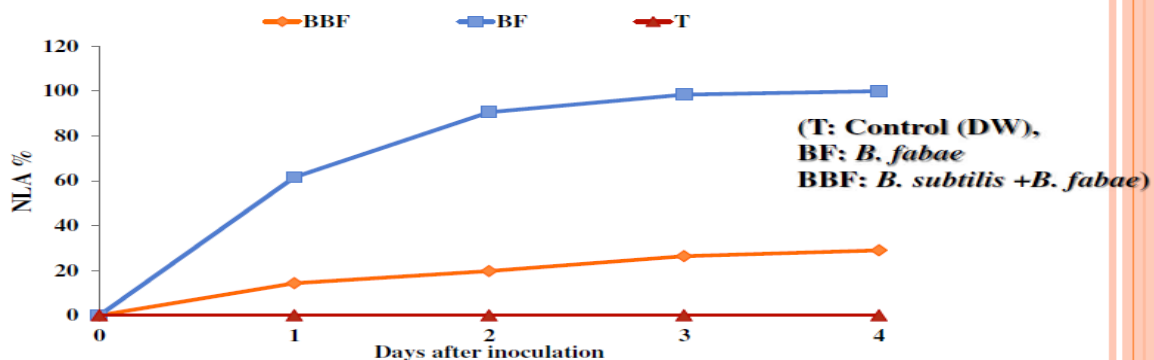


Figure 2: Effect of *Bacillus subtilis* on chocolate spot disease on detached leaf Also from this trial they found that *B.subtilis* was efficient in controlling chocolate spot disease (Kharrat. M, 2015).

3.1.4. Chemical Control

Several chemical (fungicides), both systemic and protectant were tested for control of chocolate spot in the past [18]. From these, chlorothalonil, benomyl +mancozeb were effective against chocolate spot. Chlorothalonil completely protected faba bean plants from infection when applied at weekly intervals, but extended intervals 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 2.5kg a.i. per hectare of once or twice after disease infection has reached 30% severity level [10]. The experiment that were done by using three to four sprays were applied, mancozeb at a rate of 0.7kg per hectare proved more effective than chlorothalonil [2]. According to the concept of integrated disease management, chemical treatment should only be applied as supplement to combat chocolate spot risk.

3.1.5. Integrated Disease Management

These are controlled through the use of Integrated Disease Management (IDM). Used alone, an individual management practice may not reduce the level of disease to an acceptable level, whereas the additive effect of several practices will be done. An integrated approach is the key to 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 [24, 25]. Similarly [3, 17] also found that cereal mixing with faba bean has advantages over faba bean mixing with field pea. 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 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 [22].

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 [21]. 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 [16]. With this background Ermiyas and Addisu, 2013 done some research to identifying 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 out put 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 1-9 scale) was recorded from last sowing date plot which received four times fungicide spray (Table2).

Table2: Effect of sowing date and fungicide spray frequency on 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 like wise.

Source: Ermiya *et al.*, 2013

From their study they found similar result with what [14] found that is as an effect of integrated use of the three management options; the highest yield (3903.6 kg-1ha) was harvested from plot treated with early sowing and four times fungicide spray. Finally they conclude that adjusted sowing date with resistant variety and judicious use of herbicide can be used as good option of chocolate spot management.

4. Summary and Conclusion

The faba bean (*Vicia faba*) is belonging to tribe Viciae. 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 [24]. But, there are many biotic and abiotic factors which hampers faba bean production in Ethiopia. From biotic factors chocolate spot (*Botrytis fabae*) is the major fungal disease hampering faba bean production in Ethiopia [14, 25]. 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 [14].

We can control the disease by using different methods from these substantial delays 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 [10]. Also 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 [24, 25]. Similarly [3, 17] also found that cereal mixing with faba bean has advantages over faba bean mixing with field pea. Chocolate spot was significantly reduced when faba bean was intercropped with cereals, but not when intercropped with legumes. Suppressing effects can be ascribed to a combination of host biomass reduction, altered microclimate and physical barriers to spore dispersal. Also 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 [25]. 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 [21]. In addition, early sowing, use of improved varieties and fungicide protection avoid the occurrence of chocolate spot disease at epidemic proportions [16]. Research done by Ermias and Addisu, 2013 revealed similar result. A fungicide (Mancozeb @2.5kg/ha) was integrated with sowing date and resistant faba bean variety "shalo". As an effect of integrated use of the three management options; the highest yield (3903.6 kg-1ha) was harvested from plot treated with early sowing and four times fungicide spray. Similarly, the highest TKW (543.53 gm.) was also recorded from the plot with the highest yield, which is similar to the result of [14]. In general we have to use all available control measure in combination to get a better control of the disease. Also studies which are done in our country and abroad regarding biological control of chocolate disease had shown the possibilities of controlling of *B.fabae* using some antagonistic fungi and bacteria. Isolate of *Trichoderma ovalisporum* and *Trichoderma longibrachiatum* as effective antagonists of *B. fabae* for the first time [25]. In Ethiopia, study has revealed that the biological control agents for 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. 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 management of chocolate spot disease of faba bean [24]. Also study which was conducted by Kharrat Mohamed and by his colic's confirmed that *Bacillus subtilis* which is gram positive and obligate bacteria had role as 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 they found that the *bacillus* have greatest potential to control chocolate spot disease of faba bean so, finally they conclude that *B.subtilis* can be further recommended as

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