ISSN 2515-8260 Volume 07, Issue 06, 2020

Evaluating faba bean cultivars and fungicide spray intervals for managing the chocolate spot (*Botrytis fabae* Sard.) disease in Chelia district, West Shewa, Ethiopia.

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ABSTRACT

The experiment was conducted in Farmers Training Center (FTC) at Chelia district, West Shewa Zone, Ethiopia especially on cropping season of 2018, for evaluating four faba bean cultivars (Walki, Hachalu, Asebeka and Local) and the efficacy of the fungicide, Trust –Cyomp 439.5 WP at the rate of 1.5 kg/ha at four various spray intervals (once in a week, after two weeks, after three weeks and unsprayed-control) based on conditions on the field for maintaining and managing faba bean chocolate spot disease and its impact on both yield and its relevant components. Entirely sixteen treatments are involved in factorial allignment in Randomized Complete Block Design (RCBD) with three replications. The chocolate spot disease incidence, criticality and region under disease progress curve were the highest in cultivar Local followed by Ashebeka, Hachalu and Walki in unsprayed plots. Among different spray intervals, weekly applied plots were found the most effective in disease reduction with maximum reduction in Walki and minimum in Local cultivar. The effectiveness of cultivars along with spray intervals of fungicide displayed significant variations in pods per plant, yield of the grain, and hundred seed weight; and had no significant effects on seeds per pod. The relative yield loss of 37.31, 35.0 29.0 and 28.5% were recorded from Local, Ashebeka, Walki and Hachalu in unsprayed plots, respectively. Economic analysis showed that the highest net benefits were obtained from Hachalu and Walki (46400 and 44480 birr/ ha) when sprayed at every two weeks intervals and from Ashebeka and Local, the highest benefit (41760 and 36640 birr /ha) was obtained on every one week sprayed interval plots and the least was obtained from Local unsprayed plots (28160birr /ha). The Highest rate of margin based on return was achieved when it was sprayed at every two weeks intervals by Ashebeka (374.3%) followed by Hachalu sprayed at every three weeks spray intervals (227%), but the lowest was obtained from local with spray of fungicide at every three weeks intervals (Birr 42%). The results of this study provide evidences that the reactive nature of faba bean cultivars to weekly and two weeks spray intervals of fungicide applications found to be effective in reducing chocolate spot severity and increased seed yield of faba bean cultivars under field conditions in Chelia district, Ethiopia.

Key words: Faba bean, Cultivars, Fungicides, Spray intervals, Chocolate spot disease, Yield and yield loss, Cost-benefits analysis.

Introduction

Faba bean (*Vicia faba* L.) is widely grown in the mid-altitude and highland areas (1800-3000 m. a. s. l.) of Ethiopia, where the soil and weather conditions are considered to be conducive for better growth and development of the crop (Crepona *et al*., 2010). It is utilized as a salient food for human in developing countries and animal feed in industrialized countries (Abebe *et al.*, 2014). The faba bean has a high Feeding value and this legume has been taken into consideration as a meat extender and also has a high nutrient with respect to energy and protein content (24-30 %) along with an excellent nitrogen fixer (Sahile *et al.*, 2008).

Leading producers of Ethiopia is faba bean in the world next to China and Egypt (Torres *et al*., 2006). It has gained significant importance for faba bean which is chosen as an export crop in Ethiopia by farmers for increasing the grains in the area under production (Sahile *et al.,* 2008) for 348,400 ha in 1993-95 to 427,696.80 hectares in 2018 with yield increased from 1 t/ha to 1.9 t/ha, respectively. The area under production of faba bean grains. The improved varieties yields high productivity (3.5 t/ha) compared to the country average yield (1.8 t/ha) (CSA, 2017). Oromia and Amhara are the two major faba bean producing regions of Ethiopia with 85% of the national faba bean production. West Shoa zone which is found in Oromia region occupies an area more than 20,000 hectares with annual production of 56,576.08 tones and productivity 1910 kg/ha (CSA, 2017).

The low crop productivity is accredited to proneness relevant to biotic and abiotic stresses (Sahile *et al*., 2008; Mussa *et al*., 2008). With relevance to biotic stresses, essential factors related to diseases are limited in the yield of food-legume crops as a complete and faba bean specifically in Ethiopia (Nigussie *et al.*, 2008; Berhanu *et al.*, 2003). Chocolate spot (*Botrytis faba* Sard) is one of the most destructive disease affecting faba bean productions throughout the world (MacLeod and Galloway, 2006; Torres *et al*., 2006). It is more prevalent and disease seems to be destructive, leading to production loss up to 61% among proned cultivars and 34% among tolerant cultivars in Ethiopia (Dereje and Yaynu, 2001). Endale *et al.* (2014) reported that faba bean chocolate spot disease is highly distributed aggressively in the Western parts of the country with prevalence of 100%. Similarly, Alemayehu *et al.* (2018) reported that the mean severity of chocolate spot disease in West Showa zone was ranged from 32.6 to 57 % and maximum disease severity of chocolate spot was recorded in Chelia district, West Shewa, Ethiopia.

Techniques on managing has been developed in different countries for reducing the losses in yield of faba bean mainly due to chocolate spot disease. These management options include using resistant/ tolerant genotypes, the use of chemical fungicides, adopting certain traditional practices like crop residue management and sowing date alteration (Dereje, 1993; Hawthorne, 2004). Among them, resistant varieties are the most preferred control method providing a practical, long-term and friendly to environment that means minimizing the risk from the diseases. Also, the most effective fungicides has been broadly used strategy and provides effective and reliable disease control measures (Mohamed *et al*., 1996; Teshome and Tagegn, 2013), but fungicides may not be equally effective under different weather conditions and economically feasible all over the country. More research work is expected to control the faba bean chocolate spot disease through various fungicide evaluation efficacies, because the disease still causes much devastation on crop in the country.

In Ethiopia, the protectant for fungicides need to be applied often during wet weather for inhibiting spore germination and penetration, once the pathogen enters the leaves spraying contact fungicide become ineffective. Trust-Cymocop 439.5 WP is a product having active ingredients (Copper oxchloride 397.5g/kg + cymoxanil 42g/kg), which is protectant and curative could be controled faba bean chocolate spot after infection and provide more alternatives for the management of the disease to farmers in Ethiopia. Integration of fungicide with faba bean cultivars will minimize the need of frequency of application of fungicide and able to decrease the risk to human health, contamination in the environment and improve the economic benefit of farmers. There is no documented information using of faba bean cultivars combination with Trust-Cymocop 439.5 WP fungicide and the efficacy of application frequency and application interval relationship against chocolate spot of faba bean control in central high lands of Ethiopia. Therefore, this study was carried out to investigate the integrated handling of faba bean chocolate spot using faba bean cultivars and fungicide application efficacy at different spray intervals under field conditions in Chelia district, West Shewa, Ethiopia.

Materials and Methods

Study area Description

Chelia District is located 186 km West of Addis Ababa and its geographic location is $9^0$00’N latitude and $37^0$29’E longitude. The altitude ranges from 1700-2900 m.a.s.l with temperature ranging from 9-25^{o}C with annual rain fall 1200-1500 mm where the type is black soil and loam soil with pH 6.8. The site is preferable for epidemic chocolate spot development each year due to natural conditions.

Materials used:

The experiment was conducted in Farmers Training Center (FTC) at Chelia district, West Shewa Zone, the main cropping season of Ethiopia during 2018-2019 is to evaluate four faba bean cultivars (Table 1) and the efficacy of the fungicide, Trust –Cyomp 439.5 WP at the rate of 1.5 kg/h at four spray intervals (every one week (six times), two weeks (3 times), three weeks (two times) and unsprayed-control) under field conditions for the management of faba bean chocolate spot disease and their impact on yield and yield components.

Experimental design and their applications

Collaboratively sixteen treatments were taken into consideration where the unsprayed control are presented in a composite arrangement in Randomized Complete Block Design (RCBD) with 3 replications (Table 2). Planting was done on 26th June 2018. Each experimental plot size consisted of 2.4 m x 2m area which has a total of six rows (with four harvestable central rows), distance between the plant 10 cm and between the rows 40 cm. The Spacing value among the blocks was measured 1 m and between adjacent plots 0.5 m. Seeds plantation are at the rate of two seeds per hole and thinned to one plant, 15 days after germination to ensure 72 plants per plot. One line contains 12 plants and total plants per plot were 72. NPS fertilizer, 100 kg was applied for all the treatments. Spraying of fungicide was started with the initial appearance of disease and continue based on spray schedule assigned for each treatment, unsprayed left as control. The fungicide was applied based on the requirement of the manufacturers using a knapsack sprayer that is operated manually with 15 liter capacity and applied through foliar spraying at the rate of 1.5 kg ha^{-1}. When fungicides are sprayed, plastic sheet was used to reduce fungicide drifts to adjacent plots. All agronomic practices were adopted for each plot uniformly.

Disease assessment

Disease incidence (number of plants infected) and criticality of chocolate spot was assessed as of the disease one set at 8 day's interval from pre tagged 12 plants/plot in four central rows of each plot. The total Number of plants which displayed the symptoms of chocolate spot was counted and percentage of disease incidence (PDI) was enumerated based on the formula by Wheeler, (1969).

$$\textbf{Disease incidence}\ (\%) = \frac{\text{Number of infected plants}}{\text{Total number of plants assessed}} * \mathbf{100}$$

The severity of chocolate spot disease on the leaves of faba bean was scored using standard disease scales 0-9 (Table 3) (Ding *et al.*, 1993)

$$\textbf{Severity} = \frac{\text{Area of Diseased tissue}}{\textbf{total tissue area}} x100$$

The grade on severity was then converted in to Percentage of Severity Index (PSI) according to the formula by Wheeler (1969)

$$\textbf{PSI} = \frac{\textbf{Sum of numerical ratings}}{\textbf{Number of plants scored X Maximum score on scale}} x100$$

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Reduction% (Efficacy % of fungicide interval) = $\frac{\textbf{DSC} - \textbf{DST}}{\textbf{DSC}} x10$

Where: DSC = Disease severity % in the control. **DST** = Disease severity % in the treatment

The Disease affected area in Progress Curve (AUDPC) was obtained from the PSI data recorded at involved dates of assessment as described by Campbell and Madden (1990)

$$\textbf{AUDPC} = \sum_{i=1}^{n-1} 0.5(X_{i+1} + X_i)(t_{i+1} - t_i)$$

Where n is total numbers of assessments, t1 estimates the time of ith assessment in days from the first assessment date, x_i is percentage of disease severity at i^{th} assessment. AUDPC will be expressed in percent days because the severity (x) will be expressed in percent and time (t) in days.

Disease progress rate: The rate of disease progress in time was calculated from severity of chocolate spot taken at 8 days intervals right from the aspect of initial stage of disease symptoms until the maturity of the crop in the different treatment.

Assessment of crop growth, yield and yield components

Growth parameters:

Total days to flowering for every plot was recorded on plot bases when 50% of the plants on the plot flowered and date of 90% maturity level for physiological state The height of the plants from the ground to the tips of six random sampled plants was measured at maturity.

Yield and its relevant components

The total number of plants per pod and seeds per pod was recorded on six randomly taken plants from 12 pre tagged plants from four central rows and their corresponding mean was recorded as number of pods/plant and seeds /pod, respectively. Hundred seeds weight was also obtained for each treatment. Faba bean grain yield production was obtained from four middle rows of each plot, ignoring two outer rows on both sides for avoiding the border effect. The pods that are harvested was dried in the sun and the corresponding seed yield of the different treatment was calculated. The total yield data gram per plot of each plot was converted to kg per hectare.

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Relative percent of yield loss and yield increase

The relative percentage of yield and yield component loss from each plot was computed using the following formula:

$$\textbf{Relative yield loss (\%)} = \frac{\text{Ybt} - \text{Ylt}}{\text{Ybt}} x100$$

Where, Ybt is yield of best treatment (maximum protected) and Ylt, the yield of lower treatments.

Also at the same time, increase percent in all parameters was calculated by the following formula:

$$\textbf{Yield increase over untreated check} = \frac{\text{treated} - \text{un treated}}{\text{treated}} x100$$

Economic analysis of fungicide applications

Currently cost of the grain yield per 100 kg and total sale from one hectare, cost of fungicide to spray one hectare for each treatment and labor cost to spray one hectare for every week, every two weeks and every three weeks were considered. The Prices of grains were gathered from local markets at Chelia District and total average sale from one hectare was calculated. The total price includes cost of the input like fungicides and labor cost ha^{-1} to spray one hectare land in every one, two and three spray intervals was also computed. This price was used to estimate the total returns. The cost of fungicides was estimated based on the price of company. Cost of spray and its equipment utilized for spraying every one week, two weeks and three weeks per hectare were also calculated. Cost of production practices, cost of land preparation, planting, harvesting and weeding were remained the same. According to the data recorded, benefit and cost analysis was performed using partial budget analysis (CIMMYT, 1988).

For assessing profitability the partial budgeting is employed incorporated with new technologies in practice and imposed to the agricultural business (CIMMYT, 1988). A net return for each spray frequency was calculated by reducing the cost of protecting the fungicide from the total return of that spray frequency. According to Marginal analysis with the process of choosing an alternative between factor-product small changes in the combinations. A criterion return Marginal rate calculates the effect of complimentary version capital invested on net returns using new managements compared with the previous one. It provides a benefit value obtained per the cost of supplementary cost incurred percentage (CIMMYT, 1988).

The formula is as follows $\mathbf{MRR} = \frac{\mathbf{DNI}}{\mathbf{DIC}}$

Where, DNI difference in net income compared to control, and DC =difference in input cost compared with control.

Statistical analyses:

The Occurrence and intensity of chocolate spot disease in each cultivar and each spray interval of the fungicide at all frequencies are analyzed. Analysis of variance (ANOVA) is done on disease parameters, growth parameters, yield and yield components using Statistical Analysis System (SAS) version 9.1.3 software (SAS Institute, 2002). Treatment means was separated using Least significant difference (LSD) at P<0.05 by the method described by Gomez and Gomez, (1984). For examining the correlation between intensity of the disease (AUDPC, the independent variables) Correlation analysis was performed and their yield in the field plots are taken into consideration.

Results and discussion

Effect of fungicide spray intervals on faba bean chocolate spot incidence:

The average disease incidence in all unsprayed faba bean cultivars ranged from 16.11 to 18% at the first date of assessment with minimum in Walki (16.11%) and maximum (18.00%) in local. The lowest disease incidence was recorded on Walki and Hachalu cultivars at all disease assessment dates compared to Local and Ashebeka cultivars. The disease was more rapidly on the unsprayed cultivar Local, which showed higher level of final disease incidence (97.22 %) followed by Ashebeka cultivar (94.44%) than other cultivars. At final date of assessment mean chocolate spot incidences were recorded as 77.67, 91.66, 94.44 and 97.22 % on the cultivars Walki, Hachalu ,Ashebeka and Local, respectively **(**Table 4). Disease incidence on Walki was reduced by 20% over local and 17% over Ashebeka cultivars. Minimum disease incidence recorded on Walki may be due to the inherent resistance allowing cultivars to resist the attack of the pathogen. This result is similar with Alemayehu *et al. (*2018) who reported that Walki cultivar showed lower disease incidence than Local. The report of Sahile *et al*. (2008) indicated that the disease development rate is affected by the resistant level of the crop.

The observations on sprayed plots with fungicide every 1 and 2 weeks on all cultivars showed significantly will lower disease incidence compared to the plots sprayed every three weeks and unsprayed plots. Among the fungicide spray interval, at the final stage of assessment the highest mean incidence was recorded from Local and Ashebeka plot sprayed every three weeks. Similarly, the least mean incidence was recorded from Walki (32.22%) and Hachalu (38.8 %) plots sprayed every one week, respectively. It was observed that there was a gradual decrease in disease incidence with the increase in spray frequency. On the final date of disease assessment (112 DAP) spraying fungicide at every one week, two weeks and three weeks spray interval reduced disease incidence by 58.51%, 49.92 % and 32.2% on Walki; 52.56, 44.97 and 27.56% on Local; 54.4, 54.4 and 36.28% on Hachalu and 54.4, 51.48 and 22.28% on Ashebeka cultivar as differentiated to unsprayed control plots, respectively (Table 4). The results indicated that weekly applications of fungicide resulted in maximum disease incidence reduction in all cultivars compared to the other spray treatments.

Effect of fungicide spray intervals on faba bean chocolate spot severity

The disease severity interaction between the spray intervals and cultivars were significant in reducing chocolate spot disease ($P \leq 0.01$). The recorded data, on the first date of severity assessment (72 DAP) showed that disease severity in all faba bean cultivars ranged from 9.96 to 12.96% (Table 5). At this assessment date (72 DAP) the highest mean initial disease severity was 12.96 % recorded on unsprayed Ashebeka cultivar and lowest mean initial disease severity 9.96 % was obtained from the variety of Walki, There were no significant variations on parentage of disease severity index at first date of assessment on Walki cultivar. Chocolate spot severity increased rapidly immediately after the appearance of the first symptoms. The percentage of severity index at final stage (112 DAP) remained high in unsprayed plots, showing 34.03% for Walki, 40.12% for Hachalu, 53.85% for Local and 50.66% for Ashebeka when compared to sprayed plots (Table 5). The disease increase was higher on local and Ashebeka as compared to Walki and Hachalu cultivars.

The disease was less severe in all faba bean cultivars plots treated with fungicide as compared to untreated plot. Untreated plots were significantly different from sprayed plots at all assessment ($P<0.01$). However, there was no significant different observed between every three weeks spray intervals and unsprayed at 72, 80 and 112 DAP on Local cultivar. This may be due to high disease pressure on susceptible cultivar. In this study the weekly application of fungicide for all faba bean varieties reduced the severity of chocolate spot at final disease assessment compared to other spray intervals. At last disease assessment date (112DAP), the recorded disease severity from plots weekly applied fungicide was Walki (16.66 %), Hachalu(16.53%), Ashekaba (17.59%) Local (17.89 %) compared to other spray schedule. The low disease severity scored from weekly applied fungicide could be due to frequent application of fungicide can reduce primary infection and confined secondary inoculum sources between plants. The highest disease severity reduction (51 to 69.63%) was observed from frequently applied plots on all cultivars. Generally, this result indicates disease severity decreased as fungicide application spray intervals decrease. At final day of assessment, every one week, two weeks and three weeks spray intervals, reduced disease severity in Walki (51.00, 44.23and 13.50%) followed by Local (69.69, 54.00 and 7.2 %), Hachalu (55.41, 43.84 and 10.7%) and Ashebeka (65.27, 54.93 and 8.5%) compared to unsprayed plots (Table 5). El-Sayed *et al*., 2011) reported that copper oxychloride caused a 53.3% reduction disease severity in comparison with the untreated control.

Area Under disease progress curve (AUDPC)

Area under disease progress curve is generally used to make comparison between treatments and evaluating the resistance of plant species to the pathogen (Xu, 2006). Hence, the result confirmed that the overall disease development was significantly influenced by the cultivars used and frequencies of fungicide spray. Unsprayed Ashebeka (1104.3%-day) and Local (1195.91%-day) cultivars gave the highest AUDPC and the lowest AUDPC was calculated on the plots of Walki and Hachalu cultivars which were 933.89 and 1038.78 (%-day), respectively (Figure 1). Weekly fungicide sprays resulted less AUDPC in all cultivars of this study, compared to bi- weekly and every three weeks spray intervals and also from unsprayed. From the result obtained it was confirmed that the overall disease development was significantly influenced by the cultivars used, fungicide spray frequencies (Figure 1). According to Phama *et al.* (2010) moderately resistant cultivars slow down the disease development and delay the disease progress rate.

From sprayed plots, the lowest AUDPC was recorded from Walki (477.91 %-days) and Hachalu (493.04 %-days) sprayed at every 1 week compared to Local (528.89 %-days) and Ashebeka (525.5 %-days) plots sprayed every 1 week. The AUDPC of every 2 weeks sprayed plots was ranged from 519.28 to 608.59 %-days. However, no significant differences observed on AUDPC between weekly and bi weekly spray interval on Walki cultivars. This could be due to lower percentage of severity index recorded in sprayed at every one week and two weeks compared to three weeks and unsprayed during severity assessment days. The results of Samuel *et al. (*2007) also disclosed that short day spray intervals (7-days) had a lower AUDPC than the other fungicide spray intervals. Jerger (2004) indicated that comparison of AUDPC values between treatments is the most commonly used tools for evaluating practical disease management strategies.

Parameters considered in Crop Growth

Date to flowering and maturity

The mean days of 50% flowering of faba bean varieties ranged from 54.33 to 58 days. The longest period to flowering was recorded on the cultivar Hachalu (58^{th}days) and Ashebeka cultivar (57^{th}days). Hachalu had more days leading to 50% flowering than other cultivars, this difference may resulted from genetic variations of faba bean in similar to this result of Alemayehu *et al. (*2018) reported that days to 50% flowering ranged from 61.3 to 58.7. Data presented in Table 5 showed that fungicide applications intervals significantly affect days to 90 % maturity of faba bean. When four faba bean cultivars compared, Walki and Local cultivar showed 122 and 121 days to 90% maturity, respectively (Table 6). The longest durations of 124 and 123 days to 90% maturity were recorded for the cultivars of Ashebeka and Hachalu, respectively. But there were no significant differences on Ashekaba cultivar and Local cultivars.

This difference may be due to the variation in genetic back ground of the faba bean varieties and environmental conditions.

The significant differences ($P \leq 0.05$) days to 90% maturity between weekly spray intervals and unsprayed on all cultivars. From sprayed plots, every one week fungicide spray showed longest to 90% days to maturity as compared to the other spray schedule. Cultivars Walki, Local, Hachalu and Ashebeka, showed 124,123,124 and 127 90% when weekly fungicide applied compared to untreated plots 122, 121,123 and 124 90% maturity dates, respectively. This indicated that frequent usage of fungicides that reduces disease infection and enhance the plants for perfoming its physiological function. The shortest durations of days to 90% maturity were recorded from untreated and 21-days treated plots of all cultivars. These results are also relatively confirmed by the findings of Abay *et al.* (2017) who reported that faba bean cultivar treated with fungicide showed longest days to matured when compared to untreated plots.

Plant height

The obtained data based on plant height (cm) during harvest involves the varieties that has no significant differences among fungicide spray intervals ($P<0.05$). However, measured plant height on sprayed plots are greater than those from unsprayed plots. Among the fungicide spray intervals, the highest mean plant height was recorded from plots treated every one week and the lowest from plots untreated with fungicide. Maximum plant height was observed in Hachalu (1.52 m) from plots sprayed every one week, while minimum (1.44 m) in unsprayed plots. Hachalu showed 5.5% increase in plant height over check when weekly fungicide applications used. Local cultivar treated weekly fungicide application exhibited maximum (1.45 m) plant height with minimum (1.41 m) in unsprayed plots. On Walki and Ashebeka cultivars weekly fungicide application gave maximum plant height 1.46 m and 1.47m respectively, which showing 5.0 and 7.35% increased over unsprayed plots (Table 6).

Effect on the yield of fungicide spray intervals and yield components along with loss of faba bean

Pods per plant

Data on total number of pods per plant forecasts very highly significant differences ($P<0.001$) among treatments. Among the faba bean cultivars, the maximum pods per plant were recorded in varieties of Hachalu (11.77) and Walki (10.66) and minimum pods per plant was in cultivars of Local (10.22) and Ashebeka (10.33), respectively (Table 7). This result is similar with Abay *et.al.* (2017) who reported that the significant different of pods per plant was observed among faba bean cultivars. This difference may have resulted from genetic back ground of faba bean Cultivars. Effect of fungicide sprays intervals was significantly ($P < 0.01$) different in terms

ISSN 2515-8260 Volume 07, Issue 06, 2020

of enhancing pods per plant. Untreated plots of four faba bean varieties had significant (P<0.01 less pod per plant. The results of this study were in line with Hawthorne (2004) who found that application of fungicide gave maximum pods per plant compared to unsprayed. In this study, plots treated with fungicides spray every one week showed the highest pods per plant in Hachalu (13.11), Walki (13.05), and Ashebeka (12.95) and local (12.50) whereas, the lowest pods per plant were recorded from unsprayed plots Walki (10.66), Local (10.22), Hachalu (11.17) and Ashebeka (10.33). This result is in line with Dagne *et al.* (2017) who reported that maximum pods per plant were recorded on sprayed plots than unsprayed plots. This observation also agree with the findings of Torres *et al*., (2004)) who reported that yield reductions were observed when plans lose their flower because plants fail to set pods due to chocolate spot disease.

Seeds per pod

The number of seeds available per pod is not significant differences among the four fungicides spray intervals, as well as among the four cultivars. Seeds per pod number on faba bean are dependent on the amount of fertile florets. Faba bean chocolate spot attack on pods did not affect the number of seeds per pod rather than, reduce size and weight of seeds (Table 7). This implies that the recorded chocolate spot incidence levels and severity levels on unsprayed plots did not influence seeds per pod number of faba bean among cultivars.

Hundred seeds weight

The hundred seeds weight (HSW) was significant differences among faba bean cultivars. The maximum 100 grains weight was recorded on Hachalu (60.67gm) followed by Walki (59gm), Ashebeka (56.33gm) and Local (52.67gm). This was due to genetic variations on seed size. The results in line with the wok of Abay *et al.* (2017) who found 100 seeds weight variation observed among faba bean varieties and fungicide sprayed. In all cultivars spaying fungicide increased HSW. The maximum HSW recorded from faba bean plots sprayed at weekly spray intervals from all cultivars (Table 7). HSW loses was observed on plots unsprayed on all faba bean cultivars. This suggested that Trust-Cymocop fungicide application reduced seed infections that decrease the quality of the seed due to disease. This finding is in line with Dagne *et al.* (2017) who reported that chocolate spot disease has reduced the grain yield and quality by reducing 100 seeds weight. The highest hundred seeds weight was obtained from cultivar Hachalu (66.33 g) treated every one week, while minimum in check (60.67g). Hachalu treated at every week application of fungicide showed 9.33% increased in HSW over check. Cultivar of Local treated weekly gave maximum (54.67g) HSW showing 3.80 % increase over check. Cultivars Walki and Ashebeka where the maximum hundred seeds weight were 63 and 62 g, respectively, showing 6.7 and 10.06 % increase over check. The hundred seeds weight (HSW) losses were computed relative to the average hundred seeds weight from plots with the maximum protection against the disease (i.e. plots with highest HSW and lowest disease severity in each cultivar). The highest 9.14 % relatively hundred seeds weight loss occurred on unsprayed of Ashebeka cultivar and followed 8.5 % relatively hundred seeds weight loss occurred on Hachalu cultivar (Table 7). Relatively less hundred seeds weight reduction occurred on cultivar walki. This may be due to lower percentage of disease severity index recorded on the variety. These results are also confirmed fungicide spray intervals reduced HSW loss and maximum HSW loss recorded on unsprayed plots (Dagne *et al.,* 2017).

Grain yield

The effect of Interaction of cultivars and spray intervals showed significant variations ($P<0.05$) in producing seed yield. In this study, increase in yield were higher with increased fungicide spray frequency i.e. high on weekly sprayed plot for all faba bean cultivars (Table 8). Lower yield was recorded from unsprayed plots. The highest mean seed yield (3316 kg ha-1) was recorded on Hachalu cultivar sprayed every one week with fungicide. But, it didn't showed significant variations from plots of this cultivar sprayed with every two weeks (3215 kg ha^{-1}). Related result was reported by Sahile *et al.* (2008) the maximum mean grain yield was recorded from a 7 day spray interval and lower mean grain yields was recorded from Unsprayed plots which significantly different from each other. The least mean seed yield (1759 kg ha^{-1}) was recorded from unsprayed plots of cultivar Local. On this cultivar sprayed every one weeks with fungicide gave (2740 kg ha^{-1}) mean grain seeds which significantly differed from unsprayed (1759 kg ha^{-1}). On Walki cultivar, the highest (3226kg ha^{-1}) mean grain yield was obtained from short day spray interval plot as compared unsprayed plots (2305 kg ha-1). However, yields for Walki and Hachalu cultivars were not significantly different between sprayed plots of 7-day and 14-day spray intervals. Fungicide application gradually increases the yield of predicted varieties and also, moderately resistant varieties, but to a lesser degree. This result in line with the result of Dagne *et al.* (2017) explained that spraying of fungicides every one week reduced disease intensity and hence increases the yield potential of the crop. Similar result was observed by Sahile *et al.* (2008) the highest and the lowest grain yield among the 4 cropping systems that was recorded from 7 day spray interval and unsprayed plots.

Relative yield loss and increase in grain Yield

The relative yield losses is due to chocolate spot on the grain yield of faba bean were observed between treatments. Losses on faba bean yield for various spray intervals was calculated relevant to the yield of maximally protected plots. For control plots that are not treated, the loss observed in yield were obviously more compared to protected plots with fungicide. This may be fungicide applications reduced flower abortion due to disease. Losses created by chocolate spot are due to decreased number of pods per plant. The maximum relative grain yield losses were reported from the varieties of Ashebeka and Local, 37.31 and 35 % on unsprayed plots, respectively. Based on the varieties, Hachalu and Walki, a grain production loss of about 29 and 28.54% were recorded when chocolate was allowed to develop naturally, respectively (Table 8). The yield loss variations among the cultivars could be due to the genetic make of the crop susceptibility to the pathogen. These findings were in line with Dagne *et al.* (2017) who evaluate faba bean cultivars with fungicide application schedule and found that maximum yield loss obtained from unsprayed plots compared to plots treated with fungicide. Similarly, Dereje *et al.* (1987) reported that faba bean yield loss due to chocolate spot disease was ranged 34 on susceptible genotypes and 61 on resistance genotypes. The minimum yield loss was obtained from all the cultivars sprayed at weekly fungicide application. From sprayed plots, on Walki cultivar the lowest (2.91%) yield loss were recorded, on plots sprayed every one week with fungicide as compared to every two weeks (11.34%) and every three weeks (28.54%) sprayed plots. On this cultivar, 7-days sprayed plots with fungicide gave additional yield of 84 kg ha^{-1} and 370 kg ha^{-1} as compared to 14- days and 21.days sprayed plots. On Hachalu cultivar the maximum (29%) and the minimum (1.7%) relative yield loss were recorded on unsprayed control plots and on every one week sprayed plots respectively. On this cultivar, every two week sprayed plots recorded the least (1.7 %) yield losses relative to every three weeks fungicide sprayed plots (9.5%) and unsprayed plot (29%). Yield losses recorded in local with every two weeks and every three weeks spray with fungicide was (6 % and 26 %) compared to Local unsprayed plot (35 %) and in Ashebeka sprayed at every two weeks and every three weeks spray intervals, yield loss was reduced by 6.18 and 24% compared with Ashebeka unsprayed (37.31%) (Table 8). El-Sayed *et al*. (2011) reported that foliar fungicide can reduce disease infection and increase grain yield. Similarly, Hawthorne (2004) reported that the utilization of Mancozeb as a fungicide that is protective reduces production loss due to chocolate spot as it prevents pod abortion and plant damage.

Economic analysis of fungicide management

The data depicted that fungicide treated plots displayed the highest total variable costs than untreated. Both net return and cost of chemical applications increased with the number of fungicide applications. The highest variable cost and labor cost was calculated for all varieties treated at every one week spray intervals plots. Fungicide applied every one week on all cultivars exhibited maximum sale revenue from all plots. For Local and Ashebeka cultivars, the highest net benefit were recorded from plots sprayed every one week spray intervals (Table 9). On the cultivars, Walki and Hachalu, indicated highest net benefits from plots treated with every two weeks spray intervals. The results obtained show that the economic analyses had frequent applications of fungicide that was not economical when used on varieties like Walki based on net benefit. Maximum net benefits obtained from moderately resistance Walki indicated that the variety resistance is important in chocolate spot management for the resource-poor farmers. Therefore, using fungicide application and host resistance cultivars integration in controlling chocolate spot severity have significant economic benefits. Marginal rate of return in Walki, Local and Ashebeka cultivars was highest when plots sprayed every two weeks. The obtained rate of return for Walki, Local and Ashebeka cultivars was 207, 193 and 252%, respectively. Though two weeks spray intervals on Hachalu gave the highest net benefit, the highest rate of return 228 % was obtained from every three weeks sprayed plots. The lower marginal rate of return was obtained from local every three was sprayed (39%). The marginal rate of return in the every one week treatment was 104, 118, 122and 153 recorded for Walki, Local, Hachalu and Ashebeka cultivars, respectively (Table 9).

Conclusions

The use of chemical fungicides combination with faba bean cultivars is most effective among several methods for chocolate spot disease control. In this study, the treatment of faba bean with Trust-Cymocop 439.5 WP fungicide showed lower disease incidence, severity and increased yield and yield components than those where no such treatment was applied. The chocolate spot disease incidence, severity and areas covered under disease progress curve are the highest in cultivar Local followed by Ashebeka, Hachalu and Walki in unsprayed plots. The highest disease severity was observed in untreated plots whereas least was observed in weekly treated plots. Among different spray intervals, weekly applied plots were found the most effective in disease reduction with maximum reduction in Walki and minimum in Local cultivar. The lowest disease incidence and severity was recorded on Walki and Hachalu cultivars at all disease assessment dates compared to Local and Ashebeka cultivars. The cultivars effect with spray intervals of fungicide has shown significant variations in pods per plant, grain yield, and hundred seed weight; while it has no significant effects on seeds per pod. Yield loss in the treated plots was lesser than the untreated plots. The relative yield loss of 37.31, 35.0 29.0 and 28.5% were recorded from Local, Ashebeka, Walki and Hachalu in unsprayed plots, respectively. Economic analysis showed that the highest net benefits were obtained from Hachalu and Walki, when sprayed at every two weeks intervals and from Ashebeka and Local, the highest benefit was obtained on every one week sprayed interval plots and the least was obtained from Local unsprayed plots. Highest marginal rate of return was obtained from Ashebeka sprayed at every two weeks intervals followed by Hachalu sprayed at every three weeks spray intervals, but the lowest was obtained from local with spray of fungicide at every three weeks intervals.

The results of this study provide confirmation that the response of faba bean cultivars to weekly and two weeks spray intervals of fungicide application found to be effective in reducing chocolate spot severity, increased seed yield of faba bean cultivars under field conditions in chelia district. Based on the high rate of return recorded Walki, Local and Ashebeka cultivars which are recommended to growers with every two weeks and Hachalu cultivars with three weeks spray intervals of Tust-Cymocop WP fungicide at Chelia district as well as in similar agro ecology.To ensure maximum protection further research on integrated management like integration of resistant and high yielder cultivars with plant nutrient or with other management tactics should be investigated.

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Table 1: List of faba bean cultivars, growth habit, yield, year of released and disease reaction to chocolate spot.

Faba bean var.	Production domain (m.a.s.l.)	Maturity Days	Yield Qt/ha		Year of released	Reaction to chocolate spot
			Main season	Off-season		
Walki	1800-2800	133-146	24-52	20-44	2008	Moderately Resistant
Hachalu	1900-2800	122-156	32-45	24-35	2010	Moderately Resistant
Local	1800-2800	120-135	--	--	--	Susceptible
Ashebeka	1900-2800	128-156	30-50	28-47	1994	Susceptible

Table 2: Treatment combinations used under field conditions

Faba bean varieties	Treatment combination with spray intervals
Walki	Walki + Trust-Cymocop439.5 Fungicide every one week spray
	Walki + Trust-Cymocop439.5 Fungicide every two weeks spray
	Walki + Trust-Cymocop439.5 Fungicide every three weeks spray
	Walki +No spray
Local	Local + Trust-Cymocop439.5Fungicide every one week spray
	Local + Trust-Cymocop439.5Fungicide every two weeks spray
	Local + Trust-Cymocop439.5Fungicide every three weeks spray
	Local +No spray
Hachalu	Hachalu + Trust-Cymocop439.5Fungicide every one week spray
	Hachalu + Trust-Cymocop439.5Fungicide every two weeks spray
	Hachalu + Trust-Cymocop439.5Fungicide every three weeks spray
	Hachalu +No spray
Ashebeka	Ashebeke + Trust-Cymocop439.5 Fungicide every one week spray
	Ashebeke + Trust-Cymocop439.5 Fungicide every two weeks spray
	Ashebeke + Trust-Cymocop439.5 Fungicide every three weeks spray
	Ashebeke +No spray

Table 3: Percent of infection and scales for faba bean chocolate spot

Scale	Description
0	Nil infection observed on leaves
1	Dot-like observations for less than 5% of total leaf area
3	Seperate spots less than 2 mm in diameter (6–25% of leaf area)
5	Few linkages in scattered spots, diameter 3–5 mm (26– 50% of leaf area) with a little defoliation
7	confluent spot lesions (51–75% of leaf area), mild sporulation, half the leaves dead or defoliated
9	Larger leaves that are completely destructed(covering more than 76% of leaf area), abundant sporulation, heavy defoliation and plants darkened and dead

Source: Ding *et al. (*1993)

Table 4 Initial and final percentage disease incidence of faba bean chocolate spot as influenced by different cultivars and fungicide spray intervals under field conditions

Cultivars	**Fungicide interval**	Day of disease Incidence assessment		Reduction in PDI at 122DAP (%)
		Initial 72DAP (%)	Final 112DAP (%)	
Walki	Every one week spray	12.33b	32.22g	58.51
	Every two weeks spray	13.89b	38.89g	49.92
	Every three weeks spray	13.89b	51.67e	33.2
	Unsprayed control	16.67ab	77.67b	0
	Every one week spray	13.33b	41.66fg	57.14
	Every two weeks spray	13.89b	54.22e	44.33
	Every three weeks spray	13.95ab	75.00bc	22.85
Local	Unsprayed control	18.00b	97.22a	0
Hachalu	Every one week spray	13.33b	38.88g	54.4
	Every two weeks spray	13.33b	41.67fg	54.4
	Every three weeks spray	14.22b	58.33de	36.28
	Unsprayed control	16.11ab	91.66a	0
Ashebeka	Every one week spray	13.33b	39.89g	54.9
	Every two weeks spray	13.33b	49.22ef	47.87
	Every three weeks spray	14.22ab	65.88cd	30.85
	Unsprayed control	16.11a	94.44a	0
	Mean	14.62	59.14	
	CV (%)	22.32	9.95	
	LSD (5%)	5.44ns	9.812**.	

DAP =Days after planting, PSI=Percentage severity index, CV = Coefficient of variation, LSD=Least significant difference at (P<0.05), the mean values in the column with the Different letters represent significant variations.

Table 5 Severity index and of faba bean chocolate spot as influenced by different cultivars and fungicide at different spray intervals under field conditions during the main cropping season of 2018 in chelia

		Day of disease severity assessment		Reduction in PDI at 122 DAP(%)
Cultivars	Fungicide interval	Initial 72 (DAP)	Final 112(DAP)	
Walki	Spray every 1 week	9.27b	16.66 g	51.00
	Spray every 2 week	9.56b	18.8fg	44.23
	Spray every 3 week	9.96b	29.41de	13.50
	Unsprayed control	9.96ab	34.03dc	0
Local	Spray every 1 week	9.25b	17.89 fg	69.63

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	Spray every 2 week	11.1b	26.37^{fe}	54.00
	Spray every 3 week	10.18b	49.33^{a}	7.2
	Unsprayed control	10.8ab	53.85^{a}	0
Hachalu	Spray every 1 week	8.6433	16.35^{fg}	55.41
	Spray every 2 week	8.64a	22.53^{efg}	43.84
	Spray every 3 week	9.22a	35.803^{cd}	10.7
	Unsprayed control	10.19ab	40.12^{bc}	0
Ashebeka	Spray every 1 week	7.97 b	17.59^{fg}	65.27
	Spray every 2 week	8.95 b	22.83^{efg}	54.93
	Spray every 3 week	9.57 ab	46.33^{ab}	8.5
	Unsprayed control	12.95 a	50.67^{a}	0
	Mean	9.86	31.11	
	CV (%)	19.83	11.22	
	LSD (5%)	3.91ns	6.84**	

DAP =Days after planting, PSI=Percentage severity index, CV = Coefficient of variation, LSD=Least significant difference at (P<0.05), the mean values in the column with the Different letters represent significant variation.

Table 6 Effect of fungicides spray interval on growth parameters of different faba bean cultivars

Cultivars	Plant growth parameters			
	Fungicide interval	PH	FD	MD
Walki	Every one week spray	1.46	54.33f	124.67a
	Every two week spray	1.45	54.67ef	124.00ab
	Every three week spray	1.44	54.33f	124.00ab
	Unsprayed control	1.36	55.00ef	122.67b
Local	Every one week spray	1.45	55.00ef	123.67 a
	Every two week spray	1.41	55.33def	123.33 a
	Every three week spray	1.44	55.00ef	123.00a

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	Unsprayed control	1.41	54.67ef	121.33b
Hachalu	Every one week spray	1.52	58.00a	124.33a
	Every two week spray	1.46	58.33a	124.00a
	Every three week spray	1.45	58.67a	123.33b
	Unsprayed control	1.44	58.33a	123.00b
Ashebeka	Every one week spray	1.47	55.67cde	127.00a
	Every two week spray	1.44	56.33cde	126.67a
	Every three week spray	1.46	56.67 cb	125.33 b
	Unsprayed control	1.40	57.00 b	124.000c
	Mean	1.44	56.41	125.75
	CV (%)	12.47	0.45	1.33
	LSD (5%)	0.28ns	0.74***	1.1***

FD= flowering day, MD= maturity day, PH= plant height, ns=no significant, LSD= least significant difference, CV= coefficient of variations *******= very highly significant difference at (P<0.01), **= highly significant difference at (P<0.01), *= significant difference at (P<0.05)

Table 7: Yield and yield components of chocolate spot disease as influenced by different cultivars and fungicide at different spray intervals under field conditions during the main cropping season of 2018

Cultivars	Yield and yield components					
	Fungicide intervals	Grain Yield kg/ha	PPP	SPP	HSW	Losses
Walki	Every one week spray	3226a	13.05a	2.85	63.00abcd	0
	Every two weeks spray	3142a	11.05abc	2.82	61.67ab-e	2.11
	Every three weeks	2856ab	10.33c	2.87	60.00ab-e	4.76

	spray					
	Unsprayed control	2305b	10.66c	2.73	59.00ab-e	6.34
Local	Every one week spray	2740a	12.50ab	2.67	54.67ab	0
	Every two week spray	2553a	11.5abc	2.59	53.67bdce	1.8
	Every three week spray	2014b	11.16	2.63	53.00de	3.05
	Unsprayed control	1759b	10.22c	2.62	52.67e	3.6
Hachalu	Every one week spray	3316a	13.11a	2.83	66.33a	0
	Every two week spray	3215ab	12.44ab	2.77	64.33ab	3.0
	Every three week spray	2941b	12.17abc	2.83	63.33aabc	4.5
	Unsprayed control	2353c	11.17bac	2.62	60.67aab-e	8.5
Ashebeka	Every one week spray	3057a	12.95a	2.70	62.00ab-e	0
	Every two week spray	2868a	11.16bac	2.60	61.00ab-e	1.6
	Every three week spray	2321b	10.83bc	2.57	59.33ab-e	4.3
	Unsprayed control	1917c	10.33bc	2.53	56.33ab-e	9.14
	Mean	2491.25	11.40	2.60	59.66	
	CV (%)	10.32	10.75	10.41	13.01	
	LSD (5%)	513.73**	3.48*	0.77ns	17.87*	

PPP= Pods per plant, SPP= Seeds per pod, HSW= Hundred seeds weight, ns=no significant, LSD= Least Significant Differences, CV= Co-efficient of variations, ** - Highly significant differences at P<0.01, *= Significant differences at P<0.05.

Table 8 Yield of faba bean as influenced by different cultivars and different spraying interval under field conditions during the main yield cropping season of 2018.

Cultivars	Fungicide intervals	Faba bean yield kgha-1	RYL (%)
Walki	Spray Every one week	3226 ab	0
	Spray every two weeks	3142ab	2.91
	Spray every three weeks	2856bcd	11.34
	Unsprayed control	2305fg	28.54

Local	Spray Every one week	2740ced	0
	Spray every two weeks	2553def	6
	Spray every three weeks	2014gh	26
	Unsprayed control	1759h	35
Hachalu	Spray Every one week	3316a	0
	Spray every two weeks	3215ab	1.7
	Spray every three weeks	2941acbd	9.5
	Unsprayed control	2353fg	29
Ashebeka	Spray Every one week	3057abc	0
	Spray Every two weeks	2868bcd	6.18
	Spray Every three weeks	2321fg	24
	Unsprayed control	1917h	37.31
	Mean	2667.67	
	CV%	8.24	
	LSD	366.6**	

Where RYL=Relative yield loss, YIOU**:** Yield increase over unsprayed, $kgha^{-1}$= kilogram per hectare, ns- Non-significant, LSD= Least Significant Difference, CV= co-efficient of variations, **- Highly significant difference at P<0.01, *-Significant difference at P<0.05.

Table 9 Partial budget analysis for the management of faba bean chocolate spot as influenced by different cultivars and different spraying intervals of fungicide under field conditions

Cultivars	Fungicide interval	General cost benefit							
		Faba bean yield tons/ha	Faba bean sale ($ETBt^{-1}$	Total input and labor cost(ETB/Ha)	Sale revenue (ETB)	Marginal cost(ETB $ha^{-1)}$	Net profit (ETB a^{-1})	Marginal benefit /ha)	MRR(%)
Walki	Every one week spray	3.23	16000	13650	51680	7200	44480	7520	104

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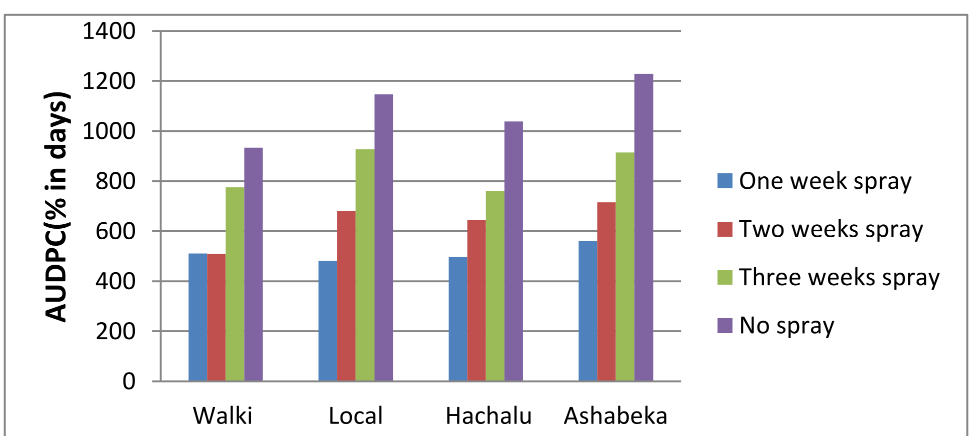
	Every two week spray	3.14	16000	10770	50240	4320	45920	8960	207
	Every three week spray	2.86	16000	9330	45760	2880	42880	5920	206
	Unsprayed control	2.31	16000	6450	36960	0	36960	0	0
Local	Every one week spray	2.74	16000	13650	43840	7200	36640	8480	118
	Every two week spray	2.55	16000	10770	40800	4320	36480	8320	193
	Every three week spray	2.01	16000	9330	32160	2880	29280	1120	39
	Unsprayed control	1.76	16000	6450	28160	0	28160	0	0
Hachalu	Every one week spray	3.35	16000	13650	53600	7200	46400	8800	122
	Every two week spray	3.22	16000	10770	51520	4320	47200	9600	222
	Every three week spray	2.94	16000	9330	47040	2880	44160	6560	228
	Unsprayed control	2.35	16000	6450	37600	0	37600	0	0
Ashebeka	Every one week spray	3.06	16000	13650	48960	7200	41760	11040	153
	Every two week spray	2.87	16000	10770	45920	4320	41600	10880	252
	Every three week spray	2.32	16000	9330	37120	2880	34240	3520	122
	Unsprayed control	1.92	16000	6450	30720	0	30720		0

$ETBt^{-1}$= Ethiopian birr per tons, $ETBha^{-1}$= Ethiopian birr per hectare, MRR= marginal rate of return



ISSN 2515-8260 Volume 07, Issue 06, 2020

Figure 1: AUDPC of chocolate spot disease in relation to cultivars of faba bean treated with different spraying frequencies of fungicides at chelia.