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Management of Chocolate Spot of Faba Bean (*Botrytis fabae*) through Fungicides and Host Resistance at South Omo, Southern, Ethiopia

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Abstract

Chocolate spot is serious disease that cause of yield reduction on Faba bean crop, thus effective management essential. The objective of this study was to management of chocolate spot of Faba bean with host resistance and fungicides in south Omo highlands. Field experiments were conducted at Gazer /doredora and Wobamer research sites during 2020/2021. Treatments were designed in RCBD factorial with three replications. Three fungicides such as Mancozeb, Copper hydroxide, Copper oxychlorid and one control unsprayed plot was evaluated at the rate of 2.5kg/ha, 1.5kg/ha and 3.25L/ha respectively. Against four varieties such as Wolkie, Hachalu, Gebelicho and Local variety. The highest chocolate spot PSI, AUDPC and disease progress rate was recorded from local unsprayed plot at both sites; the last day assessment at 84 and 92 day after planting whereas the lowest chocolate spot PSI (38.66%) and (32.66%) was recorded from Walkie treated with Mancozeb at Gazer and Wobamer respectively. The maximum Area under Diseases Progressive Curve (AUDPC) was calculated on the unsprayed plots of local variety, which were (1646.33%-days) and (1654.83%-days) both site respectively. Maximum grain yield (2678kg/ha^{-1}) and (2656.8 kg/ha^{-1}) were recorded from plots treated with Mancozeb fungicide at both locations. Percentage Severity index and AUDPC had highly significant positive correlation coefficients of r = 0.9 at both location and negative correlation coefficient of r = -0.7 with yield. In the study area Walkie Faba bean variety with fungicide treatment particularly with Mancozeb has provided best result in terms of disease control and benefit from yield production. Likewise, from this cost benefit analysis Walkie variety treated with Mancozeb fungicide spray at both experimental areas was the best combination to increase net benefits (133200, ETB). Thus it is recommended to use relatively resistant Faba bean varieties with sprays Mancozeb fungicide rate at 2.5 kg /ha^{-1}gave the highest protection against chocolate spot and the highest monetary benefit. Further study should be conducted on the frequency of those fungicides to identify the optimum level of application and thereby increase production and productivity of Faba bean in the region and elsewhere with difference agro ecological settings.

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Keywords

AUDPC, Chocolate spot, Faba bean, Fungicide, PSI, Variety.

Introduction

Grain legumes play an important role in improving livelihood, nutritional security of farmers and populations in less developed countries as well as sustainability of agriculture in dry areas worldwide (Pande *et al.*, 2009). In Ethiopia, faba bean is grown in the highlands (1780–3000 m.a.s.l.) with 700–1000 mm annual rainfall (Yohannes 2000). The area of faba bean production in Ethiopia has increased by 18.21% from

2010 cropping season to 2016;Faba bean (*Vicia faba* L.) also called as broad bean, horse bean and field bean, is one of the earliest domesticated food legumes in the world, probably in the late Neolithic period (Metayer, 2004). It is assigned to the Central Asian, Mediterranean, and South American centers of Diversity and believes to be a native to North Africa and southwest Asia and extensively cultivated elsewhere and the secondary centers of diversity are postulated in Afghanistan and Ethiopia (Singh *et al.,* 2013). It ranks sixth in production among the legumes grown in the world. China has been the main producing country, followed by Ethiopia, Egypt, Italy, and Morocco (Ermias *et al.,* 2013). Ethiopia is considered as; the secondary center of diversity and also one of the nine major agro geographical production regions of Faba bean (Hailu *et al.,* 2014). The primary producers of pulses are smallscale farmers with small and dispersed plots under rained conditions, with substantially lower yields compared to the improved Faba bean varieties and international yields (Haile *et al.,* 2016).

In Ethiopia, the average yield of Faba bean crop is about 2.53 t ha-1 which is less than yield potential (8 t ha-1) of Faba bean (CSA, 2017) Faba bean serves as a source of food and feed and is a valuable and cheap source of protein. It makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen (Sahile *et al.,* 2008). It is also an important source of income for farmers and generates foreign currency for the country. The plant is grown mainly for its green pods and dried seeds, which are rich in a protein (18.5 to 37.8%) that can substitute for animal protein in humans (El-Sayed *et al.,* 1982).

In the highlands of Ethiopia, faba bean is one of the most important food crops widely produced used for a source of cash to the farmers, foreign currency to the country and restoration of soil fertility by fixing atmospheric nitrogen and is a suitable rotation crop for cereals (Mussa *et al.,* 2008). Faba bean makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen and reduce the dependence on external fertilizer inputs and also an important source of income for farmers and generates foreign currency for the country (Agegnehu and Fessehaie, 2006). Integration of faba bean varieties with different reaction to chocolate spot with foliar sprays protected the faba bean varieties from high chocolate spot epidemics, increased yield, yield components and maximized marginal benefit compared to a single control approach (Kora *et al.,* 2016).As result of climate change different fungal pathogen evolved in new ways and faba bean production is seriously affected (Khan *et al.,* 2010; Sahile *et al.,* 2012). Thus, climate change and associated changes in disease scenarios will demand changes in crop and disease management strategies. Yield losses as high as 90% and total crop failure in severe epidemics of Botrytis fabae have been reported from areas where extended periods of wet weather conditions prevail (Singh *et al.,* 2013).

Chocolate spot is a major limiting factor in the main faba bean growing regions of Ethiopia and yield losses vary from 34 to 61 % (Dereje and Yaynu, 2001; Sahile *et al.,* 2012). Many methods of control are possible such as the use of resistant genotypes, chemicals (fungicides), and biological, induced resistant and modified cultural practices. In fact, the amount of losses in seed yield due to a disease determines the importance of that disease Management options for chocolate spot disease in Ethiopia include the use of resistant cultivars, chemical control (Mancozeb), copper oxychloride and copper hydroxide fungicide application consistently reduced chocolate spot severity and increased the yield correspondingly.

Despite its huge importance, the productivity of Faba bean in Ethiopia is far below its potential due to a number of factors, the biological limitations include inherently low grain yielding potential of the indigenous cultivars and susceptibility to biotic and abiotic stresses (Mussa *et al.,* 2008). Among the biotic stresses, chocolate spot (*Botrytis fabae*), rust (*Uromyces viciafabae*), and black root rot (*Fusarium solani*) highly contribute to the low productivity of the crop. The pathogen is the necrotrophic fungus *Botrytis fabae* Sard, which is present in nearly all faba bean cultivation areas (Cimmino *et al.,* 2011). *Botrytis fabae* is one of economically important diseases that damage the foliage, limit photosynthetic activity, and reduce Faba bean production (Torres *et al.,* 2004).Chocolate spot was caused yield losses of Faba bean that varying from 34% on a tolerant genotype up to 61% on a susceptible genotype in Ethiopia (Deere, 2000) as well as complete crop failure due to long lasting favorable environmental condition for the diseases (Mitiku, 2017).

A chemical is recommended for use when the cost of its application equals to or is less than the returns gained when the damage is below threshold level or within the tolerant limit (El-Sayed *et al.,* 2011). Kora *et al.,* (2016) reported that faba bean varieties and fungicide application consistently reduced chocolate spot severity

and increased the yield correspondingly. A research conducted by Beyene *et al.*, (2016) reported that there were lack of improved varieties and poor seed system in Ethiopia. In South Omo, Zone chocolate spot epidemics occurred frequently and caused yield losses since farmers grow local susceptible landraces and do not apply fungicides to manage the disease (Beyene *et al.*, 2016). Generally, faba bean chocolate spot is serious problems in our country including South omo zone. Therefore study objective to the effective control measure for the chocolate spot diseases of Faba bean using host resistance and fungicide application.

Materials and Methods

Description of the Study Area

The experiment was conducted at two woreda sites in Gazer/ doredora Keble and Wobamer/yedamer Keble. Hence there were a total of two location-year combination environments located in South Omo highlands during the main cropping season (June to October 2020).

The area has an altitude of Gazer and Wobamer 540-3,350 meter above sea level. The two location mean annual rain fall was 1190-1450 mm and the mean annual temperature was Gazer (south Ari) 19-21 and Wobamer22-27 c^o respectively. The two area soil type was clay loam. Source: agricultural offices of the respective woreda

Experimental design and treatments

The experiment was laid out in Randomized Complete Blocked Design (RCBD) in factorial arrangement with three replications. The 16 treatments was the combination of three improving varieties, Gebelicho, Hachalu and Walkie) and one Local varieties with 3 fungicides (Mancozeb, Copper hydroxide and Copper oxychlorid) and a control one which is untreated with fungicide. Total area 325.65m^2each plot had 2 m length and 2.2 m width with the area of 4.4 m^2. The spacing between block and plot was 1m and 0.5m respectively. The space between rows and plants was 40 cm and 10 cm respectively.

The 16 treatment combinations are as follows:-

Gebelicho without fungicide, Gebelicho with Mancozeb, Gebelicho with Copper Hydroxide, Gebelicho with copper oxychlorid, Walkie without fungicide, Walkie with Mancozeb, Walkie with Copper Hydroxide, Walkie with copper oxychlorid, Hachalu with Mancozeb, Hachalu with Copper Hydroxide, Hachalu with Copper oxychlorid, Hachalu without Fungicide, Local without fungicide, Local with Mancozeb, Local with Copper Hydroxide and Local with Copper oxychlorid Unsprayed plots (control group) were included for each variety to allow maximum chocolate spot development for comparison of the effect of disease levels on different treatments.

Experimental procedures

Experimental site selection was the first steps during field experiments. Field preparation (removing unwanted material such as plant debris, uprooting unwanted plant and weeds, ploughing the field three times, field leveling and plot preparation) was under taken prior to sowing. The recommended seed rate per hectare for row planting has been applied.

Full dose of phosphorous (46 kg /ha) and nitrogen (18 kg /ha) fertilizer was applied once during planting time in the form of di-ammonium phosphate (DAP). Foliar application of fungicides was applied three times (starting from the onset or appearance of the disease and repeated at 7 day' spray intervals) at a rate of 2.5, 3.25, 1.5 kg of per hectare of Mancozeb, Copper Oxychlorid and Copper Hydroxide respectively. All other non-experimental variables and agronomic operations have been applied uniformly to the entire experimental areas and throughout the experimental time.

Data to be collection

Chocolate Spot incidence (number of plants infected) and severity (leaf area covered with Symptoms) was assessed at 7-days interval after the onset of the disease. The number of plants that showed symptoms of chocolate spot was counted from the four central rows of each plot and percentage disease incidence was calculated. Chocolate spot severity on 10 pre-tagged plants were recorded using 0-5 scale as well as data on yield and yield components were collect and record from the middle four rows of randomly selected 10 plants.

Diseases data

Disease incidence

Calculated as No. of infected plants / Total number of plant assessed (Wheeler, 1969).

Disease incidence (I)

$$= \frac{\text{Number of infected plant units}}{\text{Total number of units assessed}} \times 100$$

Diseases severity

Disease severity was recorded as percentage of leaf area covered by lesions. The scale used for visual rating of the damage level of infected plant was 0 stands for approximately 5% infection; 1 = 15%, 2 = 25%, 3 = 65%, 4 = 75% and 5 >85% of infection level. The severity grades was then converted into percentage severity index (PSI) for analysis (Wheeler, 1969).

AUDPC

The area under the disease progress curve (AUDPC) from PSI was computed using the following formula (Campbell and Madden, 1990).

Agronomic data

Number pod per plant

The average number of pods was counted and recorded from randomly selected 10 plants in the middle four rows.

Pod length (cm)

The average length of the pod from bottom to tip was measured using ruler from randomly 3 selected pods.

Plant height(cm)

Average length of plant from the bottom to the tip of the plant was measured and recorded.

100 seed weight(g)

The weight of the 100 seed was measure by electric balance.

Total grain yield (kg/ha)

The grain yield in gram per plot was calculating per hectare basis.

Yield loss

Percent relative grain yield loss was calculated as follows:

$$RYL(\%) = (Yp - Yt)/Yp * 100$$

Where, RYL = relative yield loss in percent, Yp = yield from the maximum protected plots and Yt = yield from other plots.

Data analysis

Analysis of variance (ANOVA) was performed for disease parameters (incidence, PSI, and AUDPC), yield and yield components (pod per plant, seed per pod, and 100 seed weight) to know the effect of main treatments and their interactions. Data analyses were conducted using General Linear Model (GLM) procedure of SAS statistical analysis version 9.0. List Significant Difference (LSD) at (P 0.05) probability level was used to separate treatment means.

Results and Discussion

There was significant variation among sprays and varieties used in the experiment for chocolate spot general disease severity, Area under Disease Progress Curve values, grain yield, hundred seed weight, and plant height, pod number per plant and pod length at both locations.

Percentage severity index

Diseases severity

The analysis of variance revealed that there were significant the interaction effects of fungicide treatment by varieties showed very highly significant difference ($P \leq 0.001$) in percent severity index (PSI) of chocolate spot starting from 49DAP and 57DAP days after planting(Figure 1&2). The highest mean disease severity index at 49DAP and 57DAP days after planting was 58.66% 40.00%,38.66%,36.00% 32.00% and 68%,50.66%,40.66%,38%,41.33% recorded from Local unsprayed, Hachalu untreated, Gebelicho unsprayed, local treated Copper hydroxide, and Hachalu treated Copper hydroxide plot of variety are Gazer and Wobamer location respectively, while the minimum (13.33%) and (14.66 %) chocolate spot diseases severity index was recorded from Wolkie variety treated with Mancozeb fungicide at 49 and 57 days after planting are two location (Table 2,3and Figure 1and 2).

The highest mean disease severity index at (83.33%, 71.33%, 74.66%, 78%) and 79.66%, 60.33%, 54.66%, 62%) was record unsprayed Local variety, Hachalu

unsprayed, Gebelicho unsprayed and local Variety treated with fungicide copper hydroxide at the last date of assessment 84and 92 day after planting at Gazer and Wobamer respectively. The lowest (13.33%, 15.33%, 20%, 22.66%, 36.66%, 38.66% and 14.66%, 17.33% 20.66%,20.66%,26.66%,32.66% chocolate spot diseases severity index was recorded from Wolkie variety treated with Mancozeb fungicide at 49,56, 63,70 77,84 and 57,64,71,78,85,92 day after planting both location Gazer and Wobamer respectively (Table 2, 4and Figure 1, 2). On the other hand, Copper oxychlorid fungicide for Gebelicho, Hachalu and Local Faba bean varieties reduced the severity of chocolate spot at the final date of assessment gazer and Wobamer (84and 92) days after planting reducing severity index both location when compared with unsprayed plot of variety respectively. On the other hand, Walkie variety treated with Mancozeb resulted minimum (38.66% and 32.66%) percentage severity index at 84 DAP and 92 DAP days after planting were as both location gazer and Wobamer district respectively.

Similarly, plot sprayed with Mancozeb significantly reduced chocolate spot severity compared with unsprayed plot. Mancozeb sprayer for Gebelicho, Hachalu and Local Faba bean varieties reduced the severity of chocolate spot to the minimum level of study area (54.66%, 55.33%, 64.66%, and 38.66%, 46.33%, 48.66%) Gazer and Wobamer of Mancozeb fungicide spray at final 84 and 92 day after planting diseases severity index compared without fungicides respectively. On the other hand, spraying copper hydroxide has markedly reduced chocolate spot severity compared to unsprayed treatment, even though the effect was not statistically significant in any of the varieties except at the fourth days of assessment (Table 2 and 4).

When comparing the response of main effect of variety to the infection level, Local unsprayed variety had significantly the highest level of diseases severity index was(37.66%,42.5%,45.66%,50.83%,62% 73%and 41%, 45.5%, 46.9%, 47.08%51.9%, 62.25%)at 49DAP, 56DAP, 63DAP, 70DAP, 77DAP,84DAP and57DAP,64DAP, 71DAP, 78DAP, 85DAP, 92DAP days after planting Gazer and Wobamer respectively (Table3). while from Walkie variety lowest diseases severity index (23.83.% and 25.91%)was recorded from the first days of assessment (49and 57 days after planting) and at the last days of assessment (84 and 92 days after planting) similarly, lowest disease severity index at two location (57% and 40.58.%) was recorded from Walkie variety.

However, there is without statistically significant value between Hachalu untreated plot and local untreated variety in all days of assessment (Table 2and 4). This result is in line with the work of Woldie and Mitku (2014) reported highest PSI, Hachalu (37.5, 27.7%) and Gebelicho (32.2, 27.2%), at (Agarfa and Sinana site) respectively. At the last days of disease assessment 84 and 92 days after planting) comparing the main effect of chemical spray, the highest disease severity index (73% and 60%) Gazer and Wobamer was recorded from untreated control plot while the lowest disease severity index (53.33% and 41.58%) Gazer and Wobamer were recorded from Mancozeb fungicide followed by (%64% and 46.33%) copper oxychlorid. However, there was no statistically significant difference between copper oxychlorid treated plot and Mancozeb treated plot throughout the entire disease assessment days (Table2 &4).

This study showed that different Faba bean varieties and chemical spray influenced chocolate spot epidemics, slowing the disease progress rate and increasing Faba bean grain yield in agreement with the report by (Sahile *et al.*, 2008)and (Estyhe,A,2017).

When comparing the effect of varieties without chemical treatment, the varieties Local, Hachalu, Gebelicho and Walkie, had of (58.66%, 40.00%, 38.66%, 31.33% and (68%, 50.66%, 40.66%, 36.66%) was record both location disease severity at 49 and 57 days after planting respectively (Table 2and 4) Yekedem and Hassen(2017). From this experiment almost in all days of diseases assessment Walkie variety shows lowest level of percentage severity index. Similarly, Gebrehiwot (2011) reported that Walkie shows moderately less level of necrotic lesion index. Disagree On the other hand, Kora *et al.*, (2016) reported that the final highest diseases severity index was recorded from Walkie variety and he puts the reason as the degradation of resistant ability of faba bean variety through time and the appearance of new chocolate spot races. Beyene *et al.*, (2016) reported that there is a variation among the genotypes for chocolate spot general disease severity and area under disease progress curve values.

Chocolate spot PSI showed significant different at Gazer on all varieties at different days of recordings except first and second days of records. Similarly, fungicides showed very highly significant difference ($P<0.001$) on chocolate spot PSI. This indicated that contribution of fungicides in controlling the diseases was after two successive foliar sprays similar work Yekedem and Hassan(2017). At

Wobamer site varieties and fungicides showed significant different at all days of records on chocolate spot PSI. The mean PSI of chocolate spot was different on plots treated with three fungicides at both locations (Table 2and 4) and (Figures 1 and 2). At Gazer and Wobamer district there was similar trend that the highest chocolate spot PSI recorded from naturally infected plots, while lowest was observe Wolkie with Mancozeb from fungicide treated

Disease Progress Curve

The disease progress curves of Faba bean chocolate spot (severity versus day after planting) were presented separately for each Faba bean varieties in both locations (Figure1& 2). Each disease progress for both Faba bean varieties revealed that disease severity progressed increasingly starting from the onset of to the final severity assessment during the study periods. All disease progress curves for the integrated management of Faba bean chocolate spot (variety + fungicides) indicated that the disease progress was different for each variety. Disease severity in Local unsprayed variety was susceptible relatively higher progress curve and displayed the higher level of chocolate spot diseases severity was both location Yekedem and Hassen(2017). The disease progress curves of plots treated with Mancozeb fungicides with Wolkie varieties resistance chocolate spot and with foliar spray the lower disease progressed curve compared to the among treatments at both experimental site (Figure1& 2).

Area under Disease Progress curve

Area under disease progress curve (AUDPC) was very highly significantly (P <0.001) affected by treatments (Table.7) and above (Figure1and 2). The highest AUDPC (1646.33%-days), (1195.6%-days) and (1215%-days) was observed on the unsprayed plot of Local, Hachalu variety and local treated variety with Copper hydroxide, while the lowest AUDPC (574.67%-days),(804.33%-days) was exhibited in Wolkie and Gebelicho variety sprayed with Mancozeb at Gazer (Table 7&Figure 1). The highest AUDPC (1649.8%-days), (1217.5%-days)and(1059.7%-days) was observed on the unsprayed (control) plot of Local, Hachalu variety and Hachalu treated with Copper Hydroxide while the mean lowest AUDPC (468.0%-days), (670.7%-days) was exhibited in Wolkie variety sprayed with Mancozeb and Wolkie variety sprayed with Copper Oxychlorid at Wobamer (Table 7&Figure 2). Therefore, based on the result of AUDPC, cumulative of disease severity index, one can conclude the resistance and susceptibility levels of different varieties meaning, highest AUDPC is corresponding with susceptible to chocolate spot while the lowest AUDPC is corresponding with resistance to chocolate spot similar result with Yekedem and Hassen(2017).

This result is in line with the work of Woldie and Mitiku (2014) which reported that Significant difference was recorded among faba bean varieties (P<0.05) for their AUDPC value. Maximum AUDPC value was recorded from Degaga (2535.3%-days, 1688.8%-days), Gebelcho (2041.7%days, 1694.3 %-days) and Hachalu (2502.6, 1538.8 %-days) varieties at Agarfa and Sinana site respectively. While the minimum AUDPC value was recorded from the resistant varieties including Tumsa (1405.0%-days, 844.4 %-days), Shallo (1680.3%-days, 850.0%-days) and Walkie (1413.6%-days, 1013.9%-days) at Agarfa and Sinana site respectively. Using varieties Walkie and Gebelicho reduced the AUDPC values when compared with local variety. Using fungicides such as Copper oxychlorid and Mancozeb reduced the AUDPC values respectively when compared with untreated control plots. This result is similar with El- Sayed *et al.,* (2011) which reported that Dithane M45 (Mancozeb) significantly reduced chocolate spot diseases infection than untreated plot.

In general, AUDPC values varied among the faba bean varieties depending on the resistance levels of the varieties and it is known that AUDPC is directly related to the yield loss (Singh, 1989). Therefore, selection of faba bean varieties (Walkie) having low AUDPC value is acceptable for practical purposes

Disease Incidence

The analysis of variance (ANOVA) for chocolate spot incidence showed highly significant difference at (P<0.001) between treatments. The highest mean disease incidence (90%) was observed on the Local and Hachalu variety with unsprayed (control) while the lowest mean incidence (23%) was observed on Wolkie variety sprayed with Mancozeb 80% WP at Wobamer (Table 7). The highest mean incidence (90%) was observed on the Local and Hachalu variety with unsprayed/control plot while the lowest mean incidence (26.66%) was observed on Wolkie variety sprayed with Mancozeb 80% WP at Gazer. Whereas the highest percent Faba bean chocolate spot disease incidence was recorded at Wobamer similar to Gazer among treatment both locations was similar highest disease infestation are Local and Hachalu variety

without fungicides and the reducing chocolate spot natural infestation among treatment with Wolkie Variety with Mancozeb treated fungicides was observe both location(Table 7).

The main effect of variety showed significant difference (P<0.001) and the main effect of spray showed significant difference (p<0.001) in affecting number of plant. The highest number of diseases incidence (76.6%,71.6% and 69.1%, 65.8%) was recorded from Local unsprayed variety followed by Hachalu untreated plot both location at Wobamer and gazer experimental site respectively(Table3&5). On the other hand, the lowest disease incidence (44.9% & 46.6%) was recorded from Walkie followed by Gebelicho (54.1%&56.6%) both location at Wobamer and Gazer (Table 3&5). From the main effect of fungicide sprays, the lowest disease infection (33.3%and 48.3%) was from Mancozeb fungicides and the highest disease incident (81.6% and 80.8%) were from Unsprayed was both location at gazer and Wobamer respectively. Fungicide application increased yield and seed per plant about four times as compared to control (Teshome and Tegegne, 2013). Bitew and Tigabie, (2016) also reported similar results that among fungicides sprayed plots, This result agreement was Yekedem and Hassen(2017). Even though this value was not statistically significant from untreated plot and copper hydroxide treated plot.

Effect of the treatments on Yield and Yield Components

Plant Height(cm)

The analysis of variance (ANOVA) revealed that plant height was significantly difference (P<0.05) affected by varieties and spray chemicals. The tallest plant height (130.63 cm) was measured from the variety Hachalu with Mancozeb treated plots followed by variety Hachalu unsprayed treatment (129.63 cm). On the other hand, the shortest plant height was recorded from fungicide sprayed on Gebelicho with Copper oxychlorid and untreated Wolkie variety (111.5 and 111.56 cm) at Gazer experimental site (Table 8). On the other hand the analysis of variance affected by variety and fungicides spray on highly significantly difference (P<0.01) (Table 8). The tallest plant height (109.68cm) was recorded Wolkie variety with Mancozeb spray followed by Hachalu with Mancozeb fungicides (108.12cm) at Wobamer experimental site (Table 8). On the other hand, the shortest plant height was recorded from fungicide sprayed on Wolkie without fungicide and Local with copper hydroxide fungicide spray (98.04 and 98.24) at Wobamer experimental site.

The main effect of variety showed significant difference of (P< 0.05) in plant height. The tallest (121.97, 106.72 cm) and shortest (118.95, 103.21 cm) plant height was recorded from Hachalu, Gebelicho and shortest Local variety both location at gazer and Wobamer sites respectively. On the other hand, there was no statistically significantly different plant height are Faba bean varieties (Table 8). Analysis of variance plan height are not statistically significantly different among treatment were as both experimental location (Appendix Table3 and 4). From the main effect of fungicide sprays, the lowest (118.95 and 103.07) was from Copper hydroxide, control/untreated plot and the highest (122.41 and 108.00) were from Mancozeb fungicides were both experimental site at Gazer and Wobamer respectively. Even though this value was not statistically significant from untreated plot and Mancozeb treated plot. Fungicide application increased yield and seed per plant about four times as compared to control (Teshome and Tegegne, 2013). Bitew and Tigabie, (2016) also reported similar results that among fungicides sprayed plots.

Number of pod per plant

Faba bean varieties and fungicide spray highly significant difference ($p \leq 0.001$) variation in pod numbers per plant. Significantly, the highest number of PPP (43.33 and 46.6,) was recorded from Walkie treated with Copper oxychlorid plots and Wolkie treated with Mancozeb at gazer and Wobamer (Table 8). On the other hand, the lowest number of PPP (17.6 and 21.23) was obtained from the untreated Local variety and Local treated copper hydroxide plots were recorded both location at Gazer and Wobamer respectively (Table.8). Degife and Kiya (2015) similarly reported that this variety was highest number of pods per plant Walkie and Gebelicho with treated by Mancozeb was in line with the work of Ashenafi and Mekuria (2015) who reported that this variety had a higher number of pods per plant followed by Wolkie variety treated with copper oxychlorid at both experimental site.

However, in the study of Tafere *et al.*, (2012), Gebelicho and Wolki varieties had the smallest number of pods per plant, which disagreed with our result. Whereas, Hachalu un sprayed from improved varieties and local unsprayed variety produced the lowest number of pods/plant. Faba bean genotypes significantly varied in production of pods per plant (Hassan and Ishaq, 1972; Pilbeam *et al.*,

1992).The main effect of variety showed significant difference (P<0.001) and the main effect of spray showed significant difference (p<0.001) in affecting number of pod per plant (PPP). The highest number of PPP (39.92 and 36.14) was recorded from Wolkie variety both site followed by Gebelicho (32.86 and 28.89) was experimental site at gazer and Wobamer. On the other hand, the lowest number PPP (26.40 and 24.42) was recorded from Local variety followed by Hachalu variety (27.41 and 24.78) was both location Gazer and Wobamer respectively. From the main effect of fungicide sprays, the lowest number of PPP (26.28, 25.11and 31.08,25.90) was from Unsprayed treatment and Copper hydroxide and the highest number of PPP (36.44 and 32.58) were from Mancozeb even though this value was statistically significant difference from untreated plot and Mancozeb treated plot.

Total grain yield

From the beginning, it should be emphasized that the differences in grain yield among the varieties could be explained not only by differences in the levels of disease occurrence but also in the inherent potential yields of the varieties. Faba bean varieties and chemicals showed significant ($p \leq 0.001$) variation in their grain yield. The highest (2675.0kg/ ha^{-1}) grain yield per hectare was gained from variety Walkie treated with Mancozeb fungicide both site. The second highest grain yield (2618.2kg/ ha^{-1}) was recorded from Hachalu treated with Mancozeb fungicide and (2412.9kg/ha^{-1}) Walkie treated with copperoxychlorid both locations at Gazer and Wobamer respectively. However, this value was not statistically differed from Gebelicho treated with Mancozeb and Local treated with Mancozeb resulted grain yield of (2019.7kg/ $ha^{-1}$and 1998.5kg/ ha^{-1}) respectively. On the other hand, the lowest (964.4kg/ ha^{-1}) and (772.7kg/ha^{-1}) grain yield per hectare was recorded from unsprayed Local variety at Gazer and Wobamer site respectively (Table 10).

The main effect of Faba bean varieties showed a significant difference (p<0.001) in affecting total yield per hectare. The highest grain yield (1832.3kg ha^{-1}) and (1998.67kg/ha^{-1}) were recorded from Walkie variety both location. The next highest grain yield was obtained from Gebelicho (1648.48 kg ha^{-1}) and Hachalu (1447.53kg/ha^{-1}) at gazer and Wobamer respectively. This value was not significantly differed from grain yield resulted from Gebelicho (1648.48kg/ ha^{-1}) and Local variety (1632.00kg/ ha^{-1})at gazer study area (Table11). Lowest grain yield was obtained from local variety 1632.00kg/ ha^{-1}) and (1209.28kg / ha^{-1}) local and Gebelicho variety at gazer and Wobamer respctivety. This result is similar with the work of Negash *et al.*, (2015) which reported that the moderately tolerant cultivar, Hachalu, had better effect in reducing chocolate spot epidemics, increased seed yield and yield components, and higher economic benefits over the local cultivar.

The main effect of foliar fungicide application also showed significant difference (P<001) in affecting grain yield of faba bean. The highest grain yield (2327.84kg) and (1911.93kg) were resulted from foliar spraying of Mancozeb at two sites. The second highest grain yield (1855.49kg and 1732.57kg) was obtained by applying copper oxychlorid fungicide on chocolate spot affected plant. On the other hand, the smallest grain yield was (1244.69kg and 1009.28kg) obtained from unsprayed plot at Gazer and Wobamer site. This result is more or less similar with the work of Kora *et al.*, (2016) which reported that there were significant differences ($P \leq 0.05$) in grain yield among the main effects of Mancozeb spray intervals. Mancozeb increased the yield of faba bean varieties, compared to the respective unsprayed controls. Fungicide application increased yield and seed per plant about four times as compared to control (Teshome and Tegegne, 2013). Bitew and Tigabie, (2016) also reported similar results that among fungicides sprayed plots. Furthermore, the ranking of the varieties for yield may change, should the varieties be exposed to higher disease severity. This is mainly due to varying levels of tolerance that is expected in different faba bean varieties.

Hundred Seed Weight

Analysis of variance results revealed the presence of highly significant ($p \leq 0.001$) differences among the faba bean varieties, sprays and the interaction of the two in their 100 grain weights. The lowest and significantly different grain weight of (43.33g) and (40.00g) was recorded from unsprayed Local variety both location. However, this variety had no significant difference from unsprayed Hachalu varieties (44.33g) and treated with Local copper hydroxide (45.00g) at Wobamer experimental site. The highest Wolkie variety treated with Mancozeb had a hundred seed weight of (81.66g and 79.33g) at Wobamer and gazer respectively.

The second highest grain weights of (72.66g) Wolkie treated with copper oxychlorid at Wobamer and(68.66g) were obtained from Hachalu variety treated with Mancozeb at Gazer respectively, which did not have significant difference from Wolkie, Gebelicho, Local and

Hachalu varieties treated with copper oxychlorid and Local variety treated with Mancozeb, Wolkie, Hachalu and Local variety treated with copper Hydroxide was all treatments of chemicals as well as unsprayed plot of Walkie variety at gazer study area (Table 10).

From the main effect of variety, the highest grain weight was recorded from Wolkie and Hachalu variety (64.58g and 61.00g) at Gazer and (66.66g and 58.50g) at Wobamer respectively. On the other hand, lowest grain weight (56.41g) and (53.00g) was recorded from Local variety both location (Table 11). This result is more or less similar with the work of Haile *et al.,* (2015) reported that among varieties, Hachalu (99.1 g), Moti (91.3 g), Gebelcho (86.3 g) and Tumsa (84.5 g) were significantly ($P < 0.05$) superior in 100-seed weight to Bulga-70, Kuse and the local cultivar at Tocha. Similarly, heavier seeds were recorded from Hachalu (95.6 g), Moti (83.7 g), Tumsa (73.7 g) and Gebelcho (71.2 g) at Mari. Moti (84 g), Hachalu (82.8 g) and Gebelcho (77.1g) were the leading varieties at Turi.

Yield Loss Caused by Chocolate Spot of Faba Bean (*Botrytis fabea*).

The maximum protected plot was Walkie and Hachalu variety treated with Mancozeb followed by Wolkie variety treated by Copper oxychlorid both locations. Similar work at Estayh. A (2017). The highest yield loss (63.94%) and (70.91%) at gazer and Wobamer was observed from unsprayed plot of local variety followed by Wolkie variety treated by copper hydroxide (53.58%) at Gazer and Gebelicho unsprayed (63.7%) at Wobamer experimental site. This result is in line with the work of Dereje and Yaynu (2001) which reported that up to 68% of yield loss was recorded on unsprayed control plot. In addition, El-Sayed *et al.,* (2011) reported that foliar diseases and chocolate spot of faba bean caused a yield loss of up to 50 % on unsprayed control plot.

Association of Diseases Parameter with Yield and Yield Components

Correlation analysis of AUDPC, severity and yield revealed highly significant association among different fungicide treatments (Table 13). Percentage Severity index and AUDPC had highly significant positive correlation coefficients of r = 0.9 at both location and negative correlation coefficient of r = -0.7 with yield. PSI has had correlation coefficient of r = -0.7 with grain yield., Percentage Severity index, Incidence and Number of pod per plant, pod length are highly negative significant correlation coefficients r=-0.6,-0.7 and Percentage Severity index non-significant negative correlation coefficients Hundred seed weight and plant height r=-0.3&-0.05. AUDPC and Grain yield highly significant negative correlation coefficients of r =-0.7&-0.7 similar correlation AUDPC and yield at Gazer and Wobamer study area. Pod length, NPPP, Hundred seed weight and yield are positive correlation coefficients at both locations.

Recommendation

Faba bean (*Vicia faba* L.) also called as broad bean, horse bean and field bean, is one of the earliest domesticated food legumes in the world. The plant is grown mainly for its green pods and dried seeds, which are rich in a protein that can substitute for animal protein in humans. In the highlands of Ethiopia, Faba bean is one of the most important food crops widely produced.

In Ethiopia, the productivity of Faba bean is far below its potential due to a number of factors, among the biotic stresses, chocolate spot (*Botrytis fabae*) stands out as one of the most destructive diseases. Faba bean varieties and fungicide application consistently reduced chocolate spot severity and increased the yield correspondingly.

The analysis of variance revealed that there was significant the interaction effects of fungicide treatment by varieties showed very highly significant difference ($P \leq 0.001$) in presenting severity index (PSI) of chocolate spot symptom starting from 49DAP Gazer and 57DAP Wobamer days after planting.

The highest mean disease severity index at 49DAP and 57DAP days after planting was 58.66% and 68%was recorded from Local unsprayed plot of variety are both location respectively, while the minimum (13.33%) and (14.66%) chocolate spot diseases severity index was recorded from Wolkie variety treated with Mancozeb fungicide at 49 and 57 days after planting are the two location. Area under disease progress curve (AUDPC) was very highly significantly ($P < 0.001$) affected by treatments. The highest AUDPC (1646.33%-days), (1195.6%-days) and (1233.83%days, 1654.83%-days) was observed on the unsprayed plot of Local and unsprayed Hachalu variety bothsite while the lowest AUDPC (574.67%-days) and (804.33%-days)was exhibited in Wolkie and Gebelicho variety sprayed with Mancozeb at Gazer and (468.0%-days) and (670.7 %-days) Wolkie variety sprayed with Mancozeb and Copper Oxychlorid at Wobamer.

Table.1 Name of variety on experimental field.

Varieties	Improving year	Location
Walkie	2008	Debre berhan
Hachalu	2010	Debre berhan
Gebelicho	2006	Holta
Local		From farmer

Table.2 Chocolate spot percentage severity index (PSI) on the four Faba bean varieties and different fungicide application of Gazer doredora Keble main cropping season at 2020/2021.

Variety	**Fungicide**	49 DAP	**Day After Planting**			77DAP	84DAP
			56DAP	63DAP	70 DAP		
Local	Unsprayed	58.66^{a}	66^{a}	70^{a}	74.66^{a}	77.33^{a}	83.33^{a}
Hachalu	Unsprayed	40.00^{b}	42^{bc}	46.66^{b}	52^{b}	60.66^{bc}	71.33^{bcd}
Gebelicho	Unsprayed	38.66^{bc}	43.33^{b}	45.33^{bc}	51.33^{b}	65.33^{b}	74.66^{abc}
Local	copper hydroxide	36.00^{bc}	40.66^{bcd}	42.66^{bcd}	52^{b}	66^{b}	78^{ab}
Hachalu	copper hydroxide	32.00^{bcd}	38^{bcd}	40.66^{bcde}	40^{cd}	56^{bcd}	70^{bcd}
Wolkie	Unsprayed	31.33^{bcd}	32.66^{ef}	36.66^{de}	39.33^{cd}	50.66^{cd}	66^{cde}
Gebelicho	Copper hydroxide	30,66^{cde}	34.66^{cdef}	39.33^{bcde}	41.33^{c}	63.33^{b}	67.33^{cde}
Local	copper oxychlorid	30.66^{cde}	33.33^{def}	37.33^{cde}	40.66^{c}	56.66^{bcd}	68^{cde}
Gebelicho	copper oxychlorid	26.66^{de}	32^{efg}	37.33^{cde}	32de	56.66^{bcd}	64^{def}
Wolkie	Copper hydroxide	26.00^{de}	31.33^{efg}	36.66^{de}	34.66^{cde}	51.33^{cd}	64^{def}
Hachalu	Mancozeb	26.00^{de}	29.33^{fg}	33.33^{ef}	33.33^{cde}	47.33^{d}	55.33^{fg}
Local	Mancozeb	25.33^{de}	30^{fg}	32.66^{ef}	36^{cde}	48^{d}	64.66^{def}
Hachalu	copper oxychlorid	25.33^{de}	32.66^{ef}	32.66^{ef}	40^{cd}	51.33^{cd}	64.66^{def}
Wolkie	copper oxychlorid	24.66de	27.33^{fg}	37.33^{cde}	34^{cde}	50^{d}	59.33^{efg}
Gebelicho	Mancozeb	22^{e}	24.66^{g}	27.33^{f}	30.66^{e}	48.66^{d}	54.66^{g}
Wolkie	Mancozeb	13.33^{f}	15.33^{h}	20^{g}	22.66^{f}	36.66^{e}	38.66^{h}
	Mean	30.45	34.58	38.50	40.91	55.37	65.25
	LSD(0.05)	3.97	3.462	7.13	7.22	9.12	8.32
	CV%	15.65	12	11.11	10.58	9.8	7.22

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant differences at 5%, PSI percentage severity index, DAP: Day after Planting.

Table.3 Main effect of four Faba bean varieties and four spray level on percentage severity index, AUDPC and incidence of chocolate spot diseases at Gazer district area in 2020/21main cropping season.

Variety	49DAP	56DAP	63DAP	70DAP	Day After Planting			DI%
					77DAP	84DAP	AUDPC	
Local	37.66a	42.5a	45.66a	50.83a	62a	73a	1199.42a	69.1a
Hachalu	30.83b	35.5b	38.33b	41.33b	53.83b	65.33b	1020b	65.5b
Gebelicho	29.5b	33.66b	37.33b	38.83b	58.5a	56.15b	1015.08b	56.6c
Wolkie	23.83c	26.66c	32.66c	32.66c	47.16c	57c	849.58c	44.9cd
		Fungicide						
Unsprayed	42.16a	46a	49.66a	54.33a	63.5a	73a	1261.33a	81.6a
copper hydroxide	31.16b	36.16b	39.83b	42b	59.16a	69a	1072.83b	70.8ab
copper oxychlorid	26.83c	31.33c	36.16c	36.66c	53.66b	64b	961.08c	45.5cd
Mancozeb	21.66d	24.83d	28.33d	30.66c	45.16c	53.33c	788.83d	33.3e
LSD(0.05)	3.97	3.462	7.13	7.22	9.12	8.32	99.2	8.08
CV%	15.65	12	11.11	10.58	9.8	7.22	5.82	16.39

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant difference at 5%, PSI percentage severity index, AUDPC, Area under disease progress curve, disease incidence.

Table.4 Effect of Chocolate spot percentage severity index (PSI) on the four Faba bean varieties and different fungicide application of Wobamer district yedamer Keble main cropping season at 2020/2021.

Variety	Fungicide	57 DAP	64DAP	Day After Planting			92DAP
				71DAP	78DAP	85DAP	
Local	unsprayed	68^{a}	70^{a}	72^{a}	72.66^{a}	76^{a}	79.66^{a}
Hachalu	unsprayed	50.66^{b}	51.33^{b}	51.33^{b}	54^{b}	59.33^{b}	60.33^{b}
Gebelicho	unsprayed	40.66^{c}	41.33^{cde}	45.33^{bc}	47.33^{cd}	49^{cd}	54.66^{bcd}
Local	copper hydroxide	38^{cde}	47.33^{bc}	45.66^{bc}	41^{efg}	52^{bc}	62^{b}
Hachalu	copper hydroxide	41.33^{c}	48^{bc}	49.33^{b}	49.33^{bc}	45.33^{cde}	58^{bc}
Wolkie	unsprayed	36.66^{cde}	39.33^{cde}	41.33^{cd}	41.66^{def}	45.33^{cde}	45.66^{def}
Gebelicho	Copper hydroxide	39.33^{cd}	42.66^{bcd}	41.33^{cd}	44^{cde}	47^{cde}	57.33^{bc}
Local	copper oxychlorid	29.33^{efg}	32.66^{def}	35.33^{def}	37.33^{fgh}	40^{defg}	58.66^{bc}
Gebelicho	copper oxychlorid	31.33^{defg}	32.66^{def}	36.66^{de}	32^{hi}	30.66^{h}	36.66^{fg}
Wolkie	Copper hydroxide	29^{efg}	36.66^{def}	37.33^{de}	42^{def}	39.66^{fgh}	42.66^{efg}
Hachalu	Mancozeb	29.33^{efg}	32.66^{def}	37.33^{de}	35.66^{gh}	44^{cdef}	46.33^{def}
Local	Mancozeb	28.66^{fg}	32^{ef}	34.66^{def}	37.33^{fgh}	39.66^{efg}	48.66^{cde}
Hachalu	copper oxychlorid	25.33^{g}	33.33^{def}	29^{f}	33^{h}	41.33^{defg}	48.66^{cde}
Wolkie	copper oxychlorid	23.33^{g}	28.66^{f}	31.33^{ef}	26.66^{i}	34.66^{gh}	41.33^{efg}
Gebelicho	Mancozeb	29.33^{efg}	31.33^{ef}	31.33^{ef}	33.33^{h}	35.33^{fgh}	38.66^{efg}
Wolkie	Mancozeb	14.66^{h}	17.33^{g}	20.66^{g}	20.66^{j}	26.66^{h}	32.66^{g}
	Mean	34.687	38.58	40	40.5	43.85	50.75
	LSD(0.05)	7.94	8.79	6.45	5.36	8	9.51
	CV%	13.73	13.66	9.67	7.94	10.94	11.23

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant difference at 5%, PSI percentage severity index, DAPS: Day after Planting.

Table.5 Main effect of four Faba bean varieties and four spray level on percentage severity index, AUDPC and incidence of chocolate spot diseases at Wobamer district area in 2020/21main cropping season.

Variety	57 DAP	64 DAP	71DAP	**Day After Planting**			AUDPC	DI%
				78DAP	85DAP	92DAP		
Local	41a	45.5a	46.9a	47.08a	51.9a	62.25a	1120.25a	76.6a
Hachalu	36.66b	41.33ab	41.7b	43b	47.5b	53.33b	1004.46b	71.6b
Gebelicho	35.16b	37b	38.66b	39.16c	40.5c	46.83c	898.08c	54.1c
Wolkie	25.91c	30.5c	32.66c	32.75d	35.5d	40.58d	759.33d	46.6d
		Fungicide						
Unsprayed	49a	50.5a	52.5a	53.9a	57.41a	60a	1223.79a	80.8a
copper hydroxide	36.91b	43.66b	43.41b	44b	44.9b	55b	1021.79b	65.8b
copper oxychlorid	27.33c	31.83c	33c	32.25c	36.66c	46.33c	791.75c	54.1c
Mancozeb	25.5d	28.33c	31c	31.75c	36.41c	41.58c	744.79c	48.3d
LSD(0.05)	3.97	4.39	3.22	2.68	4	4.75	47.44	14.53
CV%	13.73	13.66	9.67	7.94	10.94	11.23	6.01	13.9

Means followed by the same later are not significantly different.

Table.6 Diseases progressive rate of sixteen treatments for Gazer and Wobamer district area

		Gazer				**Wobamer**			
Treatment combination		rate (r)	R^2	R2 (Adj)	S	rate (r)	R^2	R2 (Adj)	S
Variety	**Fungicide**								
Gebelicho	Unsprayed	0.0443	74	72.3	0.0332	0.0158	69.5	67.6	0.1323
Gebelicho	Mancozeb	0.0437	82.4	81.3	0.2561	0.0113	80	79.3	0.2204
Gebelicho	Hydroxide	0.0464	84	83	0.2573	0.0176	56.5	53.8	0.1958
Oxychlorid	Oxychlorid	0.0441	76.7	75.2	0.3084	0.0028	76	75.1	0.1943
Wolkie	Unsprayed	0.0393	77.9	76.5	0.2652	0.0109	82.4	80.8	0.1989
Wolkie	Mancozeb	0.0435	80.5	79.3	0.2711	0.0278	84.8	83.8	0.1491
Wolkie	Hydroxide	0.0437	79.8	78.6	0.2785	0.0124	69.7	68.6	0.1765
Wolkie	Oxychlorid	0.0402	83	82	0.2411	0.0195	88.1	87	0.267
Hachalu	Unsprayed	0.0371	89.8	89.1	0.1588	0.0125	76.3	75.8	0.2644
Hachalu	Mancozeb	0.0353	81	79.8	0.217	0.0205	59.1	56.6	0.216
Hachalu	Hydroxide	0.0417	77.3	75.9	0.2866	0.0125	59.7	58.6	0.1748
Hachalu	Oxychlorid	0.0455	84.7	83.7	0.2455	0.0261	57.1	54.5	0.2866
Local	Unsprayed	0.0336	72.7	71	0.2615	0.0159	79.9	78.8	0.2641
Local	Mancozeb	0.0445	87.1	86.3	0.2173	0.0214	76	75.6	0.3102
Local	Hydroxide	0.0521	87.2	86.4	0.2524	0.0215	56.7	54	0.2386
Local	Oxychlorid	0.0445	87.8	87	0.2107	0.0296	72.1	70.4	0.2331

Table.7 Effect of Faba bean varieties on disease incidence and AUDPC of Chocolate spot of Faba bean under natural condition during 2020/21 main cropping season at Gazer and Wobamer.

Treatment		Location			
		Gazer		Wobamer	
Variety	Fungicides	AUDPC (%days)	Incidence (%)	AUDPC (%days)	Incidence (%)
Gebelicho	Unsprayed	1224^{b}	83.33^{ab}	1046.5^{c}	70.0^{bc}
	Mancozeb	804.33^{h}	30^{h}	748.7^{efg}	43.3^{e}
	Copper hydroxide	1070.33^{c}	80^{abc}	978.2^{cd}	60.0^{cd}
	Copper oxychlorid	961.67^{cdef}	33.33^{gh}	735.7^{fg}	43.3^{e}
Wolkie	Unsprayed	979.33^{cdef}	66.66^{bcde}	943.3^{d}	73.3^{bc}
	Mancozeb	574.67^{i}	26.66^{h}	468.0^{h}	23.3^{f}
	Copper hydroxide	943^{efg}	50^{efg}	841.2^{e}	46.6^{de}
	Copper Oxychlorid	901.33^{fgh}	36.66^{gh}	670.7^{g}	43.3^{e}
Hachalu	Mancozeb	864.67^{gh}	40^{fgh}	819.7^{ef}	60.0^{cd}
	Copper Hydroxide	1063^{cd}	73.33^{abcd}	1059.7^{c}	76.6^{abc}
	Copper Oxychlorid	956.67^{defg}	63.33^{cde}	756.0^{efg}	60.0^{cd}
	Unsprayed	1195.6^{b}	86.66^{a}	1233.83^{b}	90^{a}
Local	Unsprayed	1646.33^{a}	90^{a}	1654.83^{a}	90^{a}
	Mancozeb	911.67^{fgh}	56.66^{def}	790.2^{ef}	66.6^{bc}
	Copper Hydroxide	1215^{b}	80^{abc}	1011.3^{cd}	80^{ab}
	Copper Oxychlorid	1024.6^{cde}	50^{efg}	813.3^{ef}	70.0^{bc}
	Mean	1021.02	59.166	945.5	62.29
LSD(0.05)		99.2	16.169	94.9	14.53
CV%		5.82	16.3	6.2	13.9

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant difference at 5%, AUDPC, Area under disease progress curve, disease incidence.

Table.8 Effect of yield and yield component of chocolate spot of four Faba bean varieties and three fungicides sprayed at both location district in 2020/21 main cropping seasons.

Treatment		Gazer			Wobamer		
Variety	Fungicide	PH (cm)	NPPP	PL	PH (cm)	NPPP	PL
Gebelicho	Unsprayed	128.9^{ab}	31.5^{cde}	17.10^{d}	106.77^{a} b	27.53^{c} d	14.80^{gh}
	Mancozeb	120.45^{a} bc	39.1^{bc}	20.60^{abc} d	106.26^{a} b	34.20 b	21.15^{bc}
	Copper Hydroxide	115.49^{a} bc	27.4^{ef}	19.967^{b} cd	107.35^{a} b	25.03^{c} d	17.48^{de} f
	Copper oxychlorid	111.5^{bc}	33.46^{cde}	22.25^{abc}	106.50^{a} b	28.83 bc	20.00^{bc}
Wolkie	Unsprayed	111.56^{b} c	30.33de	20.52^{abc} d	98.04c	27.23 cd	17.35^{de} fg
	Mancozeb	120.46^{a} bc	44.93^{ab}	24.95^{a}	109.68^{a}	43.33^{a}	24.00^{a}
	Copper Hydroxide	124.37^{a} bc	37.83^{bcd}	19.65^{bcd}	106.18^{a} b	33.86 b	18.84cd
	Copper oxychlorid	129.56^{a} b	46.6^{a}	23.10^{ab}	104.84^{a} bc	40.16^{a}	23.02^{ab}
Hachalu	Mancozeb	130.63^{a}	29.56^{ef}	20.50^{abc} d	108.12^{a}	25.16^{c} d	18.70^{cd}
	Copper Hydroxide	118.1^{ab} c	21.93^{fg}	18.50^{bcd}	103.41^{a} bc	23.50^{c} d	15.80^{fg} h
	Copper oxychlorid	109.53^{c}	32.46^{cde}	18.61^{bcd}	107.03^{a} b	26.76^{c} d	18.29^{de}
	Unsprayed	129.63^{a} b	25.7^{ef}	17.40^{cd}	107.27^{a} b	23.70^{c} d	14.40^{h}
Local	Unsprayed	115.26^{a} bc	17.6^{g}	12.217^{e}	100.20^{b} c	22.00 d	15.80^{ef} gh
	Mancozeb	118.1^{ab} c	32.2^{cde}	19.45^{bcd}	107.97^{a}	27.66^{c} d	18.65^{cd}
	Copper Hydroxide	117.86^{a} bc	26.66^{ef}	19.00^{bcd}	98.24^{c}	21.23 d	16.00^{ef} gh
	Copper oxychlorid	124.6^{ab} c	29.16^{ef}	20.80^{abc} d	106.43^{a} b	26.80^{c} d	19.30^{cd}
	Mean	120.3	31.78	19.663	105.27	28.564	18.305
	LSD(0.05)	15.572	7.0	4.1763	6.407	2.80	2.327
	CV%	7.7	13.0	12.7	3.6	11.7	7.6

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant difference at 5%, PH: Plant height, NPPP: Number of pod per plant, PL:Pod length.

Table.9 Effect of yield and yield component of chocolate spot of four Faba bean varieties and four fungicides sprayed at both location district in 2020/21 main cropping seasons.

Treatment		Location					
		Gazer			Wobamer		
Variety	Fungicide	GrianYield Kg/ha-1	HSW	RYL%	GrianYield Kg/ha-1	HSW	RYL%
Wolkie	Mancozeb	2675.0^{a}	79.33^{a}	0.0	2656.8a	81.66a	0.0
Hachalu	Mancozeb	2618.2^{a}	68.66^{ab}	2.12	1994.7b	71.33bc	24.92
Wolkie	Oxychlorid	2097.7^{b}	63.66^{bcd}	21.79	2412.9a	72.66b	9.18
Gebelicho	Mancozeb	2019.7^{bc}	67.33^{abc}	24.49	1388.6cde	65.00cd	47.73
Local	Oxychlorid	2007.6^{bc}	63.00^{bcd}	24.94	1529.5cd	61.33ef	42.43
Local	Mancozeb	1998.5^{bc}	61.33^{bcd}	25.28	1607.6c	69.00bc	39.49
Gebelicho	Oxychlorid	1789.4^{cd}	60.00^{bcd}	33.1	1385.6cde	61.33de	47.84
Local	Hydroxide	1557.6^{de}	58.00^{bcd}	41.77	1377.3cde	45.00h	48.15
Hachalu	Oxychlorid	1527.3^{ef}	64.66^{bcd}	42.9	1602.3c	65.66bcd	39.69
Hachalu	hydroxide	1428.0^{efg}	58.33^{bcd}	46.62	1148.5ef	52.66fg	56.77
Gebelicho	Unsprayed	1424.2^{efg}	55.00^{bcde}	46.75	964.4 fg	46.00gh	63.7
Gebelicho	Hydroxide	1360.6^{efg}	53.66^{cde}	49.13	1098.5ef	52.00fg	58.65
Wolkie	Unsprayed	1315.1^{efg}	57.33^{bcd}	50.83	1255.3def	54.66ef	52.75
Hachalu	Unsprayed	1275.0^{fg}	52.33^{de}	52.33	1044.7fg	44.33h	60.67
Wolkie	hydroxide	1241.7^{g}	58.00^{bcd}	53.58	1669.7c	57.66ef	37.15
Local	Unsprayed	964.4^{h}	43.33^{e}	63.94	772.7g	40.00h	70.91
Mean		1706.24	60.25		1494.31	58.56	
LSD(0.05)		241.1	12.15		277.7	6.47	
CV%		8.4	12.09		11.14	6.62	

Note: Means followed by the same later are not significantly different CV%; coefficient of variation, LSD: list significant difference at 5% , HSW: Hundred seed Weight, Yield kg/ha and RYL%: Relative yield Loss.

Fig.1 Disease progress curve of chocolate spot on weekly interval sprayed plot different days of recording four Faba bean varieties and three fungicides Sprayed at Gazer district doredora Keble at main cropping season 2020/2021.

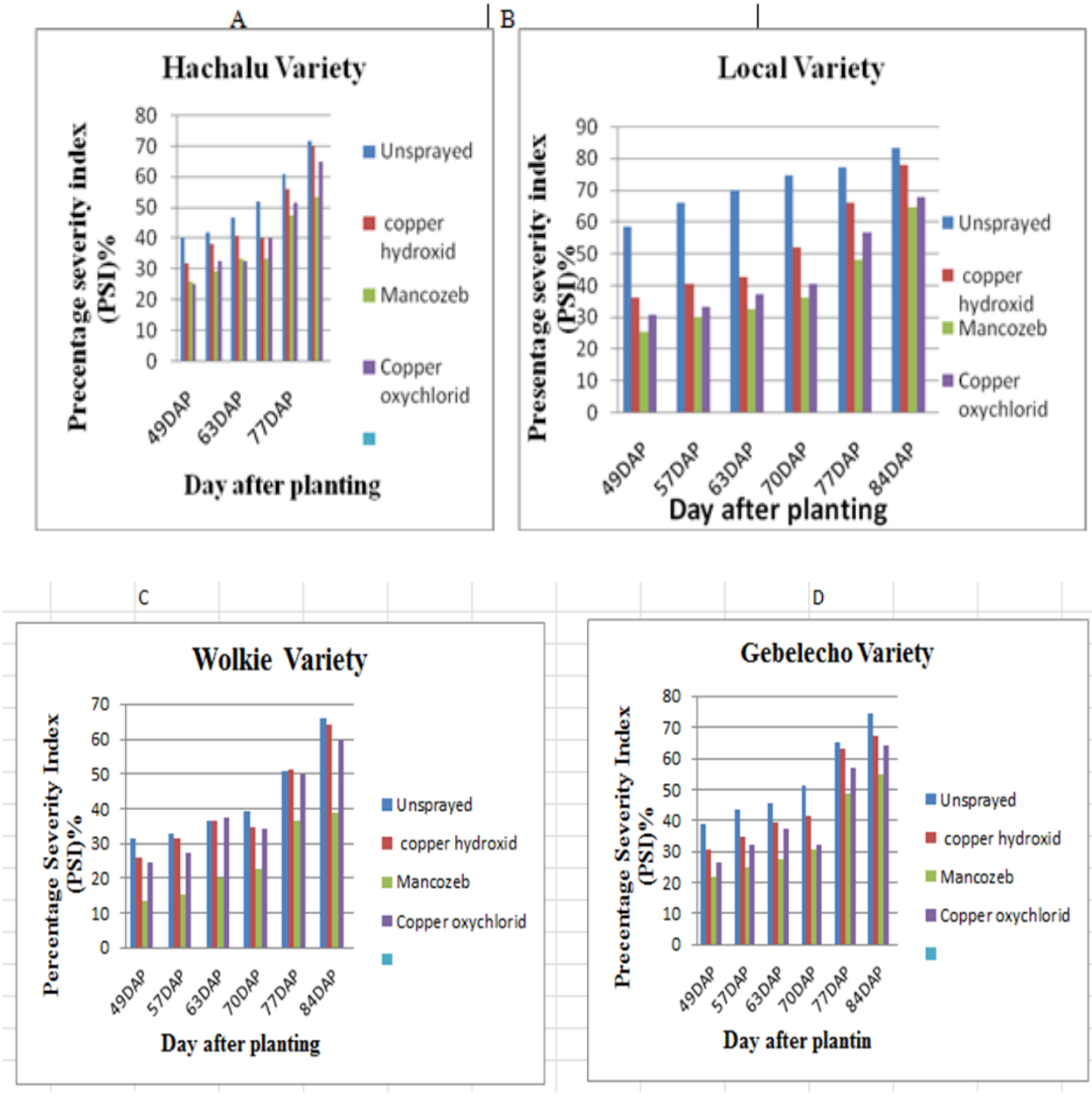
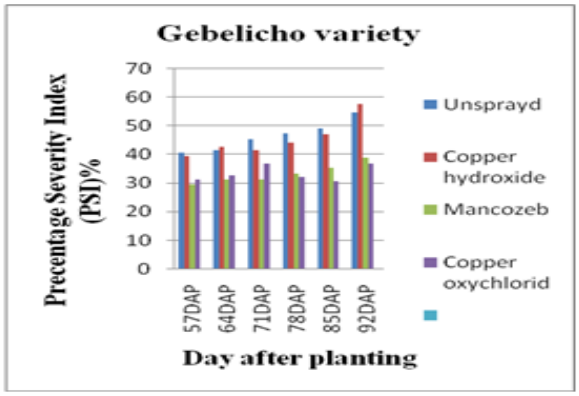


Fig.2 Disease progress curve of chocolate spot on weekly sprayed plot different days of recording four Faba bean varieties and three fungicides Sprayed at Wobamer district yedamerKeble, at, main, cropping season2020/2021.

A



B

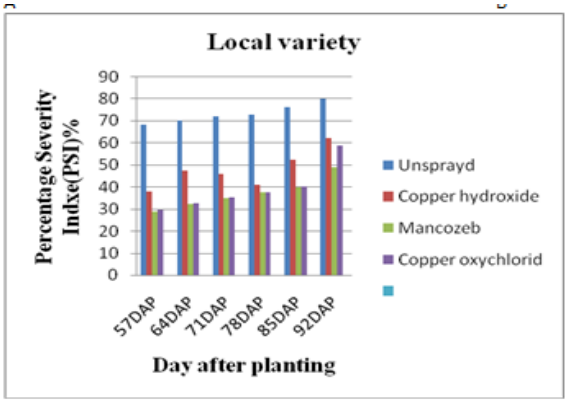
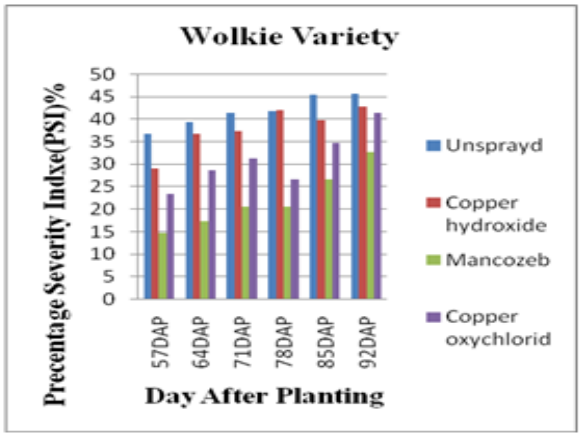


Fig.3 Chocolate spot disease progress curve are four variety and four fungicides sprayed to be interaction with above figure on the highest PSI was record all day after planting of susceptible variety and the lowest PSI represent to resistance variety.

C



D

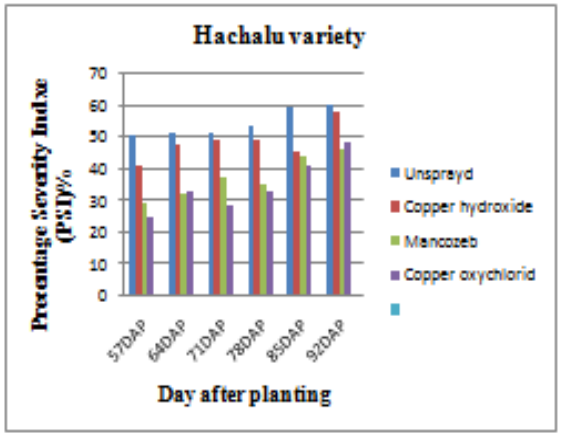


Fig.4 Affected to Symptom of Faba bean chocolate spot.

$$PSI = \frac{\text{Sum of numerical ratings} \times 100}{\text{Number of plants scored} \times \text{Maximum score on scale}}$$

Where, Snr = the sum of numerical ratings, Nps = number of plant scored, Mss = the maximum score of the scale. Means of the severity from each plot was used in data analysis.

$$\mathbf{AUDPC} = \sum_{i=1}^{n-1} [0.5(x_{i+1} + x_i)(t_{i+1} - t_i)]$$

Where, n is total number of assessment times, it is time of the assessment in days from the first assessment date, xi is percentage of disease severity at assessment. Area under disease progressive curve was expressed in percent-days because severity (x) was expressed in percent and time (t) in days.

The highest number of PPP (43.33, 46.6,) was recorded from Walkie treated with Copper oxychlorid plots and Wolkie treated with Mancozeb at gazer and Wobamer. The lowest number of PPP (17.6, 21.23) was obtained from the untreated Local variety and Local treated copper hydroxide plots were recorded both location at Gazer and Wobamer respectively. The highest (2675.0kg/ ha-1) grain yield per hectare was gained from variety Walkie treated with Mancozeb fungicide both site. The lowest (964.4kg/ ha-1) and (772.7kg/ha-1) grain yield per hectare was recorded from unsprayed Local variety at Gazer and Wobamer site respectively. The highest Wolkie variety treated with Mancozeb had a hundred seed weight of (81.66g and 79.33 g) at Wobamer and gazer respectively.

The highest yield loss (63.94%) and (70.91%) at gazer and Wobamer was observed from unsprayed plot of local variety. From this cost benefit analysis Walkie variety treated with Mancozeb fungicide was the best combination to increase net benefits of the farmer. From chemicals Copper oxychlorid was relatively effective for almost all varieties next to Mancozeb. Percentage Severity index and AUDPC had highly significant positive correlation coefficients of r = 0.9 and PSI has had correlation coefficient of r = -0.7 with negative correlation of grain yield. Recommend to the generally, in order to combat the effect of chocolate spot of faba bean, farmers need to use integration of Walkie variety with Mancozeb fungicide(2.5kg/ha) with improved technology. Furthermore, research need to be conducted with additional chemicals and varieties as well as on the constraints and opportunities of faba bean production in the study area.

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