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Fungicidal Management of Field Pea (*Pisum sativam* L.) Powdery Mildew (*Erysiphe polygoni* DC) Disease

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ABSTRACT

Ethiopians produce peas primarily to prepare their traditional dish called shiro. It is not wrong to say that most Ethiopians eat enjera with shiro wot once a day or a three day. Therefore, recognizing the importance of the crop, farmers in Koga Irrigation scheme have started producing peas, but have constraint to grow crops due to the powdery mildew disease. Therefore the experiment was conducted to evaluate and recommend effective fungicides against powdery mildew of field pea. The experiments were conducted during 2019 G. C cropping season through irrigation by using completely randomized block design (RCBD). The result of the experiment shows that, spraying of tebuconazole, propiconazole and Triadimefon can reduce the disease in to 81%, 77.6% and 68.2%, respectively compared to untreated control. Correspondingly, spraying of thus fungicide increase seed yield by 33.5%, 29.6% and 28.8%, respectively, as compared to the untreated control. Therefore, the application of tebuconazole, propiconazole and triadimefon is recommended for the management of powdery mildew on field pea crop.

Keywords: Field pea, Fungicide, Powdery mildew.

INTRODUCTION

Field pea (*Pisum sativum* L.) is a self-pollinated diploid (2n=14) annual herbaceous of the most important staple cool season pulse crop and is valued as high protein food (McKay et al., 2003). In Ethiopia field pea is the second highland pulse which is widely grown in highlands and mid highland parts of the country with altitude ranging from 1800-3000 m.a.s.l. (Tadesse et al., 2018). It is cultivated extensively in the north, south, west and central parts of the country (Ofga & Petros, 2017). According to recent estimates, there are approximately 1.8 million farmers growing field pea on 220 thousand hectares of land with production of 3.6 million quintals, representing 14% of total crop area covered by pulse and 12% of the pulse consumption (CSA, 2018).

Field pea plays an important role in the lives of Ethiopian farmers' because of their diversity of utilization; it serves as a source of food and feed with a valuable and cheap source of protein. It plays a significant role in soil fertility improvement as it fixes atmospheric nitrogen and considered as an ideal rotation crop for cereal-based cropping system (Tadesse et al., 2018). The grain is primarily used for the preparation of 'shirowot', an Ethiopian cultural stew, which is served as a main dish to be eaten with "injera" (Westphal, 1974; Yirga et al., 2013). Also the crop has great economic value due to its better adaptation under low rainfall environments as compared to other pulses such as faba bean and lentil (Mohammed et al., 2016). However, the productivity of field pea (1.6 t ha-1) in Ethiopia is far below the world average (2.0 t ha-1) (FAOSTAT, 2017) due to several factors including biotic and abiotic factors (Tadesse et al., 2018). Among biotic factors Powdery mildew of field peas caused by the fungus Erysiphe polygoni is the most destructive disease; which can cause 20 to 53% yield loss in Ethiopia (Gorfu, 2000).

Powdery mildew is air born obligate parasite which develops on plant surfaces as a white fungal growth and obtains nutrients from the host through specialized feeding structure haustoria in epidermal cells (Agrios, 2005). It is also stubble and seed-born pathogen where inoculums infecting plant parts are responsible for disease transmission (Tadesse et al., 2018). Powdery mildew develops in dry, warm weather accompanied by nights with dew (Endres et al., 2016). The disease cannot cause severe infection in high rainfall areas of Ethiopia, because of spore removal from the plant tissue by rain. Nevertheless, late sown and off-season fields were reported to be highly suffered by the disease (Mussa et al., 2009). The disease affects all green parts of the pea plant

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caused reduced grain weight and yield-related parameters (Sharma et al., 2017).

In the area farmers start to produce field pea under irrigation condition, but now a days the production restrain due to sever attack of powdery mildew. To minimize losses caused by powdery mildew early planting, crop rotation, sprinkler irrigation, use of fungicides and planting resistant varieties are the most important management methods (Tadesse et al., 2018; Fondevilla & Rubiales, 2012). According to Fondevilla and Rubiales (2012) review, only two recessive (er1 and er2) and one dominant (Er3) genes for powdery mildew resistance have been described so far in Pisum germplasms. In the absence of resistance cultivars application of proper fungicides seems to be the only effective method to manage the disease. Therefore the experiment was conducted to identify and recommend effective fungicides against powdery mildew of field pea.

MATERIALS AND METHODS

The field experiment was conducted during the 2019 irrigation cropping season in the northwestern part of the country at the Qoga irrigation scheme. The five fungicides with untreated control (Table 1) were laid in a completely randomized block design (RCBD) with three replications. Each plot has a size of 4.0 m long and 1.6 m width, containing eight rows with spacing of 20 cm. An improved variety sefinesh was planted in 10 cm plant spacing. The spacing between plots and replications were 1m and 1.5m, respectively. Recommended fertilizer rate 46 kg P_2O_5 were applied during planting. Weeding and all other agronomic practices were applied according to the recommended practices for the field pea production in the area. The experimental fields were irrigated uniformly through surface irrigation with 7 days interval.

The fungicides were sprayed by using a hand sprayer of 5 liter capacity and the untreated check did not receive any fungicide treatment. Application of fungicides was started soon at the onset of the disease and sprayed 3 times at 15 days interval. All sprays were applied when the wind velocity was low to avoid any drifting effect from the sprayed plot to neighboring ones. The crop was protected from the infestation of both sucking pests (aphid) and pod borers through the application of Agro-Thoate 40% EC (dimetheote 40%) and karate 5% EC (lambda-cyhalotrin) insecticides based on the factory recommendation rate in all experimental fields uniformly to avoid the yield losses due to insects.

Disease incidence was assessed on central rows starting from the onset of the disease up to all the plants in the plot show disease symptom. The first disease severity score was started when the powdery growth of fungus becomes fully visible on leaves of field pea plant at 75 days after planting. Ten plants were randomly tagged from the central rows of each plot in a diagonal manner. Disease severity had been recorded from the leaves of 10 pre-tagged plants, based on 0 to 10 scale where, 0= no visible symptom, 1= 5%, 2=10%, 3=15%, 4=20%, 5=33%, 6=46%, 7= 60%, 8=73%, 9=86%, 10=100% (Falloon et al., 1995). The severities recorded from each plot were finally converted to percent severity index (PSI) using the formula below (Scott & Hollins, 1974).

Seed yield of each plot were weighed by using sensitive balance after harvesting, drying, threshing and winnowing. Simultaneously, moisture content of each plot were measured by the help of moisture tester. Finally, the yield obtained from each plot were converted in t ha-1 base and adjusted by their corresponding percentage of moisture content. Also, the weight of 100 randomly sampled seeds were weighed by using analytical balance, after counting hundred seeds of each plot and its value was noted down. Maturity days i.e. the number of days from planting date to physiological maturity (90% of pods on the plant are golden-brown) were recorded for each plot.

The severity data recorded at different time were entered in excel worksheets and AUDPC values were calculated for each treatment using formula below (Wilcoxson et al., 1975; Campbell & Maddon, 1990). Area under disease progress curve (AUDPC) is a better indicator of disease expression over time (Vanderplank, 1963).

Table 1 Fungicides used as treatment

Trts	Trade name	Common name	Chemical family	Modes of action	Rate as factory
1	Natura 250 EW	Tebuconazole	Triazole	Systemic	0.5 l/ha
2	Tilt 250 EC	Propiconazole	Triazole	Systemic	0.5l/ha
3	Bayleton 25 WP	Triadimefon	Triazole	Systemic	0.75 Kg/ha
4	Ridomil Gold MZ 68 WP	Metalaxyl+ Mancozeb	Aclamine	Systemic + contact	3 kg/ha
5	Curzate R WP	Cymoxanil+Copper oxychloride	Acetamide+ Dithiocarbomate	Systemic + contact	0.3 kg/ha
6	Control				

EC=emulsifiable concentrate; EW = emulsion, oil in water; WP= wettable powder; l=liters; ha= hectare.

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

Where,

x_i is the cumulative disease severity expressed as a proportion at the ith observation,

t_i is the time (days after planting) at the ith observation,

The percent disease control (PDC) were calculated separately for each of the treatments with different levels of disease as per the standard formula below (Mayee & Datar, 1986).

$$\text{PDC} = \frac{\text{PSI in control plot} - \text{PSI in treated plot}}{\text{PSI in control plot}} \times 100$$

Where; PDC = Percent Disease Control PSI = Percent Severity Index

The relative yield losses were frequently expressed as the fraction (percentage) of the attainable yield (protected plot) lost to disease injuries (unprotected plot). Losses were calculated separately for each of the treatments with different levels of disease severity, based on the following formula (Savary & Willocquet, 2014).

$$RL = \frac{\text{YPP - YUPP}}{YPP} \times 100$$

Where; RL=relative yield loss, YPP= Yield of protected plot, YUPP= Yield of unprotected plot

The data generated from the field experiment were subjected to ANOVA following the procedure described by Gomez & Gomez (1984) for one factor complete randomized block design (RCBD) using the PROC GLM procedure of SAS 9.4. Significant means were separated by using LSD method at 5% probability.

The cost and benefit of each treatment were analyzed partially, and marginal rate of return were computed by considering the variable cost available in the respective treatment (CIMMYT, 1988). Yield and economic data were collected to compare the advantage of fungicide treatment. Marginal rate of return provides the value of benefit obtained per the amount of additional cost incurred percentage. The formula is as follows:

$$\text{MRR} = \frac{\text{DNI}}{\text{DIC}}$$

Where, MRR is marginal rate of returns, DNI, the difference in net income compared with control, DIC, the difference in input cost compared with control.

RESULTS

The Effect of Fungicides on Powdery Mildew Severity:

Late in the season, there was high level of powdery mildew disease incidence and severity at all experimental sites. All the treated and untreated plots showed an incidence of 100% at all experimental sites on the second date of assessment. The disease severity recorded before fungicide spray (75 DAP) indicates statistically nonsignificant variation among experimental plots (Table 2). This shows that the experiment was conducted under uniform inoculum distribution among experimental units. Analysis of variance for disease severity recorded after the first (90 DAP) and second (105 DAP) spray showed a highly significant difference (P< 0.001) among treatments (Table 2). On both date of assessment the highest mean severity 60% and 77.8% ware recorded from the unsprayed control plot but severity did not exceed 20% on plots protected by tebuconazole and propiconazole (Table 2).

Similarly, there was a statistically highly significant difference (p<0.001) regarding on final severity (120 DAP) in all experimental sites (Table 2). The untreated plots showed a maximum severity of 94.4% at the end date of assessment. This shows that the experiment was conducted under an adequate level of disease pressure. The combined data stated in Table 2 indicated that different fungicidal treatments reduce disease severity significantly as compared to the untreated control. Maximum percent disease control (81.0%) (Figure 2) with reduced severity (17.9 %) (Table 2) was obtained from the experimental plot treated with tebuconazole. Correspondingly spraying of propiconazole and triadimefon can reduce disease severity in-to 21.1% and 30% with 77.6% and 67.2% percent disease control. However, spraying of metalaxyl + mancozeb and cymoxanil + copper oxychloride was ineffective to reduce disease severity. Minimum percent disease control of 5.8% and 8.2% (Figure 2) with maximum severity 88.9% and 86.7% were recorded from experimental plots treated with metalaxyl + mancozeb and cymoxanil + copper oxychloride, respectively. Statistically, the difference between untreated control and plots treated with metalaxyl+ mancozeb and cymoxanil + copper oxychloride was insignificant.

The effect of fungicides on area under disease progress curve (AUDPC):

Data pertaining to AUDPC values of different fungicides and untreated control is given in Table 3. Results of the combined analysis revealed that application of fungicides showed a highly significant reduction in AUDPC values with maximum reduction attained from tebuconazole (265.0) followed by propiconazole (256.7) and triadimefon (487.5). The variation between tebuconazole and propiconazole was not significant but both fungicides significantly differed from triadimefon. The maximum AUDPC value (2589.4) was calculated from untreated control. The result obtained through the application of a mixture of metalaxyl plus mancozeb (2106.3) and cymoxanil

Table 2 Mean percent severity index at different date of assessment of all sites

Fungicide	Site 1				Site 2				Site 3				Combined			
	75 DAP	90 DAP	105 DAP	120 DAP	75 DAP	90 DAP	105 DAP	120 DAP	75 DAP	90 DAP	105 DAP	120 DAP	75 DAP	90 DAP	105 DAP	120 DAP
Tebuconazole	16.7	20.0	20.0	20.0	10.0	13.3	16.7	13.3	16.7	20.0	20.0	20.3	14.4	17.8	18.9	17.9
Propiconazole	20.0	23.3	20.0	23.3	10.0	13.3	16.7	16.7	16.7	20.0	23.3	23.3	15.6	18.9	20.0	21.1
Triadimefon	20.0	33.3	36.7	33.3	10.0	13.3	30.0	30.0	16.7	20.0	26.7	26.7	15.6	22.2	31.1	30.0
Metalaxyl 4% + Mancozeb 64%	20.0	53.3	73.3	93.3	10.0	36.7	76.7	86.7	16.7	56.7	80.0	86.6	14.4	48.9	76.7	88.9
Cymoxanil + Copper oxychloride	13.3	53.3	80.0	86.7	10.0	50.0	73.3	86.7	20.0	50.0	80.0	86.6	15.6	51.1	76.7	86.7
Control	26.7	53.3	70.0	96.7	10.0	60.0	80.0	93.3	16.7	66.7	80.0	93.3	17.8	60.0	77.8	94.4
Sig.	ns	**	***	***	ns	***	***	***	ns	***	***	***	ns	***	***	***
LSD	ns	15.4	20.7	14.7	ns	14.0	9.2	12.7	ns	9.2	10.0	11.8	ns	7.7	7.0	6.7
CV%	22.3	21.5	22.8	13.4	5	24.6	10.3	12.8	31.2	13.0	10.3	11.0	26.0	22.2	14.4	12.2

DAP= days after planting; sig= level significance; ns represent non significance at P < 0.05; ** represent highly significance difference at P < 0.01; *** represent very highly significance difference at P < 0.001, LSD= List significance difference; CV=coefficient of variation.

Abyssinia Journal of Science and Technology Vol. 5, No. 2, 2020, 29-37

Table 3 Mean AUDPC values calculated for all sites

Fungicide	Site 1	Site 2	Site 3	Combined
Tebuconazole	307.5	500.0	265.0	265.0
Propiconazole	340.0	501.7	256.7	256.7
Triadimefon	511.7	823.5	487.5	487.5
Metalaxyl+ mancozeb	2484.7	2731.7	2106.3	2106.3
Cymoxanil + copper oxychloride	2360.2	2613.2	2199.0	2199.0
Control	2735.4	2528.4	2589.4	2589.4
Sig.	**	**	**	**
Lsd	290.6	446.2	167.05	167.05
Cv%	10.9	15.2	6.9	6.9

Sig.= level significance; ** represent highly significance difference at P < 0.01; LSD= List significance difference; CV=coefficient of variation.

Table 4 Mean of grain yield and hundred seed weight

Fungicide	Site1			Site2			Site3			Combined		
	DM	HSW (g)	GY (t/ha)	DM	HSW (g)	GY (t/ha)	DM	HSW (g)	GY (t/ha)	DM	HSW (g)	GY (t/ha)
T1	130.7	16.7	3.4	133.3	16.8	1.9	129.7	17.7	2.4	131.2	16.8	2.57
T2	130.3	16.5	3.2	133.3	17.1	1.8	128.3	17.4	2.4	130.7	16.8	2.43
T3	130.0	16.5	3.4	131.7	17.1	1.5	127.7	17.6	2.4	129.8	16.8	2.40
T4	127.7	14.2	2.7	129.3	16.1	1.3	125.7	17.1	2.0	127.6	14.8	1.97
T5	128.0	14.9	2.6	129.0	15.5	1.3	125.7	16.4	1.9	127.6	15.5	1.90
T6	127.0	15.5	2.3	129.3	15.6	1.5	125.3	17.0	1.3	127.2	15.7	1.71
Sig	**	**	**	**	*	*	**	ns	**	**	**	**
LSD	1.6	1.2	0.5	2.3	1.1	0.4	1.3		0.4	1.0	0.9	0.26
CV%	6.8	4.08	9.5	9.5	4.1	15.0	5.6	3.1	16.2		4.6	12.6

T1: Tebuconazole, T2: Propiconazole, T3: Triadimefon, T4: Metalaxyl + Mancozeb, T5: Cymoxanil + copper oxychloride, T6: Control, GY=Grain yield; t ha^{-1}=ton per hectare; HSW= 100 seed weight; g=gram; DM= days to maturity; RL= relative yield loss; ns = non significance at P < 0.05; ** = highly significance difference at P < 0.01; *** = very highly significance difference at P < 0.001 LSD= List significance difference; CV= coefficient of variation.

Table 5 Result of partial budget analysis for fungicide applications used for controlling powdery mildew disease of field pea at Koga irrigation scheme

Items	Treatments					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
Av. grain yield (t/ha)	2.6	2.5	2.4	2	1.9	1.7
Adj. grain yield (10%) (t/ha)	2.3	2.2	2.2	1.8	1.7	1.5
Average grain price per tone	27, 000	27, 000	27,000	27, 000	27, 000	27, 000
Gross benefit(birr/ha)	62,100	59,400	59,400	48,600	45,900	40,500
Amount of fungicide used	1.5 L	1.5 L	2.3 kg	9.0 kg	0.9 kg	0
Cost of fungicide (birr per L/kg)	1000	1000	1200	1400	1200	0
Total cost of fungicide(birr/ha)	1500	1500	2760	12600	1080	0
Cost of labour/Person (ETB)	90	90	90	90	90	0
Total cost of labour (ETB)	270	270	270	270	270	0
Total variable cost (ETB)	1770	1770	3030	12870	1350	0
Net benefit (ETB)	60,330	57,630	56,370	35,730	44,270	40,500
marginal benefit (MB) (birr/ha)	19,830	17,130	15,870	-4,770	3,770	0
MRR (%)	1120.34	967.80	523.76	-37.06	279.26	

NB: T1-Tebuconazole, T2-Propiconazole, T3-Triadimefon, T4-Metalaxyl + mancozeb, T5 -Cymoxanil + copper oxychloride, T6-Control, MRR = marginal rate of return, ETB = Ethiopian birr

plus copper oxychloride (2199.0) significantly lower than AUDPC values calculated from untreated control, nevertheless the result was significantly higher in comparison with superior fungicides tebuconazole and propiconazole.

The effect of fungicides on field pea maturity:

Analysis of variance for days to maturity showed a significance difference at p<0.001 between treatments at all experimental sites. Averagely the prolonged maturity (131.2 days) was recorded from

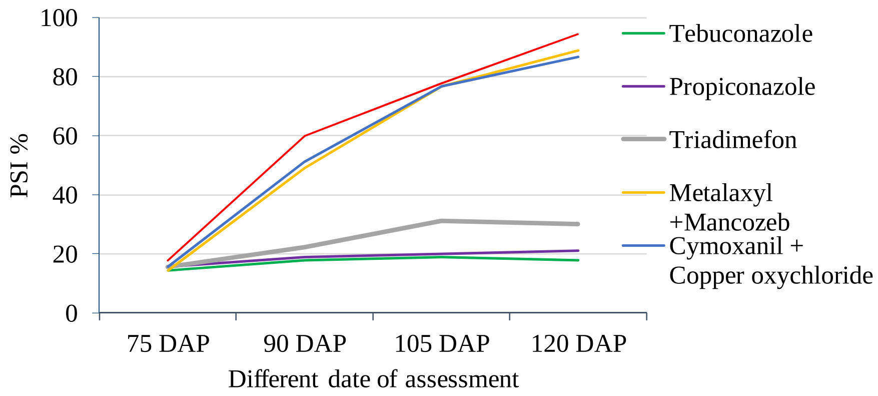

Fig. 1: Disease progress curve for combined PSI

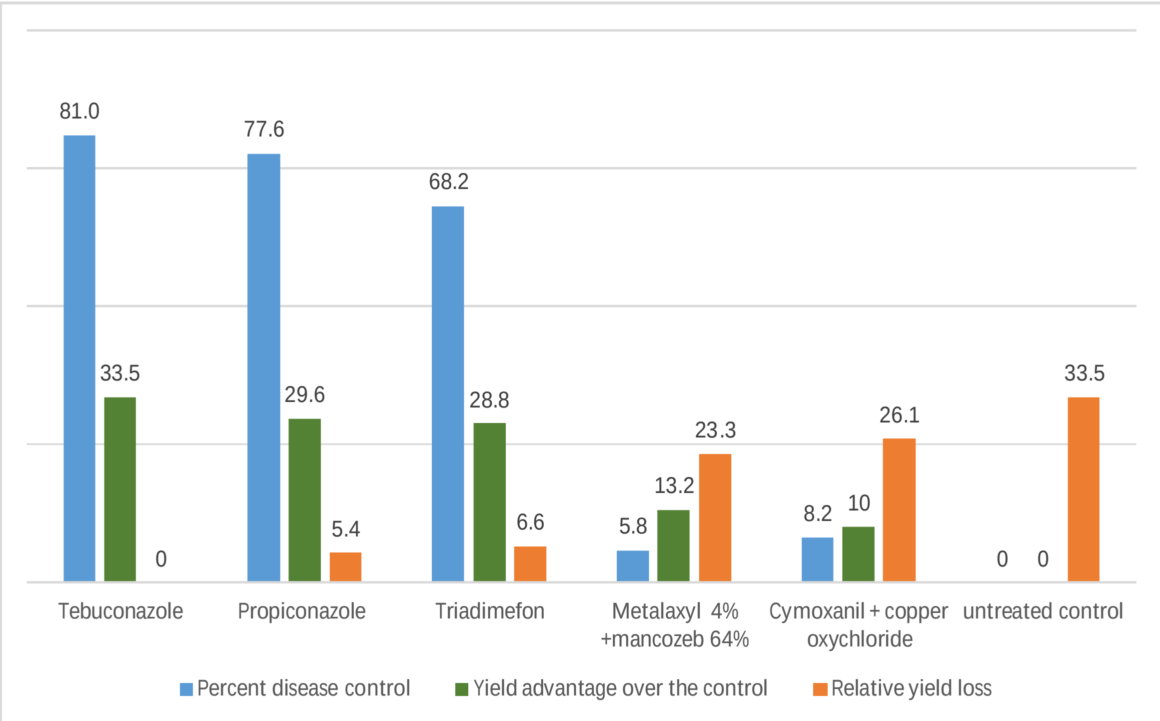

Fig. 2: Percent disease control, yield advantage of each fungicide relative to the untreated control plot and relative yield loss of each treatment in comparison with the best protected plot

the experimental plots treated with tebuconazole (Table 4). However experimental plots treated with propiconazole were not significantly differerent from tebuconazole. There were significant differences between triadimefon and all other fungicides, but statistical variation between triadimefon and propiconazole was insignificant. On average 'untreated control mature early with 127.2 days to maturity (Table 4). Similarly, experimental plots treated with metalaxyl + mancozeb and cymoxanil + copper oxychloride were mature early with the same 127.6 days to maturity (Table 4).

The effect of fungicides on seed yield and 100 seed weight:

The statistical analysis showed that there was a significant difference at p<0.005 between different fungicidal treatment and untreated control in seed yield and hundred seed weight (Table 4). On the average, the highest seed yield (2.6 t ha-1) was obtained from experimental plots treated with tebuconazole. However, similar yields (2.4 t ha-1) obtained from experimental plots sprayed with propiconazole and triadimefon were not significantly different from tebuconazole (Table 4). Unfortunately, tebuconazole, propiconazole and triadimefon sprayed plots produce the heaviest but similar mean hundred seed weight (16.8 g) (Table 4). The lowest grain yield (1.71 t ha-1) was obtained from unsprayed control. Statistically, seed yield produced from experimental plots treated by (metalaxyl + mancozeb and cymoxanil + Copper oxychloride) were not different from untreated control (Table 4). Unexpectedly the lowest mean HSW (14.8 g) was obtained from experimental plots treated by metalaxyl + mancozeb followed by Cymoxanil+Copper oxychloride (15.5 g). However, mean HSW (15.7 g) obtained from untreated control plots were not significantly differerent from metalaxyl + mancozeb and cymoxanil + copper oxychloride sprayed plots (Table 4). As compared to untreated controls, the experimental plot treated by tebuconazole, propiconazole and triadimefon had 33.5%, 29.6% and 28.8% yield advantage (Figure 2). However, the experimental plot treated by metalaxyl + mancozeb and cymoxanil + copper oxychloride showed less than 13% yield advantage over the control which doesn't cover cost of fungicides (Figure 2).

The overall combined data revealed that the loss % of yield for the test variety Sefinesh was 33.5 % in comparison with the best-protected plots. Of all the treatments the higher loss % were obtained from the unprotected plot (Figure 2). On average the lowest relative yield loss (< 6.6%) was observed from the DMI fungicides. On the other hand, the mean relative yield loss obtained from a mixture of metalaxyl + mancozeb and Cymoxanil+copper oxychloride were 23.3% and 26.1% (Figure 2).

Partial budget analysis:

The partial budget analysis of this study indicated that the fungicides treatment resulted high net benefit and marginal rate of returns (Table 5). The maximum net profits (60,330, 57,630 and 56,370 birr/ha) were recorded from tebuconazole, propiconazole and triadimefon fungicide treated plots, respectively as compared with other treatments. However, the lowest net profits (35,730 birr/ha) was obtained from cymoxanil + copper oxychloride sprayed plots. The highest marginal net benefit (MB) (19,830 birr/ha) was obtained from tebuconazole treated plots followed by propiconazole (17,130 birr/ha) and triadimefon (15,870 birr/ha). Whereas, the lowest marginal benefits (-4,770 birr/ha) was calculated from metalaxyl + mancozeb treated plots. Generally, among five tested fungicides the lowest marginal benefit was recorded from metalaxyl + mancozeb sprayed treatment (Table 5). The highest marginal rate of return (MRR) (1120.34%) was calculated from tebuconazole treated plots followed by propiconazole treated plots (967.80%). However, experimental plot treated by metalaxyl + mancozeb had the lowest MRR (-37.06%). As this result showed that application of metalaxyl + mancozeb and even cymoxanil + copper oxychloride fungicides for the management of field pea powdery mildew is not advisable (not profitable) as compared with tebuconazole and propiconazole treated plots.

DISCUSSION

It was noticed that fungicides tebuconazole, propiconazole, and triadimefon reduced the disease intensity and AUDPC, increased seed yield and extend maturity significantly as compared to untreated control. The application of these fungicides, increase yield advantage and/or reducing yield loss, thus bring about maximum net profits and marginal benefits. The results were in conformity with the findings of Sharma et al. (2017) tebuconazole was found significantly superior as compared to other fungicides they tested for field pea powdery mildew. Similarly, Pramod and Dwivedi (2007) and Hiremath and Lal (2018) reported that spraying of propiconazole promotes the growth of the plant by preventing disease caused by Erysiphe polygoni resulting in effective diseases management and increased seed yield. Also Fondevilla and Rubiales (2012) showed that a single application of triadimefon at early flowering prevents powdery mildew infection of pods, increases yield, and delay maturity, thus improving crop quality. Fungicides in a traizole family provide curative and protective activity at low application rates and have a high degree of systemic movement in the plant (Burrows et al., 2017). Fungicides in a Triazole family (sterol demethylation inhibitors) had proven very effective in controlling pea powdery mildew (Fondevilla & Rubiales, 2012). This is achieved because the structure and function of some of the fungal membrane are disorganized (Woods et al., 2005). They inhibit the formation of sterols, which are required for fungal cell wall formation, and thus are effective at preventing hyphal growth (Burrows et al., 2017). Even though there is insignificant variation between three triazole fungicides, the maximum relative efficacy with seed yield was obtained from an experimental plot treated by tebuconazole followed by propiconazole and triadimefon. This is because, over time, triadimefon accumulates at the leaf margins, leaving other parts of the leaf more open to infection. But tebuconazole is active over the whole leaf for a longer period, giving more sustained management (Fondevilla & Rubiales, 2012). However spraying of metalaxyl + mancozeb and cymoxanil + copper oxychloride were ineffective to control powdery mildew colonization on leaves, stems and pods of field pea, thereby greater severity and AUDPC were recorded. Thus, the application of these fungicides doesn't bring any significant improvement in seed yield and HSW from the unsprayed plot. On the other hand, fungicides belonging to acalamine family-like metalaxyl+ mancozeb are very effective against a wide range of downy mildew-causing plant pathogens (Woods et al., 2005). The highest and rapid growth and reproduction of the disease resulted highest severity and AUDPC values on the unsprayed plot. Thus causing early maturity and lower seed yield production. In accordance with this Agrios (2005) stated that plant pathogens induce earlier maturity of the plant. Also, Kraft and Pfleger (2001) wrote disease like field pea powdery mildew hasten crop maturity. Based on the experimental data, the occurrence of powdery mildew at the post-flowering stage of the crop causes 33.5% yield loss relative to best fungicide sprayed plots. In accordance with this previously 37% yield loss was reported in Ethiopia (Tadesse et al., 2018). In addition, late sown and off- season fields were reported to be severely affected by the disease (Tadesse et al., 2018).

In conclusion, in the present study adequate protection was achieved through foliar spraying of systemic fungicides tebuconazol, propiconazole, and triadimefon. This also concluded that the application of Tebuconazol, propiconazole, and triadimefon significantly increased the seed yield and yield attributing characteristics as compared to the untreated control and other fungicides. However, spraying of metalaxyl+ mancozeb and cymoxanil + copper oxychloride was ineffective to reduce disease severity and yield loss caused by powdery mildew. Therefore, it is recommended to spray economically profitable fungicides tebuconazol, propiconazole, and triadimefon for the control of powdery mildew interchangeably based on market availability for irrigated areas.

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