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Yield loss evaluation in faba bean caused by faba bean gall (*Olipidium viciae* Kusano)

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ABSTRACT

Aim: The study was aimed to quantify the losses incurred due to the disease and to evaluate the economic gain from fungicide application.

Materials and Methods: Experiments were conducted at Degem (hot spot for the disease) on farmer's field. The soil types of the trial site were red soil and local variety was used to execute the experiment. Redomil MZ with its recommendation rate (2 kg ha^{-1}) was applied while randomized complete block design (RCBD) with three replications was used. Spray frequency was scheduled at 15 days interval and spraying of fungicides was started when the first symptoms of the disease appeared and continued according to spray schedule designated for each treatment.

Results: Besides, losses in yield, the disease also affect the quality of grain yield. Significantly differences were recorded on plots received different spray frequencies in disease severity, AUDPC, pod per plant, seed per pod, thousand kernel weight and grain yield. The highest disease severity score (43.10%) and AUDPC (1676.7 % in days) were recorded on unsprayed plots whereas the least severity (23.57%) and AUDPC (1205.0 % in days) were on three times sprayed plots, respectively. A relative yield loss of 30.06% - 66.27% was recorded. Three times sprayed plots recorded the highest grain yield of (1450.7kg/ha) whereas unsprayed plot recorded the lowest yield (489.3 kg/ha). Three times sprayed plots also gave the highest net benefit (ETB 37671) with a marginal rate of return (393.03%) followed by (ETB 26541) net profits and (304.15%) marginal rate of return, respectively.

Conclusion: It was concluded that spraying of Redomil MZ three times reduced "*faba bean gall*" disease severity and AUDPC while the highest were recorded from unsprayed plots. Application of this fungicides three times gave high yield and net profit than the other treatments.

Keywords: Faba bean gall, Spray frequencies, Net benefit, Yield loss.

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Introduction

Faba bean (*Viciafaba* L.) is the third most important pulse crop in the world (Turk and Tawaha, 2002). Total cultivated area of faba bean was approached 25 million hectares with 18.4million tons of seed yield production in the world (FAO, 2004; Alghamdi, 2007). In Ethiopia, grain crops are grown annually on approximately 12.5 million hectares of land, of these, 1.5 million hectares is covered by pulses out of which 443,074.68 hectares is dedicated to Faba bean with annual production of about 8,389,438.97 quintals (CSA, 2014).

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). Cultivated faba bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries. It can be used as a vegetable, green or dried, fresh or canned. It is a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia (Bond *et al.,* 1985). The feeding value of the crop is high and is considered in some areas to be superior to field peas or other legumes. Faba bean has been considered as a meat extender or substitute and as a skim-milk substitute. The protein content of bean seeds is high, amounting to about 20-25% (Rai *et al.*, 2005). It is one of the most important winter crops for human consumption. Straw from faba bean harvest fetches is considered as a cash crop and can also use for brick making and as a fuel in parts of Sudan and Ethiopia (Bond *et al.*, 1985).

However, its production is constrained by biotic and abiotic constraints (Agegnehu and Fessehaie, 2006). Among the various constraints, the diseases have always been the major limiting factor for faba bean cultivation. Faba bean is attacked by more than 100 pathogens (Hebblethwaite, 1983). The most important fungal, bacterial and viral diseases are: chocolate spot (*Botrytis fabae* and *B. cinerea*), rust (*Uromycesviciaefabae*), black rootrot (*Thielaviopsisbasicola*), stem rots (*Sclerotiniatrifoliorum, S. sclerotiorum*), root rots and damping off (*Rhizoctonia spp*.), downy mildew (*Pernosporaviciae*), pre-emergence damping-off (*Pythium spp*.), leaf and pod spotyui;ol's or blight (*Ascochytafabae*), foot rots (*Fusarium spp*.), bacterial common blight, brown spot and halo blight, likewise viral diseases bean yellow mosaic virus, bean true mosaic virus and bean leaf roll virus (Van Emden et al., 1988).

In recent years, the emerging faba bean gall disease, caused by *Olpidiumviciae,* is the major and most destructive disease in major faba bean growing regions of the country. The disease affects all above ground plant parts and *a* gall symptom mainly appear on leaves and stems and later affect pods. The disease became more severe at an altitude of above 2400 m.a.s.l. and higher rain fall areas (Endale *et al.* 2014). The disease can cause yield losses as high as 100% during seasons favouring disease development (Beyene and Wulita, 2012). Application of some fungicides reduced disease severity (Wulita *et al.,* 2019). Among the fungicides spraying of Redomil gold MZ 68 WG was reduced diseases severity and increases the production of the crop (Dereje *et. al.* 2012, Teklay *et. al.* 2018). Thus, the objectives of this study were to quantify the losses incurred due to the disease and to evaluate the economic gain from fungicide application.

Materials and Methods

The experiments were conducted at Degem (hot spot for the disease) on farmer's field in 2015 main cropping season. The site was located at an altitude of 3152 m.a.s.l with mean annual rainfall of 916 mm and annual temperature range of 6-24^0 C. The soil types of the trial site were red soil and local variety was used to execute the experiment. Redomil MZ with its recommendation rate (2 kg ha^{-1}) was applied. Randomized complete block design (RCBD) with three replications was used and spray frequency was scheduled at 15 days interval. Spraying of fungicides was started when the first symptoms of the disease appeared and continued according to spray schedule designated for each treatment. Control plots were kept unsprayed during the experiment. The plants were shielded with polyethylene sheets during spraying to avoid fungicidal drifts.

Disease Assessment

Disease incidence (%): FBG was assessed by counting the number of diseased plants per total number of plants inspected and expressed as percentage of total plants. Percent disease incidence was competed according to the following equation.

$$\text{Disease incidence (\%)} = \frac{Number\ of\ diseases\ plants}{Total\ number\ of\ plants\ inspected} x100$$

Disease severity (%): A 0-9 scale was used where 0 = no disease symptom observed, 1 = < 2% plant parts infected, 2 = 2 - 5% plant parts infected, 3 = 6 - 10% plant parts infected, 4 = 11 - 25% plant parts infected, 5 = 26 - 50% plant parts infected, 6 = 51 – 75% plant parts infected, 7 = 76 - 90% plant parts infected, 8 = 91 - 99% plant parts infected, 9 = 100% plant parts infected (Ding et al., 1993). Disease severity scores were converted into a percentage severity index (PSI) for analysis (Wheeler, 1969).

$$\text{PSI} = \frac{Snr}{Npr\ x\ Msc} x100$$

Where, Snr is the sum of numerical ratings, Npr is number of plant rated, Msc is the maximum score of the scale. Means of the severity from each plot were used in data analysis.

Disease Progression Analysis

Area under disease progress curve (AUDPC): AUDPC was calculated for each plot using the formula of Shaner and Finney (1977) and was expressed in %-days as follows.

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

Where Xi was the cumulative disease severity expressed as a proportion at the ith observation, ti is the time (days after planting) at the ith

observation and n is the total number of observations.

Relative Yield Loss (%)

Percent relative grain yield loss was calculated as follows:

$$\text{RYL}(\%) = \frac{(\text{Yp} - \text{Yt})}{Yp} x100$$

Where, RYL= relative yield loss in percent, Yp = yield from the maximum protected plots (sprayed three times) and Yt = yield from other plots.

Cost - Benefit Analysis

Price of faba bean seeds, Birr/kg was assessed from local market in each location, taking into account the total price of one quintal (100 kg) obtained from a hectare bases and total sale from one hectare was computed. Price of Redomil kg^{-1} and total price incurred to spray one hectare of faba bean fields at different spraying frequencies were calculated. Labor to spray chemicals and to manage the experiment was computed. Cost of spray and spray equipment to spray once, twice and three times the treatments was calculated. Based on the data obtained from field, the cost-benefit analysis was performed using partial budget analysis. The difference between treatments, the option economic data was subject to analysis using the partial budget analysis method (CIMMYT, 1988). Marginal rate return was calculated using the formula.

$MRR\% = \frac{\Delta NI}{\Delta IC} \times 100$

Where, MRR- is marginal rate of returns, ΔNI – change in net income compared with control, and ΔIC – change in input cost compared with control.

The following points were considered during cost benefit analysis using partial budget.

- Costs for all agronomic practices were uniform for all treatments within sites.
- Price of grain yield per tons for each treatment was the same.
- Costs of labor and spray equipment were taken based on the price in the locality.
- Costs, return and benefit were calculated per hectare basis.

Data Analysis

The data for incidence and severity assessment of FBG disease and spray frequencies were examined. Analysis of variance was performed for disease parameters (incidence, PSI, AUDPC), seed yield and yield components (pod per plant, seed per pod and HSW) using Statistical Analysis System (SAS) version 9.1.3 software (SAS Institute, 2002). Least significance difference (LSD) was used to separate treatment means (P≤0.05).

Results and Discussion

Applications of fungicide were started on the onset of disease symptom. The analysis of variance (ANOVA) revealed that there was significant difference (p ≤ 0.05) among sprayed frequencies in disease incidence, percent severity, plant height and AUDPC (Table 1). When the disease developed naturally, the unsprayed plot showed highest disease incidence (69.53%) and disease severity (43.10%), whereas three times sprayed plot recorded (44.52%) disease incidence and (23.57%) disease severity followed by two times sprayed plot with (55.71%) and (30.24%) disease incidence and disease severity in the order mentioned. Also unsprayed control plot recorded the highest AUDPC (1676.7%/days) while the lowest (1205.0%/days) were recorded from three time's sprayed plots.

Significant difference were also recorded on plots in pod per plant, seed per pod, grain yield and thousand kernel weight between spray frequencies but not in plant height (Table 1). The highest number of pod per plant and seed per pod were recorded on three times sprayed plots while the lowest (3.167) and (1.743) were recorded on unsprayed control plots respectively. Three times sprayed plots recorded the highest grain yield of (1450.7 kg), followed by two times sprayed plots of (1014.7 kg), while unsprayed plots recorded the lowest (489.3 kg) grain yield.

Relative Yield loss and Yield advantage

Relative grain yield loss due to faba bean gall disease showed prominent differences among spray frequencies (Table 2). The highest yield loss (66.27%) was observed on unsprayed plots as compared to plots sprayed three times while; the lowest yield loss (30.06%) was recorded on plots received two times spray. Similar result was reported that, application of foliar fungicide reduced losses in seed yield and quality from faba bean gall disease (Wulita *et al.*, 2015, Belachew *et al.*, 2016). Three times and two times sprayed plots gave (196.49%) and (107.38%) yield advantage as compared to unsprayed plots respectively. The findings were in line with Dereje *et al.* 2012, found that Redomil MZ spray reduces the diseases intensity as compared to unsprayed plots.

Table 1. Effect of fungicide spray frequencies on faba bean gall diseases severity, yield and yield components

Fungicide spray frequency	DI (%)	DS (%)	AUDPC (%-days)	PH	PPP	SPP	HSW (g)	Yield kg ha-1)
One time	64.05ab	34.28b	1335.8ab	60.22a	4.337b	1.953b	42.000ab	695.3bc
Two times spray	55.71b	30.24c	1242.5b	72.34a	5.727a	2.450a	44.000a	1014.7ab
Three times spray	44.52c	23.57d	1205.0b	71.18a	6.670a	2.507a	43.667a	1450.7a
Control	69.53a	43.10a	1676.7a	58.67a	3.167b	1.743b	39.000b	489.3c
Mean	58.45	32.80	1365.00	65.60	4.98	2.16	42.170	912.5
LSD	8.83	2.49	358.37	15.22	1.233	0.393	4.614	442.6
CV (%)	7.56	3.80	13.14	11.61	12.40	9.08	5.480	24.28

DI: Disease Incidence, DS: Disease Severity, PH: Plant Height, AUDPC: Area Under Disease Progress Curve, PPP: Pods per plant, SPP: seed per pod, TSW: Thousand Kernel weight, LSD: List Significant Difference, CV: Coefficient of variation, Means with the same letters are not significantly different.

Table 2: Partial budget analysis for fungicide application frequencies for management of faba bean gall disease

Spray frequencies	Yield (kg ha-1)	YIOUP %	RYL%	Sale Revenue	Net profit (ETB ha-1)	Marginal benefit (ETB ha-1)	Marginal rate of return (%)
One time	695.3	42.101	52.071	20859	18909	4230	216.92
Two times spray	1014.7	107.378	30.055	30441	26541	11862	304.15
Three times spray	1450.7	196.485	0.000	43521	37671	22992	393.03
Control	489.3	0.000	66.270	14679	14679	0	0

RYL: Relative yield loss, YIOUC: Yield increase over unsprayed control

The higher net benefit (ETB 37671) and marginal rate of return of (393.03%) were recorded on three times sprayed plots. The result showed that with the supplement of fungicides the disease can be managed and can increase the crop production.

Conclusion

It was concluded that that spraying of Redomil MZ three times reduced "*faba bean gall*" disease severity and AUDPC while the highest were recorded from unsprayed plots. Application of this fungicides three times gave high yield and net profit than the other treatments. Considering economic benefits, application of three times this fungicide were profitable. Thus, it is recommended to use this fungicide with three spray frequencies as it gave the best net benefit as compared to other spray frequencies and unsprayed control plots. Thus, variety with the supplement of this fungicide and some cultural practices will increase the crop production.

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