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Faba bean gall (*Olipidium viciae* Kusano) disease management using fungicides in North Shewa, Highlands of Ethiopia

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Abstract

Faba bean gall becomes the worst problem for the crop production. The diseases can cause up to complete crop failure. Studies showed that, applications of some fungicides and seed dressings have certain effects of reducing faba bean gall diseases and increases yield. Thus, the study aims to select best effective and economical fungicide for faba bean gall disease management. The experiment was conducted at farmers' field on hot spot areas to manage the disease using fungicides in 2019/20 cropping season. Randomized complete block design with three replications was used. Nativo SC 300, Eminant star, Rex-Dou and Mancozeb 80 WP fungicides were applied as manufacturers' recommendations. Significant difference between plots in plant height, disease severity, area under disease progress curve, grain yield and thousand kernel weights were recorded. The highest (46.67%) disease score were recorded in control plots followed by Rex-Dou (40.0%) sprayed plots. Whereas the lowest, disease severity (15.11%) were recorded from Eminant star sprayed plots. The highest grain yield was recorded in Eminant star (3.08 ton ha^{-1}) sprayed plot followed by Nativo Sc 300 (3.01 ton ha^{-1}) and Mancozeb 80 WP (2.54 ton ha^{-1}) sprayed plots respectively. Eminant star sprayed plots also gave the highest economic benefit ETB (102770.0) and marginal rate of return (1678.46) followed by Nativo Sc 300 with net benefit of ETB (99190.0) and a marginal rate of return (925.40) were received. Pod per plant was not showed significant difference between plots.

Keywords: Faba bean gall; Cost-benefit; Fungicide; Grain yield

1. Introduction

Faba bean (*Vicia faba* L.) is a cultivated plant from the onset of agriculture and is an important crop until the present [1]. It is the most widely grown food legume in Ethiopia with an estimated annual production of 838,943.90 1,006,751.83 metric tonnes obtained from a cultivated area of 466,697.68ha [2]. Ethiopia is among the major faba bean-producing countries in the world ranking second next to China [3]. In Ethiopia, faba bean is grown primarily for its edible seeds that are used for human consumption In Ethiopia, faba bean is grown primarily for its edible seeds that are used for human consumption. The mature seeds are eaten fresh or cooked in different forms and are rich in proteins and minerals such as calcium, phosphorus as well as vitamins [4]. Thus, faba bean is among the most liked legume crops because of its versatile use. In addition to providing food for humans and maintaining soil fertility, it is also used as a fodder, reduces soil borne diseases when used in crop rotation agricultural systems [5] and attracts pollinators through its beautiful flowers [6].

Faba bean is used as an important human food in developing countries and as animal feed in developed countries. Ethiopian farmers are familiar of the role of the crop in improving soil health by fixing atmospheric nitrogen, and widely use it in rotation with cereals [7]. Despite the availability of high yielding varieties of the crop and its wide economic

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importance, the average national yield of faba bean under small-holder farmers is not more than 2.16 t ha^{-1} [2]. The diseases become a very serious disease of the crop that affects major producing areas of the country [8, 9]. The gall forming disease has different local names: Qormid (North Shewa and South Wollo), Kolsim and Kortim (North Gondar), Aqorfid (East Gojam), Chimid and Kurnchit (South Gondar); but in many places of the country, it is known by the name Qormid which is based on its symptoms on the leaf [10]. This disease can cause up to 100% severity and complete crop failure over wide areas within short period of time [11]. The disease was highly expanding and distributing aggressively in the northern and central part of the country from year to year. The disease affects leaves, stems and pods [8]. Applications of some fungicides have certain effects of reducing faba bean gall diseases and increases yield [12]. As a result, finding effective alternative fungicide is devised to curb and manage the disease. Fungicides are used because they provide effective and reliable disease control, deliver production in the form of crop yield and quality at an economic price and can be used safely [13]. When assessing a crop for risk, it is also necessary to assess it for the potential to cover the cost of chemical. Therefore, the objectives of this study were: -

- To select effective fungicides for faba bean gall disease management
- To evaluate the economic benefits driven from application of fungicides for FBG disease management.

2. Material and methods

The trial was conducted at Degem (hot spot for FBG) on farmers' field using local faba bean variety in 2019/20 cropping season. Four fungicides i.e., Nativo 300 SC, Eminant Star, Rex-Dou and Mancozeb were used. Recommended rate for all fungicides and nil application were arranged in RCBD design with three replications. A plot size of 3.2 m width and 4 m length with 0.4m inter-row spacing was used. The spacing between plots and replications was 1m and 1.5m wide respectively. Recommended seed rate, fertilizer rates, urea, DAP and fungicides rates were used. Fungicides were applied at early to mid-flowering crop growth stage using knapsack sprayer. Fungicides were applied three times at the time of diseases appearance and repeated two times based on the nature of the fungicides. Plastic sheets were used to avoid fungicides drift.

2.1. Data collected

Disease's severity was recorded by examining visually the whole plants using percent leaf area affected. disease severity (%), Plant height, Number of pods per plant, number of seed per pod, thousand seed weight and seed yield (grain yield) were recorded.

2.2. Disease Progression Analysis

Area under disease progress curve (AUDPC): AUDPC was calculated for each of the plots using the formula of [14] 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 X_i is the cumulative disease severity expressed as a proportion at the i^{th} observation, t_i is the time (days after planting) at the i^{th} observation and n is the total number of observations

2.3. Partial budget analysis

Partial budget analysis is concerned with evaluating the consequences of changes in treatments that affect only parts than whole. For evaluation of treatments only variable costs were used. A price of faba bean seed (Birr ton^{-1}) from local market in one hectare was computed. Labor cost and fungicides and application costs for one-hectare fields are the costs incurred for the amount of applied based on recommendation 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 [15]. 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.

2.4. Data analysis

Analysis of variances for the experiment was done and means comparisons were carried out using List Significant difference (LSD) at 5% level of probability.

3. Results and discussion

Applications of fungicides were started at the beginning of symptom appearance. During the season, disease symptom was starts at seedling stage and becomes more severe till flowering growth stage. Significant differences among treatments were recorded on disease severity, AUDPC, plant height, thousand kernel weight and grain yield but not in pod per plant. The highest disease severity score was recorded on control plot followed by Rex-Dou sprayed plots. Whereas, minimum disease scores were recorded on Eminant star (15.11), Nativo SC 300 (16.67) and Mancozeb 80% WP (16.67) sprayed plots. Also unsprayed control plot was recorded the highest AUDPC (1706.7%-days) value and followed by Rex-Dou (1481.7%-days) sprayed plots and the least (674.2%-days) was recorded on Nativo SC 300 sprayed plots. The highest plant height (137.00cm) was recorded on Eminant star sprayed plots while the shortest plant height (102.33cm) was recorded on Rex-Dou sprayed plot. Rex-Dou sprayed plot showed allelopathic effects on the plant. It results the plant to become shrink and dwarf. Pod per plant did not recorded significant differences between treatments. . Thousand grain weights and grain yield were showed significantly differences among fungicides (Table 1).

Figure 1 Eminant stars sprayed plots (left) and unsprayed plot (right)

Table 1 Effect of fungicides on Faba Bean gall diseases severity and yield and yield components

Fungicides	Severity (%)	AUDPC (% days)	PH(cm)	PPP	TKW (g)	Yield (t ha^{-1})
Nativo SC 300	16.67b	674.2b	127.33a	20.20a	457.60a	3.01a
Eminant star	15.11b	772.5b	137.00a	21.47a	446.93ab	3.08a
Rex-Dou	40.00a	1481.7a	102.33b	16.93a	419.56b	1.37c
Mancozeb 80% WP	16.67b	836.7b	125.67a	19.87a	464.25a	2.54ab
Unsprayed	46.67a	1706.7a	130.00a	22.20a	424.08b	2.06b
Mean	27.00	1094.33	124.67	20.13	442.49	2.37
LSD	16.84	264.93	19.92	9.06	29.32	0.58
CV%	33.13	12.86	8.5	23.90	3.52	12.90

AUDPC: Area Under Disease Progress Curve, PH: Plant Height, TKW: Thousand Kernel weight, LSD: List Significant Difference, PPP: Pods per plant, CV: Coefficient of variation, values in a column with the same letters is not significantly difference.

The highest thousand grain weight (464.25g) were recorded on Mancozeb 80 WP sprayed plots whereas, the lowest (419.56g) was recorded on Rex-Dou sprayed plots. Better grain yield were recorded on Eminant star (3.08 t ha^{-1}), Nativo 300 SC (3.01 t ha^{-1}) and Mancozeb 80% WP (2.54 t ha^{-1}) sprayed treatments. Rex-Dou sprayed treatments recorded the least grain yield (1.37 t ha^{-1}). It was recorded smaller yield than the control plots (Table 1). The fungicide is not effective for the disease management and not recommended for the users.

4. Cost-Benefit Analysis

Partial budget analysis was calculated based on cost of variable inputs of the year 2019/20 cropping season and net benefit was estimated based on mean of local market price. The highest, i.e. ETB 104720.0 ha^{-1} followed by ETB 102340 ha^{-1} total gross yield benefit were obtained from plots sprayed with Eminant star and Nativo SC 300 fungicides respectively (Table 2). On the other hand, the lowest total gross yield of ETB 46580.0 ha^{-1} was obtained from the Rex-Dou sprayed plots. Also, the highest net benefit (ETB 102770.0 ha^{-1}) with marginal rate of return (MRR) 1678.46% was obtained from plots sprayed with Eminant star as compared to unsprayed control plots, followed by ETB 99190.0 ha^{-1} net benefit with a MRR of 925.40% obtained from plots sprayed with Nativo SC 300, whereas the lowest ETB 44555.0 ha^{-1} net benefit and MRR of (-1258.52%) was obtained from Rex-Dou sprayed plots. Unsprayed control plot was recorded higher (70040.0) net benefit than Rex-Dou sprayed plots.

Eminant star and Nativo 300 SC fungicides were more effective and profitable than other treatments and are recommended for this disease management. However, Rex-Dou fungicide is not effective for management of the disease. From the results indicated, Eminant star, and Nativo 300 SC and Mancozeb were the most competitive treatments (Table 2).

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

Treatments	Yield (t ha^{-1})	Sale revenue (ETB Birr)	Net profit (ETB ha^{-1})	Marginal benefit (ETB ha^{-1})	Marginal rate of return (%)
Nativo SC 300	3.01	102340	99190.0	29150.0	925.40
Eminant Star	3.08	104720	102770.0	32730.0	1678.46
Rex-Dou	1.37	46580	44555.0	-25485.0	-1258.52
Mancozeb	2.54	86360	78560.0	8520.0	109.23
Control	2.06	70040	70040.0	0.0	0.0

5. Conclusion

The research result showed that Eminant star and Nativo SC 300 fungicides showed best disease management responses under natural infection. Thus, it is recommended to use these fungicides as they gave the best protection against "*faba bean gall*" and the best monetary benefit as compared to the other fungicides and unsprayed control. These fungicides can be used for integrated management package, including plant resistance, crop rotation, field sanitation and some cultural practices.

Compliance with ethical standards

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research and with the comparable ethical standards.

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