Management of Faba Bean rust (*Uromyces viciae-fabae*) Using Fungicides and Host Resistance in the Hararghe Highlands, Ethiopia

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Abstract

Two field experiments were carried out at Haramaya and Hirna of Hararghe highlands, Ethiopia in 2009/2010 to determine the effect of four fungicides on the epidemics of faba bean rust (*Uromyces viciae-fabae*), using moderately resistant (Gebelcho) and susceptible (NC58) varieties. Disease severity, disease progress rate (r), and area under disease progress curve (AUDPC) were used to evaluate treatment effects. Rust epidemics were 0.12 and 0.19 units per day at Haramaya and Hirna, respectively on the susceptible cultivar, NC58, while it was 0.07 and 0.09 units per day at Haramaya and Hirna, respectively on the moderately resistant cultivar, Gebelcho under natural disease epidemics. The severity and rate of rust progression were significantly influenced by resistance of the cultivars. Fungicide application significantly reduced rust severity and AUDPC. Treatment of faba bean with mancozeb at the rate of 1.6 a. i. kg/ha resulted in significant reductions in final rust severity, disease progress rate and AUDPC, and producing the highest yield of 4.4 and 4.6 t/ha at Haramaya and Hirna, respectively. Integration of Gebelcho and mancozeb foliar sprays proved the best option out of all, which provided 275% and 366% marginal rate of return (MRR) at Haramaya and at Hirna, respectively. Differences existed between locations and these could be due to differences in environmental factors.

Introduction

Faba bean (*Vicia faba* L.) is the first among pulse crops cultivated in Ethiopia and covers about 459,000 ha of land with a total production of 0.58 million tons ever year (CSA, 2007). Diseases are the most important biotic factors causing faba bean yield reduction (Yohannes, 2000). The most important yield limiting diseases are rust (*Uromyces viciae-fabae*), chocolate spot (*Botrytis fabae*), black rot (*Fusarium solani*), aschochyta blight (*Aschochyta fabae*), and faba bean necrotic yellow virus (FBNYV) (Dereje and Tesfaye, 1994). Among these, rust is the most important disease in different parts of the world, wherever faba bean is grown. Most of the time rust epidemics begin late in the season, when pod filling has started and yield losses usually range from 5 to 20% (Sillero *et.al.*, 2000). However, when the infection starts early in the season, severe epidemics can occur and yield losses can be as high as 70% (Rashid and Bernier, 1991). Rust is widely distributed in Ethiopia and causes yield losses up to 27% (Dereje and Tesfaye, 1994).

The disease is favored by high humidity, cloudy and warm weather conditions (Hawthorne *et.al.*, 2004). The pathogen (*Uromyces viciae-fabae*) produces numerous, small, orange-brown pustules, each surrounded by a light yellow halo that develops on the leaves. On stem, rust pustules are larger and longer than those found on the leaves (Hanounik and Bisri, 1991). Isolated rust pustules may also appear on the pods, which can reduce seed weight. Severe infection may cause premature defoliation, resulting in reduced seed size (Richardson, 2008).

Different control methods have been proposed against rust, including cultural practices, the use of chemicals and resistant varieties. Prevention of rust may be difficult because its spores can be carried long distances by wind to infect crops far away from the initial source of inoculum. Cultural practices, such as adjusting plant density, nitrogen fertilitization or crop mixtures can significantly influence rust infection (Fernandez-Apricio *et.al.*, 2006). However, use of resistant varieties is recognized as the most desirable, efficient and economical strategy as management option (Bond *et.al.*, 1994). In commercial production, fungicides may be used in the absence of resistant or tolerant varieties. Still, a rational disease management using chemical should be based on a precise knowledge of the relationship between disease severity and yield loss in case of rust (Zadoks, 1985). Foliar sprays of mancozeb, chlorothalonil and copper hydroxide have been recommended against rust in Australia (Hawthorne *et.al.*, 2004). Yeoman *et.al.* (1987) also used a range of fungicides to control rust for two years on spring-sown field beans in UK. However, no such attempt has been made to find effective fungicides for the management of rust under Ethiopian conditions.

Currently, Faba bean production in Ethiopia is threatened by rust because local cultivars grown by farmers are highly susceptible to rust and resistant varieties are not yet available to satisfy the need of the producers. In some farms, complete loss of the crop has been reported. It is therefore thought that the loss would be minimized through fungicides and host resistance. Hence, any program that aims at improving the production of faba bean in Hararghe highlands has to address these problems. The present study was conducted with the objectives to; (i) identify effective fungicides for rust management (ii) assess the effect of integrating host resistance and fungicide foliar sprays in rust management of faba bean.

Materials and Methods

Experimental site

Field experiments were conducted at Haramaya University Research station on the main campus and Hirna sub-Research Station during the 2009/2010 cropping season. Haramaya is located at 42 ^{0}30'E longitude and 9 ^{0}26'N latitude at an altitude of 1980 m.a.s.l. The site receives a mean annual rainfall of 780 mm with mean minimum and maximum temperatures of 1.4 ^{0}C and 23.4 ^{0}C, respectively. Hirna sub-Research station is located at 41^{0}6'E longitude and 9^{0}13'N latitude at an altitude of 1816 m.a.s.l. The site receives a mean annual rainfall of 1000 mm with an average temperature of 24 ^{0}C.

Faba bean cultivars

Two improved faba bean varieties of viz, Gebelcho (EH96009-1) and NC58 were used for the trials in both the locations. Cultivar Gebelcho is moderately resistant, while cultivar NC58 is susceptible (MoARD, 2006).

Fungicides application

The fungicides used in this study were triadimefon, mancozeb, chlorothalonil and copper hydroxide. These fungicides were sprayed at doses and schedules indicated in Table 1. Spraying of the fungicides started 70 days after planting (DAP) at Haramaya and 74 DAP at Hirna, soon after rust was detected in the plots. A control plot was left unsprayed. During fungicide sprays, plastic sheet was used to separate the plot being sprayed from the adjacent plots to prevent inter-plot interference. The fungicides were sprayed using a manual knapsack sprayer.

Table 1. List of fungicides, their respective doses and spray schedules

Fungicide		Dosage (kg/ha)	Fungicide spray schedules
Trade name	Common name		
Bayleton 25 WP	Triadimefon	0.5	Every 15 days (4 sprays at Haramaya, 3 sprays at Hirna)
Pencozeb 80 WP	Mancozeb	1.6	Every 10 days (5 sprays at Haramaya, 4 sprays at Hirna)
Odeon 82.5WDG	Chlorothalonil	1.55	Every 10 days (5 sprays at Haramaya, 4 sprays at Hirna)
Kocide 101 WP	$Cu(OH)_2$*	2.4	Every 10 days (5 sprays at Haramaya, 4 sprays at Hirna)
Unsprayed	-	-	-

*Copper hydroxide

Experimental design and management

A 2 x 5 factorial treatment combination of two cultivars (Gebelcho and NC58) and four fungicides along with the non-treated controls were arranged in randomized complete block design with three replications. Planting was done on July 17, 2009 at Haramaya and July 19, 2009 at Hirna. The net plot size was 6.4 m^2 (4 rows with 40 plants in 2 rows). The spacing was 1.5 m between blocks, 0.6 m between plots, 0.4 m between rows and 0.1 m between plants. Weeding was done manually as required.

Disease assessment

Severity of faba bean rust was assessed 7 times at Haramaya and 6 times at Hirna at weekly intervals starting from the first appearance of the disease symptom in the experimental plots. Disease severity was recorded from 15 randomly selected and tagged plants in the central two rows of each plot separately, for the three layers of the canopy (top, middle and bottom). Severity was rated using a 1–9 scale, where 1 indicates no visible symptom and 9 represents disease covering greater than 80% of leaf area (ICARDA, 1986). Disease severity scores were converted into percentage severity index (PSI) for analysis (Wheeler, 1969).

Means of canopy layers were determined per plant and then mean per plot was determined for data analysis.

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

Seed weight and yield

Grain yield was harvested from two middle rows of each plot, leaving two outer rows on both sides to avoid the border effect and adjusted at 9% seed moisture level. The yield data was converted to ton per hectare.

Data analysis

The data had better fit to logistic model than to the Gompertz model and the parameter estimates and their standard error presented are based on the logistic model. The data on disease severity were transformed using logistic transformation, ln[y/(1-y)] (Van der Plank, 1963), before statistical analysis. The transformed data were then regressed over time (as DAP) so as to get the disease progress rate, which is the coefficient of the regression line. In all cases, DAP was used as predictor and severity was used as response variables. Area under the disease progress curve (AUDPC) was calculated from severity assessments using the following formula:

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

where n is total number of assessment made, t_i is time of the i^{th} assessment in days from the first assessment date, x_i is percentage of disease severity at i^{th} assessment. AUDPC values were used in the analysis of variance to compare amount of disease