Seed Treatment and Foliar Application of Fungicide for the Control of Bean Anthracnose

Tesfaye Beshir[1] and Z.A. Pretorius[2]
[1]*Plant Protection Research Center, EARO, P.O.Box 37, Ambo, Ethiopia*
[2]*Department of Plant Sciences (Plant Pathology), University of the Free State Bloemfontein, South Africa*

Abstract

Bean anthracnose (Colletotrichum lindemuthianum Sacc & Magn.) is one of the most devastating seed-borne diseases of common bean (phaseolus vulgaris L.). The primary source of inoculum of the disease is infected seed. Field experiments were conducted at Ambo and Bako (Ethiopia) to assess effectiveness of fungicides to control bean anthracnose. Three fungicides were tested: benlate 500 g a.i. /kg WP (at a rate of 2 g a.i /kg as seed dressing and 1 kg a.i./750 L as foliar spray), mancozeb 800g a.i./kg WP (at a rate of 200g a.i./100 L as foliar spray) and difenoconazole 250 ml a.i./EC (at a rate of 87.5 g a.i/ha as foliar spray). Treatment combinations were benlate seed treatment, benlate seed treatment + benlate foliar spray, benlate seed treatment + mancozeb foliar spray, benlate seed treatment + difenoconazole foliar spray, mancozeb foliar spray, difenoconazole foliar spray, benlate foliar spray, and an untreated control. Foliar sprays were applied three times at 20 days intervals commencing seven days after inoculation with *C. lindemuthianum.* Compared with other treatments, seeds treated with benlate followed by difenoconazole, or difenoconazole alone reduced anthracnose severity by 62% and 64% respectively at Ambo, and by 31% and 25% respectively at Bako. At Ambo, all treatments resulted in significantly ($P < 0.05$) high yields, and the yield after seed treatment + difenconazole was four times higher than that of the control.

Key words: Anthracnose, fungicide, foliar application
Running title: Fungicidal control of bean anthracnose

Introduction

Anthracnose, caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Briosi et Cav., is one of the most devastating seed-borne diseases of common bean (*P. vulgaris*) (Schwartz & Singh 1982). The pathogen affects all aerial parts of the plant and total yield losses are possible when contaminated seed is planted and where favourable conditions exist (Schwartz 1991). Infection results from crop residues and secondary inoculum from other infected plants.

In Africa, farmers retain their seeds for planting during the next seasons. When infected, these seeds serve as a primary source of inoculum for disease development. Hence, disease intensity proportionally increases as infected seeds increase. Although use of clean seed is an appropriate option to control anthracnose, there is little effort in this regard. In most African countries, structured seed production and certification schemes do not exist and there is little opportunity for obtaining disease-free seed (Fredrica & Teri 1985).

The use of seed treatments is an important tactic for disease control in general and for anthracnose control in particular in developed countries (Berger & Wolf 1974, Smith & Black 1983, Wilson et al. 1983, Freeman et al. 1997). However, seed treatment alone could be inefficient and would often require follow-up applications of protectant or systemic foliar fungicides (Yourman & Jeffiers 2000, Koch 1996).

Furthermore, chemical disease control should form part of an integrated disease management system including host resistance, cultural practices and manipulation of environmental conditions (Schwartz et al. 1982).

Various control strategies have been advocated in an attempt to reduce losses caused by anthracnose (Zaumeyer and Thomas 1957, Chaves 1980. Ferraz 1980). However, grower acceptance and utilization of fungicides are not always possible, especially in the case of subsistence farmers. These growers possess few land holdings and resources and often are unable to readily obtain or adopt the recommended practices for their region (Schwartz et al. 1982). At present, no information is available on the chemical control of bean anthracnose under Ethiopian conditions. Therefore, this study was undertaken to investigate the efficacy of three fungicides as a seed treatment, foliar spray or their combination in controlling *C. lindemuthianum* on common bean.

Materials and Methods

Field experiments

Field studies were carried out at Ambo and Bako Research Centers, Ethiopia, in 2001. The anthracnose-susceptible common bean variety Mexican 142 was used to compare fungicide treatments. Plots consisted of ten rows of 4m each and spaced 40 cm apart. Intra-row spacing was 10 cm. Treatments were arranged in a randomized complete block with six replications.

Treatments

Seed treatment and foliar fungicide applications studied were:

- benlate (500 g a.i./kg WP) spplied as a seed dressing at a rate of 2 g/kg seed.
- benlate seed dressing 2 g/kg seed followed by benlate foliar spray at a rae of 100 g/ha.
- benlate seed dressing 2 g/kg seed followed by mancozeb (800 g a.i./kg WP) foliar spray at a rate of 200g a.i./ha
- benlate seed dressing 2 g/kg seed followed by difenoconazole (250 ml a.i./EC) foliar spray at a rate of 87.5 g a.i./ha
- mancozeb foliar application 800 g a.i./kg WP
- difenoconazole foliar application 250 ml a.i./EC
- benlate foliar application 500 g a.i./kg WP
- control (untreated), pure water sprayed

Foliar fungicides were applied three times at 20-day-intervals, starting from 14 days after planting (trifoliate leaf stage).

Inoculation

Plots were inoculated with mixed isolates of *C. lindemuthianum* collected from different bean growing areas in Ethiopia. The inoculum were prepared by harvesting conidia from 7-day-old cultures multiplied on sterilized bean leaves embedded on potato dextrose agar medium. A spore suspension of 1.2×10^6 spores/ml was sprayed at trifoliate leaf stage (three weeks after planting) using a knapsack sprayer.

Anthracnose assessment

Twenty randomly selected plants from the central four rows were tagged for disease and yield assessment. Disease severity was rated nine times on a 1–9 scale at 10 days intervals (Schoonhoven & Pastor-Corrales 1987), where, 1=1–10%, 2=11–20%, 3=21–30%, 4=31–40%, 5=41–50%, 6=51–60%, 7=61–70%, 8=71–80%, 9 $\geq$ 81% infection. Incidence was evaluated by rating the proportion of infected plants.

Data analyses

Yield and 100 seed weight were determined on the 20 tagged plants per plot. To investigate the effect of locations and treatments on disease severity, yield and 100 seed weight, combined analyses of variance were made using Agrobase (2000). Mean comparisons between treatments were carried out following the Fisher's LSD procedure at P = 5%.

Results

Fungicide treatments had a significant effect on disease severity and incidence as well as on plot yield and 100 seed weight (Table 1). All variables measured were significantly ($P < 0.05$) influenced by location and interaction between treatments and location for all except plot yield. Disease severity was significantly ($P < 0.05$) lower in all fungicide-treated plots at Ambo as compared to the untreated control (Table 2). Disease incidence was reduced except for the seed treatment followed by mancozeb foliar application. Difenoconazole provided better protection at Ambo, reducing severity by 64% and incidence by 68%. Similarlly, difenoconazole alone (25% reduction in severity), or in combination with benlate (30% reduction), reduced disease significantly at Bako (Table 2). With regard to yield measurements, all treatment significantly improved yield and 100 seed weight at Ambo. However, none of the fungicide treatments caused significant yield improvement at Bako, except three treatments that increased 100-seed weight (Table 2).

Table 1. Combined analysis of variance of different parameters on bean variety Mexican 142 tested for fungicidal efficacy at two localities in 2001

Variable	Source of variation[a]	df	Mean Square	F-value
Severity	Treatment (T)	7	1166.945	21.95**
	Location (L)	1	835.676	15.72**
	Treatment X Location (T X L)	7	424.52	7.98**
	Replication (R)	5	102.57	1.93**
	Error (E)	75	53.17	
Incidence	Treatment (T)	7	3785.719	37.00**
	Location (L)	1	14292.788	139.69**
	Treatment X Location (T X L)	7	448.750	4.39**
	Replication (R)	5	103.981	1.02**
	Error (E)	75	102.318	
Yield per pot	Treatment (T)	7	1202895.061	2.88*
	Location (L)	1	3263806.260	7.81**
	Treatment X Location (T X L)	7	792446.599	1.90^{ns}
	Replication (R)	5	1633698.584	3.91**
	Error (E)	75	418100.633	
100 seed weight	Treatment (T)	7	17.458	21.42**
	Location (L)	1	22.533	27.63**
	Treatment X Location (T X L)	7	7.560	9.27**
	Replication (R)	5	1.752	2.15^{ns}
	Error (E)	75	0.815	

* and ** represent significance of differences at 5 and 1% probability levels, respectively.
^{ns} = no significant differences; df = degree of freedom; a = locations (L) were Ambo and Bako and the treatments (T) included three fungicides separately applied as seed treatment or in combination as seed treatment and foliar spray.

Table 2. Mean anthracnose severity and incidence, yield per 20 plants and 100-seed weight after fungicide treatments at Ambo and Bako in 2001

Treatment	Severity (%)		Incidence (%)		100-seed weight (g)		Yield/20 plants (kg)	
	Ambo	Bako	Ambo	Bako	Ambo	Bako	Ambo	Bako
Seed dressing (Sd)	45.62ab	42.38a	62.00bc	82.87b	14.27a	12.46ab	1.58b	1.71b
Sd + spray	33.60bc	38.63ab	37.07cd	81.04b	14.30a	14.54a	2.10a	1.95a
Sd + mancozeb	52.83b	40.8a	77.78b	87.77b	13.97abc	12.49ab	1.32bc	1.88a
Sd + difenoconazoie	27.34c	31.07b	25.27e	55.08c	14.88a	12.46ab	2.23a	2.04a
Mancozeb	52.55b	40.43a	69.20b	86.06b	13.72abcd	12.31ab	1.40b	1.98a
Difenoconazoie	26.6c	33.53b	26.63e	56.22c	15.12a	12.56ab	2.01a	1.94a
Benomyl	44.18ab	37.58ab	46.75c	81.47b	14.30a	13.78ab	1.28bc	2.14a
Control	73.57a	44.65a	82.00a	91.42a	9.38d	11.60c	0.52c	1.74b
LSD	3.71	8.30	8.45	11.28	0.85	0.91	0.66	0.52

LSD = least significant difference ($P \leq 0.05$).

Discussion

This study revealed that the application of difenoconazole as a foliar spray, or benlate seed treatment followed by foliar applications of difenoconazole reduced disease severity, incidence and increased yield per plot and 100 seed weight. Benlate seed dressing with mancozeb and mancozeb foliar spray alone were found least effective in controlling anthracnose at both sites. It is apparent that seed treatment alone will not guarantee effective control of anthracnose. However, benlate as seed treatment reduces initial inoculum and protects seedlings from seed and soil-borne infection. A point to consider here is the risk of development of resistance by the pathogen to the fungicide. For instance, several studies (Griffee 1973, Cook & Pereira 1976, Okioga 1976) have reported the occurrence of tolerance in *C. lindemuthianum, C. coffeanum* and *C. musae* to benlate and related benzimidazole compounds. If benlate is to be used regularly in anthracnose control, a fungicide resistance management strategy should be devised. Fungicide mixtures or alterations should be developed to avoid the anticipated build-up of resistance in the population of *C. lindemuthianum* to fungicides in Ethiopia.

Difenoconazole was effective in controlling bean anthracnose. According to Freeman et. al. (1997), this is due to the protective and systemic mode of action, bringing a reducation in a primary and secondary infection levels. Although other compounds such as benlate have the same mode of action, they were not as effective as difenoconazole in this study. Foliar application of mancozeb with or without benlate seed treatment was less effective than difenconazole but, it was comparatively better than the control at both locations. In a similar study, mancozeb compound (Dithane Z-78) was the least effective of those fungicides tested in controlling both *C. lindemuthianum* (Sindhan & Bose 1981) and *Sclerotium oryzae* (Shama & Mehrotra 1985).

All fungicide applications increased yield both at Ambo and Bako regardless of differences in reducing the level of anthracnose sevenrity and incidence. However, yield improvements at Bako were not significant at 5% level. Seed treatment and foliar application with benlate and difenoconazole increased yield by 328 % at Ambo and by 172% at Bako. Foliar application with difenoconazole alone increased yield by 287% at Ambo and by 115 % at Bako. All fungicide applications increased 100 seed weight at Ambo ranging from 13.9 to 15.1 g as compared to the control 9.4 g. At Bako, 100 seed weight varied from 12.5 to 14.5 g as compared to the untreated control 11.6 g. A similar yield increase of 105% was recorded after applying benlate to control bean anthracnose (Sindhan & Bose 1981).

Information on the efficacy and feasibility of chemical control of bean anthracnose in Ethiopia was not available. It can also be assumed that at present, chemical control could not be the primary disease control tactic. The acceptance of fungicides by farmers and their regular use is impractical due to small land size and un affordability of costly compounds and application equipment. Furthermore, fungicides are often not readily available to commercial and small-scale farmers in Ethiopia. However, findings of this study suggest that seed treatment followed by a foliar application of a suitable compound such as difenoconazole, can effectively control bean anthracnose to sufficiently increase yield economically. Fungicide applications, where appropriate, in combination with other anthracnose disease management

tactics such as host resistance, multilines, sanitation and other cultural practices, would enhance the overall efficiency of bean production in Ethiopia

References

Agrobase. 2000. *Users guide and reference manual. Agronomix Software*, INC., Manitoba, Canada.

Berger RD and EA Wolf. 1974. Control of seed and borne and soil borne mycoses of Florida sweet corn by seed treatment Plant Disease Raporter 58: 922–923.

Chaves G. 1980. Anthracnose. in: Schwartz HF and GE Galves (eds) Bean production problems: Disease, insect, soil and climatic constraints of *Phaseolus vulgaris*. Centro Internacional de Agricultural Tropical, Cali. Colombia 37–54 Pp.

Cook RTA and JL Pereira. 1976. Strains of *Colletotricum coffeanum,* the causal agent of coffee berry disease, tolerant to benzimidazole compounds in Kenya. Annals of Applied Biology 83: 365–379.

Ferraz S. 1980. Angular leaf spot. In: Schwartz HF and GE Galvez (eds), Bean production problems: Disease, insect, soil and climatic constraints of *Phaseolus vulgaris,* Centro Internacional de Agricultural Tropical, Cali, Colombia. 55–65 Pp.

Fredrica MS and JM Teri. 1985. Yield losses in *Phaseolus* beans induced by anthracnose in Tanzania. Tropical Pest Management **31**: 60–62.

Freeman S, Y Nizanl, S Dotan S Even and T Sando. 1997. Control of *Colletotrichum acutatum* in strawberry under laboratory, greenhouse, and field conditions. Plant Disease 81: 749–752.

Griffee PJ. 1973. Resistance to benomyl and related fungicides in *Colletotrichum musae*, Transaction of British mycological society.

Koch SH. 1996. Detection of seed-born *Colletotrichum lindemuthianum* on·seed of *Phaseolus vulgaris*. Ph.D. Thesis. University of Pretoria.

Okioga DM. 1976. Occurrence of strains of *Colletotricum coffeanum* resistant to methyl benzimidazo1-2-ylcarbamate (carbendazim) and chemically similar compounds. Annals of Applied Biology 84: 2130.

Schoonhoven VA and MA Pastor-Corrales 1987. Standard system for the evaluation of bean germplasm. CIAT (Centro Internacional de Agricultural Tropical). Cali, Colombia, 54 Pp

Schwartz HF. 1991. Anthracnose. Pages 16–17 in: Hall, R (ed) Compendium of bean diseases. American Phytopathological Society, USA.

Schwartz HF. MA Pastor-Corrales, SP Singh, 1982. New sources of resistance to anthracnose and angular leaf spot of beans (*Phaseolus vulgaris L.)* Euphytica **31**: 741–754.

Sharma SK, RS Mehrotra. 1985. Evulation of some fungicides against stem rot of rice caused by *Sclerotium oryzae. Indian Phytopathology* 38: 662–665.

Sindhan GS, SM Bose. 1981. Evaluation of fungicides against anthracnose of French bean caused by *Colletotrichum lindemuthianum*. Indian Phytopathology 34: 325–329.

Smith BJ and LL Black. 1983. In-vitro activity of fungicides against *Colletotrichum fragariae*. ACTA Horticulture 348: 509–512.

Wilson DOJ, SK Mohan, EA Mnot B Shafii. 1983. Evaluation of fungicide seed treatments for shrunken-2 ("super sweet") sweet com. Plant Disease **77**: 348–351.

Yourman LF, SN Jeffiers, RA Dean. 2000. GFenetic analysis of isolates of *Botrytis cinerea* sensitivity and resistance to benzimidazole and dicarboximide fungicides. Phytopathology 90: 851–859.

Zaumeyer WJ, HR Thomas. 1957. A monographic study of bean diseases and methods for their control: A Review. Department of Agriculture, Washington, DC, USA. Technical Bulletin. No. 868. 255 Pp.