Dry Bean Yield Losses Caused by Ascochyta, Angular, and White Leaf Spots in Colombia

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ABSTRACT

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Diseases caused by *Ascochyta* sp., *Pseudocercosporella albida,* and *Isariopsis griseola* reduced dry bean yields by 43, 47, and 80%, respectively, in Colombia. White leaf spot, caused by *P. albida*, was controlled by foliar applications of benomyl or by plant resistance.

Additional key words: *Colletotrichum lindemuthianum,* inoculation methodology, *Phaseolus vulgaris*

Dry beans (*Phaseolus vulgaris* L.) are an important food crop throughout Latin America and are produced in highly diversified ecological zones. Regions with annual mean growing temperatures between 17.5 and 27.5 C produce nearly 80% of the total Latin American bean crop (4). These temperature regimes provide an ideal environment for survival of and infection by the more than 250 pathogens that infect *P. vulgaris* (7,8,10). Many of these pathogens are restricted to regions with the specific environmental factors required for their survival and perpetuation, but others are widespread throughout Latin America and other regions of the world.

Many fungal pathogens of beans are not widespread but may still seriously threaten the crop in specific regions. Few if any data are available on their yield loss potential and the feasibility of specific strategies to control diseases such as Ascochyta leaf spot (caused by *Ascochyta boltshauseri* Sacc., *A. phaseolorum* Sacc., and *A. pisi* Lib.) and white leaf spot (caused by *Pseudocercosporella albida* (Matta & Belliard) *comb. nov.*), both of which occur in cool highland sites (1,700–2,200 m elevation) in Guatemala and Colombia (6,9,10).

This paper reports yield loss data for Ascochyta leaf spot, angular leaf spot, and white leaf spot at a highland location in Colombia. We also describe inoculation and disease evaluation methods used in our study and measures to control white leaf spot.

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MATERIALS AND METHODS

All trials were at Popayán (Las Guacas site) in the Department of Cauca in southwestern Colombia. Popayán is at an elevation of 1,850 m, has an annual mean temperature of 18 C, and a mean rainfall of 1,600 mm/yr. The highly acidic, phosphorus-deficient soils (pH <5) required preplant incorporation of 2–3 tons of lime, 150 kg of 10-30-10 (NPK), and 150 kg of triple superphosphate per hectare, in addition to foliar applications of liquid fertilizer (4 L/ha) and urea (5 kg/ha) to assure normal plant development.

Seed was treated with Terracoat SD-205 (pentachloronitrobenzene plus 5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole) at 2.5 g/kg of seed to reduce losses from root rot pathogens. Carbofuran was applied to the seedbed at 6.7 kg/ha to reduce losses from root-knot nematodes. Paraquat at 1.2 L/ha and fluorodifen at 13 L/ha were applied before emergence to control weeds, with subsequent manual weedings when required.

Experiments 1 and 2 were during March to June, and experiment 3 was during September to December in 1979, corresponding to the bimodal distribution of rainfall. Each experiment included apropriate inoculated and chemically protected plants that were physically separated by 5-m buffer plots. Entries were selected on the basis of previous adaptation and disease reactions at Popayán (3) and were replicated three times in a randomized complete block design.

All plots were five rows wide with a 75-cm space between rows that were 4 m (experiment 1 and 2) or 3 m (experiment 3) long. The two side rows and outer 50 cm of the three central rows were not used for disease evaluation or yield assessment.

A mixture of benomyl (0.6 g/L) and mancozeb (2.4 g/L) was applied to control plots every 14–20 days from 3 wk after germination of seed until physiologic maturity.

Experiment 1. Five isolates of *Ascochyta* sp. (ASC26-76, ASC27-76, ASC28-76, ASC86-77, and ASC385-79) were grown separately on potato-dextrose agar (PDA) at 19–21 C in darkness for 8 days or until sporulation was abundant. Conidia were harvested from the plates in sterilized distilled water and transferred to 125 or 250 ml Erlenmeyer flasks half filled with sterilized young green bean pods. Flasks were incubated at 19–21 C with alternate 24-hr dark/light periods for 8 days.

Equal proportions of the colonized pods of all isolates were blended together, and a conidial suspension was obtained by filtering the homogenate through cheesecloth. A final concentration of 1.2×10^6 conidia/per milliliter (plus 1 ml of Triton AE/L) was used to inoculate foliage by aspersion 3, 5, and 7 wk after germination of seed. During late afternoon or early evening hours, inoculum was applied with a Solo Micronizer Model 423 (Solo Kleinmotoren GMBH, Sindelfingen, West Germany) at a discharge volume of 1.5–2.0 L/min.

A natural epidemic of white leaf spot subsequently occurred in the experiment.

Experiment 2. Four isolates of *Colletotrichum lindemuthianum* (CL8-76, CL51-76, CL72-76, and CL74-76) were grown as described for *Ascochyta* sp., except that conidial suspensions were harvested from the PDA in 1% dextrose. Inoculation procedures and dates were identical to those in experiment 1, except that Triton AE was not added.

A natural epidemic of white leaf spot also occurred in this experiment.

Experiment 3. Two isolates of *Isariopsis griseola* (IG23-77 and IG19-78) were grown separately on V-8 medium (1) at 19–21 C in darkness for 8 days or until sporulation was abundant. Cultures were blended, and a final concentration of 2×10^4 conidia per milliliter was used to inoculate foliage 3 and 5 wk after germination of seed.

A natural epidemic of Ascochyta leaf spot subsequently occurred.

Disease evaluations. Disease was rated on the 10 most severely infected plants in each plot at the time of maximum development of each disease. Angular and white leaf spot ratings were based on actual leaf area infected, and those for Ascochyta leaf spot and anthracnose were based on estimated foliage infected, using the following scale: 1 = immune, 0%; 2 = light infection, 1–2%; 3 = moderate infection, 3–10%; 4 = heavy infection, 11–25%; and 5 = severe infection, more than 26% of actual leaf or estimated foliage area infected.

Entries were harvested at maturity, and yields were adjusted to a standard 14% moisture content. The harvest density varied from 140,000–170,000 plants per

Table 1. Effects of three diseases on yields of dry beans in Colombia

Entry	Yield (kg/ha)[w]			Disease severity[w,x]			
	Inoculated	Control	Yield loss (%)[y]	Inoculated	Control	Inoculated	Control
Experiment 1				**Ascochyta leaf spot**		**White leaf spot**	
PI 313755	1,139 a	1,927 ab	41 *	4.7 a	1.0 b	1.0 d	1.0 a
Mexico 6	1,121 a	1,967 a	43 *	3.0 bc	1.0 b	1.0 d	1.0 a
BAT 522	1,217 a	2,125 a	43 *	3.7 b	1.0 b	3.3 c	2.0 a
BAT 496	831 b	1,543 bcd	46 *	3.3 bc	1.0 b	4.0 bc	1.3 a
BAT 76	506 cd	1,130 e	55 *	2.3 c	1.0 b	4.3 ab	2.0 a
BAT 256	729 bc	1,842 abc	60 *	3.7 b	1.0 b	4.3 ab	1.7 a
EMP 9	531 cd	1,438 de	63 *	3.3 bc	1.0 b	4.7 ab	1.3 a
DOR 12	465 cd	1,388 de	67 *	2.7 bc	1.0 b	5.0 a	2.3 a
BAT 341	370 d	1,470 cde	75 *	3.3 bc	1.3 a	5.0 a	2.3 a
CV (%)	18.6	12.9	···	16.2	18.6	11.1	46.9
Experiment 2				**Anthracnose**		**White leaf spot**	
BAT 146	969 b	1,015 cd	5 NS	3.0 a	1.0 a	3.3 b	1.7 c
BAT 44	1,505 a	2,055 a	27 NS	1.0 b	1.0 a	3.0 b	2.0 bc
BAT 93	850 bc	1,495 bc	43 NS	1.3 b	1.0 a	5.0 a	2.3 bc
BAT 508	838 bc	1,577 a	47 *	1.0 b	1.0 a	4.7 a	3.0 ab
BAT 48	563 bc	1,113 bcd	49 *	3.7 a	2.7 a	4.7 a	2.7 abc
BAT 328	452 c	942 d	52 NS	3.3 a	2.0 a	5.0 a	3.7 a
BAT 429	550 bc	1,172 bcd	53 NS	3.0 a	1.0 a	5.0 a	3.7 a
CV (%)	31.3	21.2	···	29.3	68.0	9.1	24.6
Experiment 3				**Angular leaf spot[z]**		**Ascochyta leaf spot**	
BAT 160	880 ab	910 ab	3 NS	4.0 bcd	1.0 a	2.0 b	2.0 a
BAT 48	1,149 a	1,428 ab	20 NS	3.7 cde	1.0 a	2.3 ab	2.0 a
BAT 256	663 bc	841 b	21 NS	3.3 edf	1.0 a	2.3 ab	2.0 a
BAT 346	872 ab	1,106 ab	21 NS	2.7 gf	1.0 a	2.3 ab	2.0 a
BAT 332	871 ab	1,195 ab	27 NS	2.0 g	1.0 a	2.3 ab	2.7 a
A 21	1,012 ab	1,545 a	35 *	4.3 abc	1.0 a	2.7 ab	2.3 a
BAT 76	887 ab	1,419 ab	37 NS	3.0 ef	1.0 a	2.7 ab	2.0 a
Carioca	853 ab	1,528 a	44 *	4.7 ab	1.0 a	3.0 ab	2.3 a
BAT 148	635 bc	1,247 ab	49 *	4.7 ab	1.0 a	3.3 a	2.3 a
BAT 394	274 c	1,342 ab	80 *	5.0 a	1.0 a	2.0 b	2.0 a
CV (%)	28.8	26.1	···	11.9	0.0	26.4	17.5

[w] Mean of three replicates. For each experiment, values in a column followed by a different letter are significantly different ($P = 0.05$) according to Duncan's multiple range test.

[x] Disease scale of 1 = no infection to 5 = severe infection.

[y] * = Yield loss significant, NS = not significant according to Student's t test ($P = 0.05$).

[z] Disease scores generally increased later by an additional scale point due to leaf chlorosis induced by the local toxin production of the fungus.

hectare in experiments 1 and 2 to 90,000–130,000 plants per hectare in experiment 3.

RESULTS AND DISCUSSION

Disease severity. Disease severity varied greatly in and among experiments and generally was highest 9–10 wk after germination. Although inoculations successfully initiated infection, sporadic rainfall throughout the first growing season of 1979 was not conducive to severe infection of susceptible entries by the *Ascochyta* and anthracnose fungi in experiments 1 and 2, respectively. The natural epidemic of white leaf spot was severe in both experiments, however.

Abundant rainfall and low to moderate temperatures persisted throughout the second growing season in 1979 and were conducive to infection by the angular leaf spot fungus in experiment 3. The natural epidemic of Ascochyta leaf spot occurred late in the season and was not severe.

Yield losses. Ascochyta leaf spot alone caused 41 and 43% yield reductions in PI 313755 and Mexico 6, respectively, in experiment 1 (Table 1). We consider this a conservative estimate of the potential threat to dry beans, since disease severity was moderate. Combined infection by the Ascochyta and white leaf spot fungi caused 43–75% yield reductions, depending on the entry.

The anthracnose epidemic did not develop sufficiently or incite adequate pod infection to accurately measure its yield loss potential.

White leaf spot alone cause 47% yield reduction in BAT 508 in experiment 2. This epidemic was severe, and we believe that this loss estimate is fairly representative of the yield reduction that white leaf spot may cause to dry beans grown where plant densities are moderate (140,000–170,000 plants per hectare). Recent work suggests that white leaf spot may be more severe when the population density is reduced from 260,000 to 60,000 plants per hectare (Schwartz, *unpublished*).

Angular leaf spot caused 80% loss in yield in BAT 394 in experiment 3. Earlier workers reported losses of only 40–60% in Colombia (2), but Crispin et al (5) reported 80% yield losses to angular leaf spot infection in Mexico.

Disease evaluation. Visual estimation of leaf or foliar damage was generally reliable and consistent for the diseases we studied. Differences in the degree of varietal susceptibility and multiple infections precluded correlation of disease severity with yield reductions caused by each pathogen.

It is apparent that this leaf damage scale was not directly applicable for angular leaf spot. For example, yield reductions in BAT 160 and BAT 332, although not statistically significant, were not reflected in the corresponding disease ratings. The disease reaction of these materials is currently being re-evaluated by using a more specific disease scale to determine their potential as resistance sources for the Centro Internacional de Agricultura Tropical bean breeding program.

Disease control. Benomyl and mancozeb effectively reduced Ascochyta leaf spot, anthracnose, and angular and white leaf spot. White leaf spot can be completely controlled by benomyl applications every 14 days at 1 g/L (Schwartz, *unpublished*).

White leaf spot can also be controlled by plant resistance (9), and our studies showed that PI 313755 and Mexico 6 were highly resistant to this disease. Additional sources of field resistance have been identified in other germ plasm and breeding lines such as BAT 527 developed at our center (3).

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