Bean Accessions with Resistance to *Rhizoctonia solani* Under Field Conditions in Colombia[1]

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ABSTRACT

Selected bean accessions were evaluated in two tests established in a field with a history of severe incidence of *Rhizoctonia solani* (Rs) root and hypocotyl rots at the CIAT Experiment Station near Popayan, Colombia. A total of 113 and 65 accessions were included in the first and second test, respectively. All accessions were evaluated in paired rows with and without artificial inoculation with Rs and were arranged in a randomized block design with three replications. In both evaluations, the bean accessions differed significantly (P = 0.05) in emegence, stand count, seed yield, disease severity ratings and adaptation scores. BAT 477, BAT 332, BAT 1753, RIZ 30, EMP 81, A 300 and ICA Pijao were among the accessions most resistant to Rs. In contrast, Sanilac, Mortino, Diacol Calima, Ecuador 605, DOR 210 and Zamudio 1 were among the most susceptible accessions at this location.

COMPENDIO

Accesiones seleccionadas de frijol fueron evaluadas en dos ensayos en una estación del CIAT aproximadamente a 10 km de Popayan, Departamento del Cauca, Colombia con historia de alta incidencia de pudrición de la raíz y del hipocotilo causado por *Rhizoctonia solani* (Rs). Un total de 113 y 65 accesiones fueron evaluadas en el primero y segundo ensayo, respectivamente. Todos los cultivares fueron evaluados en surcos pares con y sin inoculación artificial de Rs en un diseño de bloques completamente al azar (BCA) con tres replicaciones. En ambas evaluaciones, se establecieron diferencias significativas (P = 0.05) entre las accesiones de frijol por su emergencia, número de plantas por surco, rendimiento, severidad de la enfermedad y adaptación. BAT 477, BAT 332, BAT 1753, RIZ 30, EMP 81, A 300 e ICA Pijao.

INTRODUCTION

Rhizoctonia solani Kuhn causes seed rot, damping-off, stem cankers, root rot, pod rot and web blight diseases of beans (*Phaseolus vulgaris* L.) in many production areas in Latin America and elsewhere (3, 7, 8, 20). Seed and seedling infections result in reduced plant stands that are often observed in severly affected fields. *Rhizoctonia solani* (Rs), anamorph of *Thanatephorus cucumeris* (Frank) Donk. is worldwide in distribution, has an extensive host range, and exists in nature in the form of many anastomosis groups and strains that differ in cultural appearence, physiology, and pathogenicity (5, 12, 20).

Detailed information on bean yield losses attributed to Rs are limited. The authors, however, have observed close to 100% incidence of Rs infections where, at times, complete losses of bean plantings have occurred near Popayan, Colombia; the coastal areas of Peru, and the central and western bean-growing areas of New York State, United States. Close correlation has been reported between initial soil densities of Rs and growth parameters of snap beans grown in field microplots (2, 17). In addition, Beebe *et al* (6) reported that Rs caused an 89% reduction in seed yield of beans in the artificially inoculated plots of the susceptible cultivar Sanilac. It was also reported (6, 25) that severely infected bean plants with Rs emerged, developed slower and yielded less than uninfected plants. Both reports suggested that Rs infections did not affect the overall yield of dry beans unless plant density was severly reduced.

Management of Rs and its damage to snapbean through the implementation of integrated control strategies was recently demonstrated (16, 24). However, the use of resistant bean cultivars is the best and most efficient control strategy, particularly for small farmers with low inputs that predominate in most of the bean-growing regions of Latin America and Africa. Only limited information is available on the reaction of bean germplasm to Rs (6, 7, 13, 26).

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The objective of this study was to evaluate selected bean accessions, including breeding lines being used at the Centro Internacional de Agricultura Tropical (CIAT), for their reaction to **Rs** under severe natural and artificial soil infestations.

MATERIAL AND METHODS

Two evaluation tests were established at the CIAT's Popayan substation in a field that had a history of severe incidence of **Rs** root and hypocotyl rots of beans. Infection of beans with **Rs** has occurred in epidemic proportions within most fields on this farm and often required the application of PCNB (Brasicol 75 wp) as a soil treatment to secure adequate plant densities. The substation is located at about 1850 m above sea level with a mean annual temperature of 17.5°C (27.5°C max. and 10.8°C min.) and a mean precipitation of 1923 mm/yr. The soil of the field used was sandy loam with a pH of 5.5 and 25% organic matter. About 1 t/ha of dolmitic lime is applied prior to each planting.

The plot area was plowed and fitted with tractor-mounted equipment, but was marked and planted manually. A total of 113 and 65 bean accessions were included in the first (planted on September 18, 1985) and second (planted on November 7, 1985) tests, respectively. Many of the accessions selected for testing in this study, in addition to having tropical adaptation, had been previously evaluated under field conditions as intermediate or resistant to other root rot pathogens such as *Macrophomina phaseolina* and *Fusarium oxysporum* f. sp. *phaseoli* (18, 19). Other accessions included were known for their susceptibility to *R. solani*, while the rest had been used in the bean breeding program at CIAT as parental breeding lines. The accessions were arranged in a randomized block design with three replications. Each plot consisted of three and two rows in the first and second test, respectively, and was 1 m long. The rows were opened manually and fertilized with a complete fertilizer (10-30-10, NPK) at 300 kg/ha. Carbofuran (Furadan) was mixed with the fertilizer at 1 kg a.i./ha to control soil insects. The rows were scratched with a hoe to lightly incorporate the fertilizer and insecticide. Fifteen seeds of each accession were planted in each 1 m row. Prior to covering the seed furrows, seeds in one row (in both the first and second tests) were inoculated with 1 liter of the **Rs**-infested soil-potato inoculum (2%, v:v; soil inoculum source: field soil) prepared according to the procedure of Ko and Hora (14). Sources of inocula of four isolates of **Rs** were produced separately and were then mixed in equal volumes to produce the 2% **Rs**-infested soil-potato inoculum. All isolates were obtained from naturally infected hypocotyls of beans collected from fields on this same farm and all belonged to anastomosis group 4 (authors' unpublished data). After covering the furrows, the test area was immediately sprayed with a mixture of the herbicides linuron (Afalon), paraquat (Gramoxone) and pentimethalim (Prowl) at 1.3 and 2 liters/ha respectively, diluted in 200 liters of water. The tests were maintained according to the local commercial production recommendations, including the foliar applications of fertilizers with micronutrients, disease and insect control schedule, and manual weeding and irrigation as needed.

Total number of emerged plants were recorded at two weeks after planting. Plants of each accession from the extra noninoculated row planted in the first nursery and from one replicate in the second test were dug up at five weeks after planting. The roots and hypocotyls were washed in water and rated for disease severity using the CIAT scale (8) of 1 (no visible symptoms) to 9 (approx. 70% or more of the hypocotyl and root tissues with lesions and exhibiting severe rotting). Numbers of surviving plants and seed weight per plot were recorded at harvest time.

RESULTS

The 113 and 65 bean accessions evaluated in the first and second tests respectively differed significantly ($P = 0.05$) in their reaction to infection by *R. solani* (Rs) (Table 1). Except for the known susceptible checks, all bean accessions having a susceptible reaction to *Rhizoctonia solani* in the first test were not included in the second test. The incidence and severity of **Rs** infection in the noninoculated plots was high in both tests, but somewhat greater in the first test as suggested by the seed weight and disease severity data (Tables 1, 2, 3). Therefore, plants artificially inoculated with **Rs**-infested soil showed a slight additional increase in disease severity and damage to beans. In both tests, significant differences ($P = 0.05$) were detected among the bean accessions in number of emerged plants, number of plants at harvest, seed yield, disease severity and adaptation ratings (Tables 1, 2, 3). The number of plants at harvest was the most consistant parameter in assessing the reaction of bean accessions against **Rs**. The number of plants surviving severe infection pressure of **Rs** also correlated highly ($P = 0.05$) with seed weight ($r = 0.595$ and 0.513 for the first and second nurseries, respectively). The bean accession showing the highest resistance to **Rs** in the first and second nurseries are listed in Table 2 and 3 respectively, along with a few highly susceptible accessions. Many accessions were consistent in their reaction to **Rs** in both evaluation trials. These accessions included RIZ 30, BAT 477, BAT 1753, BAT 332, EMP 81, A 300, ICA Pijao and CG 82-106. Diacol Calima, Sanilac, Mortino and Ecuador 605 (Tables 2 and 3) were among the accessions most susceptible to **Rs** in both tests.

DISCUSSION

Several bean accessions were found to be highly resistant to *Rhizoctonia solani* (**Rs**) under the severe disease pressure that prevailed during this investigation. Many of these lines with resistance to **Rs** are used by breeders at CIAT as parental germplasm because of other desirable characteristics. For example, RIZ 30 is one of the best nodulating and high N2-fixing bean accessions (9). BAT 477 and BAT 332 are drought-tolerant and resistant to *Macrophomina phaseolina* (Tassi) Goid. (10, 18). EMP 81 is highly tolerant to the leafhopper (*Empoasca kraemeri* (15) and also resistant to bean rust (9).

Beebe *et al.* (6) evaluated numerous bean accessions of Latin American origin for reactions to root rot pathogens, including **Rs**. Susceptible accessions such as Sanilac and Canario Divex included in their tests were also susceptible in this study. In contrast, ICA Pijao exhibited a resistant reaction in both studies. However, some accessions such as G 00881 (P.I 203958), Diacol Calima, Jamapa and Cornell 2114-12, G 05697 that were resistant to **Rs** in their test exhibited susceptible reactions in our tests conducted near Popayan, Colombia. Many other sources of resistance to **Rs** in dry and snapbean germplasm have been reported from several countries (6, 7, 11, 20, 21, 26). Some of these studies included results obtained from tests conducted in the greenhouse. Results of preliminary tests, where bean accessions were assessed for reaction to **Rs** in the greenhouse at CIAT, did not closely correlate with those obtained under field conditions. For example, Ecuador 605 and Diacol Calima were very susceptible in field tests, but were among the most resistant in greenhouse tests (authors' unpublished data). Many factors may contribute to differences in reaction of bean accessions in field and greenhouse tests. Factors that could influence such results include changes in

Table 1. Range of reactions of bean accessions to infection by *Rhizoctonia solani* in field tests near Popayan, Colombia in 1985-1986.

Parameter Measured	Treatment with Rs inoculum[a]	Range	Average	LSD (P = 0.05)
1st. Nursery (113 accessions):				
Emergence (No./1 m)	–	0.0 – 13.7	9.4	4.8
	+	0.7 – 15.3	9.4	4.8
Plants at harvest (No /1 m)	–	0.0 – 10.3	5.1	4.9
	+	0.0 – 12.0	5.1	4.1
Seed weight (g/ 1 m)	–	0.0 – 196.3	39.9	42.4
	+	0.0 – 149.3	37.6	47.3
Disease severity ratings (1-9)	–	3.5 – 8.6	5.2	2.3
	+	–[b] –	–	–
Adaptation (1-9)	–	4.0 – 9.0	7.6	–
	+	4.0 – 9.0	7.7	–
2nd. Test (65 accessions):				
Emergence (No /1 m)	–	2.0 – 14.5	8.6	5.5
	+	3.0 – 13.0	8.3	5.5
Plants at harvest (No./1 m)	–	0.0 – 13.0	6.6	6.2
	+	0.0 – 13.0	5.5	4.9
Seed weight (g/1 m)	–	0.0 – 142.0	51.0	80.2
	+	0.0 – 119.5	44.6	64.4
Disease severity ratings (1-9)	–	2.0 – 6.0	4.6	–
	+	3.0 – 7.0	5.1	–
Adaptation (1-9)	–	4.0 – 9.0	6.8	3.1
	+	4.0 – 9.0	6.9	2.3

a Inocula consisted of composite isolate of *Rhizoctonia* (AG4) and were prepared according to the soil-potato procedure of Ko and Hora (12) at 2%(V:V, *Rhizoctonia* source inoculum: field soil).

b Indicates that data were not recorded or calculated

Table 2. Influence of natural and artificial soil infestation with *Rhizoctonia solani* on selected resistant and susceptible bean accessions planted on September 26, 1985, in a field near Popayan, Colombia. Data from 15 out of 113 accessions are listed below.

Bean Accession[6]	Emergence[1]/1 m		Stand Count[2]/1 m		Seed W., g[3]/1 m		DSR[4]	Adapt.[5]
	Inoc.[7]	Nat.[8]	Inoc.	Nat.	Inoc.	Nat.	(1-9)[5]	(1-9)
BAT 477	15.3	11.3	12.0	8.0	92.3	73.3	5.2	6
RIZ 30	14.0	13.3	11.0	10.3	121.0	116.0	4.3	6
BAT 1385	10.3	9.7	10.3	5.7	31.0	15.0	5.3	7
BAT 332	13.3	7.7	9.3	6.7	118.0	62.3	4.0	6
A 197	11.7	10.3	9.0	7.3	34.3	17.0	6.3	7
A 107	11.0	12.7	8.7	8.7	51.7	83.7	4.1	8
BAT 1753	9.7	12.0	8.3	9.7	63.7	196.3	3.9	7
EMP 81	10.3	12.3	7.0	9.3	32.0	94.0	6.0	5
A 300	8.7	10.7	6.7	5.7	129.0	104.0	4.3	6
CG 82131	11.7	9.0	6.3	4.3	44.3	50.3	6.6	5
ICA PIJAO	7.0	8.3	5.7	6.0	51.0	87.0	4.0	7
D CALIMA	6.7	4.3	1.0	0.7	3.7	1.7	7.7	8
SANILAC	3.7	5.3	1.0	1.0	2.3	3.3	8.6	9
MORTINO	9.3	8.0	0.0	0.0	0.0	0.0	7.7	9
ECUADOR 605	12.7	7.7	0.0	1.7	0.0	7.3	6.3	9
LSD (P = 0.05[9])	4.8	4.8	4.1	4.9	47.3	42.4	2.3	–

1 and 2 Emergence and stand counts were recorded at 2 weeks after planting and at harvest time, respectively as number of plants/ 1m row. Fifteen seeds were planted/1 m row

3 Bean pods were shelled and seed weight was recorded

4 Disease severity ratings were recorded at 5 weeks after planting using the CIAT scale (13) of 1 (no visible symptoms) to 9 (approx. 70% or more of hypocotyl and root tissues with lesions and exhibiting severe rotting and reduced roots).

5 The adaptation evaluation was recorded at physiological maturity and was based on number and shape of pods, number of seeds per pod and seed size. The CIAT scale (13) of 1 (excellent) to 9 (very poor) was used

6 All bean accessions can be obtained from CIAT, Cali, Colombia as designated above.

7 and 8 refer to plots that were artificially inoculated with *Rhizoctonia* or nontreated, respectively.

9 The LSD reported are those from all the accessions included in the trial

the physiology of the plant, speed of emergence and seedling vigor, characteristic of inocula and environmental conditions. In addition, Sumner (23) demonstrated the differential responses of bean cultivars and accessions to the different anastomosis groups of **Rs** and **Rs**-like fungi and suggested the importance of characterizing the prevailing strains of the fungus in the development of resistant bean cultivars. Thus, it would be important to evaluate the identified **Rs**-resistant bean accessions in many bean-growing areas. Based on this study, an international **Rs** root rot bean nursery consisting of 40 accessions has been established and can be obtained from CIAT in Cali, Colombia. Such nurseries should be established in areas where severe **Rs** damage to beans has occurred repeatedly. However, the reaction of bean accessions included in these nurseries specifically to **Rs** should be assessed carefully and separately from other root disease pathogens that may be present. Root rot diseases of beans can be caused by several plant pathogenic fungi and plant parasitic nematodes acting singly or in several combinations, thus the development of root disease complexes (7, 19). In Latin American countries and elsewhere, the major root diseases that limit production generally differ from one bean growing region to another (1). For example, **Rs**, root-knot nematodes (*Meloidogyne* spp.), and to a lesser extent *Fusarium solani* (Mart.) Appel and Wr. f. sp. *phaseoli* (Burk.) Snyd. and Hans., are the major bean root pathogens in the southern coastal areas of Peru; *F. oxysporum* Schlecht f. sp. *phaseoli* Kendrick and Synder and *Macrophomina phaseolina* are most important in the northeast bean growing region of Brazil, whereas **Rs** alone is the major root pathogen in the Popayan area in Colombia. Accordingly, it is critical to identify other root pathogens present in

Table 3. Influence of natural and artificial soil infestation of *Rhizoctonia solani* on selected bean accessions in a field near Popayan, Colombia when planted on November 26, 1985. Data from 15 of the 65 accessions are listed below.

Bean Accession[6]	Emergence[1]/1 m		Stand Count[2]/1 m		Seed Wt. g[3]/1 m		DSR[4]		Adapt[5]	
	Inoc.[7]	Nat.[8]	Inoc.	Nat.	Inoc.	Nat.	Inoc.	Nat.	Inoc.	Nat.
RIZ 30	12.0	10.0	13.0	11.0	118.0	76.0	4	2	5.0	5.0
BAT 1753	11.7	10.7	11.0	10.5	99.0	106.5	4	5	5.0	5.0
EMP 81	9.7	9.0	10.0	9.5	92.5	102.5	3	4	6.0	5.5
BAT 477	12.0	11.5	10.0	9.0	58.0	122.0	5	4	5.0	5.0
ICA-Linea 24	13.0	13.0	9.0	12.0	35.0	66.0	4	3	5.0	5.0
ICA Duva	10.7	10.0	9.0	10.0	81.0	88.0	5	4	5.0	5.0
CG 82-131	9.0	9.7	9.0	8.0	58.5	94.0	5	3	5.5	5.5
ECUADOR 1056	11.3	11.3	9.0	8.5	18.0	16.0	7	6	8.0	8.0
ICA Pijao	8.3	8.7	8.5	9.0	100.0	95.0	4	3	4.0	4.0
BAT 332	11.5	12.0	6.0	9.0	49.0	52.0	4	4	6.0	6.0
A 300	4.3	7.7	4.0	7.5	103.0	142.0	3	3	5.5	5.5
D. CALIMA	5.0	10.0	2.5	9.0	16.0	46.0	6	5	6.5	6.0
SANILAC	3.0	4.7	0.0	0.5	0.0	1.5	7	6	8.5	8.5
ECUADOR 605	11.0	5.0	0.0	0.0	0.0	0.0	7	6	9.0	9.0
MORTINO	7.0	6.7	0.0	0.0	0.0	0.0	7	5	9.0	9.0
LSD (P = 0.05)	5.5	5.5	4.9	6.2	64.4	80.2	–	–	2.4	3.1

For footnotes see Table 2.

the evaluation site in addition to Rs. The latter can be accomplished by the inclusion in the nursery of susceptible and resistant bean accessions to the suspected root rot pathogens present. Many bean accessions with resistance to *M. phaseoli* and *F. oxysporum* f. sp. *phaseoli* have been recently identified (18, 19).

The Rs-resistant bean accessions identified in this study had rapid emergence, high seedling vigor and greater plant survival at harvest time as compared to susceptible accessions. These results are in agreement with those reported by Beebe *et al.* (6), who concluded that plant survival under severe attack is a better criterion for assessing resistance to Rs than disease severity assessment or other parameters. However, van Bruggen *et al.* (25) reported that Rs delayed emergence, growth development and maturation of dry beans, but it did not reduce the overall yield in artificially infested field microplots. Their inocula consisted of sclerotia of Rs produced on autoclaved green bean pods and were added to soil at a density of 500 sclerotia/liter of air-dried soil. The dry individual sclerotial inoculum may not function as rapidly or be as aggressive as other form of natural and artificial inocula in causing damage to bean seeds and seedlings. Hypocotyls of bean tissues are highly susceptible to infection by Rs during the first two weeks after planting, but become progressively resistant thereafter (4, 22).

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