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Evaluation of *Capsicum* Germplasm for Sources of Resistance to *Rhizoctonia solani*

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Abstract. **A reliable screening method to detect *Rhizoctonia solani* Kuhn resistance in chiles (*Capsicum annuum* L.) was developed using infested corn (*Zea mays* Bonaf.) kernels as inoculum. The most aggressive New Mexican isolate of *R. solani* (PWB-25) was used to screen 74 *Capsicum* accessions for resistance to root rot caused by the fungus. The accessions differed in resistance, with disease ratings ranging from 2.9 to 8.6 on a 0 (no disease) to 9 (seedling dead) scale. The percentage of resistant plants, those in the interaction phenotype index class 0, 1, 2, and 3, ranged from 2.4% to 77.1%. Nineteen accessions representing four species had ≥50% resistant individuals and would be useful in breeding programs.**

New Mexico leads the United States in chile production and processing (Lucier and Green, 1993). Chile (*Capsicum annuum*) is New Mexico's most valuable horticultural crop, with the processing-chile crop valued at more than $250 million (New Mexico Dept. of Agriculture, 1992).

Rhizoctonia root rot of chiles is caused by *Rhizoctonia solani* [telemorph: *Thanatephorus cucumeris* (Frank) Donk], a fungal pathogen of many plant species (Sherf and MacNab, 1986; U.S. Dept. of Agriculture, 1960). On chiles, this soilborne fungus can cause seed decay, pre- and postemergence damping-off, wirestem, root rot, and necrotic spots on the hypocotyl or tap root (Sherf and MacNab, 1986). Rhizoctonia root rot is most severe on chile grown on clay soils; this disease becomes more problematic as chiles are planted in the same field for several consecutive years (Shannon and Cotter, 1986).

Several methods can be used to control *R. solani*, including crop rotation, fungicides, and resistant cultivars. Crop rotation provides only limited protection because the fungus survives as a saprophyte in the soil for several years (Hecker and Ruppel, 1977). Fungicides may reduce the disease incidence (Shannon and Cotter, 1986), but using chemicals raises environmental concerns. The most effective and environmentally safe method for controlling plant diseases is with resistant cultivars (Sherf and MacNab, 1986). To our knowledge, no commercial chile cultivars are known to be resistant to *R. solani*, presumably because no sources of resistance have been found. Therefore, we evaluated *C. annuum* and three other chile species to identify possible sources of resistance to rhizoctonia root rot.

Several investigators have developed screening techniques to identify sources of genetic resistance to *R. solani* in sugarbeet, (*Beta vulgaris* L.) (Ruppel et al., 1979), peas (*Pisum sativum* L.) (Shehata et al., 1981), carrots (*Daucus carota* L.) (Howard and Williams, 1976), snap beans (*Phaseolus vulgaris* L.) (Prasad and Weigle, 1970), and lima beans (*Phaseolus limensis* Macfady) (Warren et al., 1972). Soil infestation is the most common screening method. Shehata et al. (1981) reported that using corn (*Zea mays* Bonaf.) kernels as a soil infestation method gave better separation between resistant and susceptible pea genotypes than a cornmeal sand medium. Our report describes a reliable technique (Muhyi, 1990) that was developed at New Mexico State Univ., Las Cruces, to screen sources of genetic resistance to *R. solani* in four *Capsicum* species.

Materials and Methods

Samples of suspected *R. solani*-infected chile plants and seedlings were collected from several locations in New Mexico. Cultural and microscopic examination identified the fungal isolates as *R. solani* (Parmeter, 1970). The fungus was purified by the hyphal-tip technique. We identified anastomosis grouping (AG) of the *R. solani* isolates as described by Kronland and Stanghellini (1988). The AG-tester isolates were obtained from Earl Ruppel (U.S. Dept. of Agriculture, Agricultural Research Service, Crops Research Lab., Fort Collins, Colo.). Each tester pairing was replicated two or three times, and the experiment was repeated once. Seven isolates belonged to AG 2-1, and 11 belonged to AG-4. The most aggressive, isolate PWB-25, was placed in AG-4.

Screening Capsicum germplasm for resistance to R. solani. Seventy-four accessions belonging to four *Capsicum* species (Table 1) from several origins were scored for resistance level (Muhyi, 1990). Several preliminary experiments established the adopted methods we described. Our experiment was a randomized complete-block design with 24 plants of each accession in each of two replicates. We used a postemergence inoculation method.

Chile seeds were surface-sterilized with 10% (w/v) trisodium phosphate for 30 min and then rinsed in distilled water (Rast and Stijger, 1987). Immediately following this treatment, the seeds were soaked for 15 min in 0.5% (v/v) sodium hypochlorite and then air-dried. Two chile seeds were placed in each cell (3.9 × 2.7 × 5.5 cm) of a 12-cell bedding plant container previously filled with a commercial peat-lite (RediEarth 3CF; Grace Sierra, Milpitas, Calif.) mixture. Each bedding plant container was placed in a 51.5 × 25.5 × 5.7-cm plastic tray with a 1-cm layer of vermiculite placed on the bottom of the tray. Three to four beads of a controlled-release fertilizer (14N–14P–14K) were placed on the surface of each cell. After planting, the trays were watered as needed to maintain good plant growth (usually daily). The trays were placed on a greenhouse bench where the air temperature was maintained at 28 ± 1C day/15 ± 1C night. In this

Table 1. Diseases indices (DI) and percentage of resistant plants for the 19 most resistant and two most susceptible *Capsicum* accessions among 74 inoculated with *R. solani* isolate PWB-25.

Accession identification[z]	*Capsicum* species[y]	DI (SD)[x]	Resistant plants (%)[w]
PI 439410	C.b.	2.9 (2.9)	70.8
PI 555611	C.b.	3.0 (3.1)	77.1
Long Chili	C.a.	3.2 (2.7)	66.7
PI 167061	C.a.	3.3 (3.0)	71.3
PI 257130	C.b.	3.4 (3.3)	65.9
PI 273420	C.b.	3.5 (3.3)	63.9
Aji blanco	C.b.	3.8 (3.2)	60.4
Giant Szegedi	C.a.	3.9 (3.8)	60.6
NMCA1016	C.a.	3.9 (3.3)	56.3
NMCA1003	C.a.	3.9 (3.7)	56.1
NMCA5037	C.b.	4.2 (3.5)	59.6
NMCA1036	C.a.	4.3 (3.5)	56.8
Sandia	C.a.	4.3 (2.5)	52.2
PI 171555	C.a.	4.3 (3.4)	59.1
PI 171559	C.a.	4.4 (3.7)	54.2
Tabasco	C.f.	4.4 (2.7)	50.7
NMCA3009	C.c.	4.6 (3.6)	55.2
Santa Fe Grande	C.a.	4.9 (3.8)	50.9
Florida VR2	C.a.	4.9 (3.5)	50.0
TAM Hildalgo	C.a.	7.8 (1.9)	4.7
NMCA6002	C.b.	8.6 (1.1)	2.4

[z]NMCA = New Mexico *Capsicum* accession, PI = U.S. Dept. of Agriculture plant introduction.
[y]C.a. = *Capsicum annuum* L., C.b. = *C. baccatum* L., C.c. = *C. chinense* Jacq., and C.f. = *C. frutescens* L.
[x]Mean of two replications (24 plants each) was calculated from an interaction phenotype scale (0 = healthy, 9 = dead). DI: 0 to 3 = resistant, 3 to 5 = partially resistant, and 5 to 9 = susceptible.
[w]Percentage of resistant plants is equal to the sum of interaction phenotype classes 0, 1, 2, and 3 divided by the total and the result multiplied by 100.

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successful screening protocol, placing the inoculated plants on a greenhouse bench was adequate environmental control to identify chiles resistant to *R. solani*.

Inoculum preparation. Corn kernels were soaked in tap water for 48 h and rinsed in running tap water for 15 min. Then, the kernels (115 to 120 g wet weight) were placed in a 250-ml, wide-mouth Erlenmeyer flask. Each flask received 15 to 20 ml distilled water and was autoclaved for 20 min at 121C. After autoclaving, we placed three hyphal plugs (1 cm in diameter) of *R. solani* AG-4 (PWB-25) into each flask. The flasks were incubated at 23 ± 1C for 2 weeks and then shaken by hand every 4 to 5 days. The colonized corn kernels then were used to infest the soil.

At the three to four true-leaf stage, two infested corn kernels were placed in the soil at a 2-cm depth next to the seedling but not touching the seedling. The seedlings were evaluated 20 days after the postinoculation treatment using the following interaction phenotype scale to rate the length (in millimeters) of superficial necrotic lesions on hypocotyls or tap roots: 0 = no lesions; 1 = 1 to 2; 3 = 3 to 5; 5 = 6 to 10, sometimes girdling; 7 = 11 to 30, girdling, stunting of plant, leaf dropping; 9 = death of seedlings. Even numbers were used to assess intermediate responses. To quantify the disease, a disease index (DI) was calculated using the following formula: DI = , where i = interaction phenotype class (0 to 9), j = number of plants/class, n = total number of plants. When scoring the *Capsicum* germplasm, the following DI categories were considered: 0 to 3 = resistant, >3 to 5 = partially resistant, >5 to 9 = susceptible.

The percentage of resistant plants was calculated by adding the number of plants in the resistant category, then dividing by the total number of plants, and multiplying the product by 100.

Results and Discussion

Resistance to *R. solani* varied widely among the *Capsicum* accessions, indicating a range in genetic variability for rhizoctonia root-rot resistance. With the postemergence inoculation technique, there were significant differences ($P \leq 0.0001$) among the 74 *Capsicum* accessions in their response to isolate PWB-25. The percentage of resistant plants was highly correlated with the DI ($r = -0.97$, $P \leq 0.0001$). We list (Table 1) DIs and the percentage of resistant plants only for the 19 accessions most resistant to rhizoctonia root rot and two susceptible accessions. DI ranged from 2.9 to 8.6. The most resistant chile accessions, PI 439410 and PI 555611, were *C. baccatum*.

Because it was sufficiently rigorous to separate resistant and susceptible individuals, the postemergence method was chosen to screen chile accessions. The *C. baccatum* accessions are considered resistant to rhizoctonia root rot, having mean disease indices <3.1 and the highest percentage of resistant plants. However, introgression of resistance from these accessions into *C. annuum* will be difficult due to F_1 sterility (Greenleaf, 1986). The *C. annuum* accessions, 'Long Chili' (a Korean hybrid) and PI 167061, had 67% and 71% resistant individuals, respectively. The high proportion of resistant plants makes these accessions useful for introducing *R. solani* resistance into *C. annuum* cultivars. In addition, several *C. annuum* accessions contained a notable percentage of resistant plants, so selection within a cultivar could result in an improved cultivar.

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