Resistance to Rhizoctonia Stem Rot in Peas as Influenced by Temperature, Watering Method, and Period of Disease Development

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ABSTRACT

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Under controlled environmental conditions, disease severity of susceptible and moderately resistant pea cultivars to *Rhizoctonia solani* AG4 varied with temperature, period of disease development, and method of watering. The distinction between susceptible and moderately resistant plants was difficult to determine when plants were kept either under high temperature and high soil moisture for a long period or under low temperature and high soil moisture for a short period. A breakdown of the moderate resistance to this disease occurred under environmental conditions that favored the pathogen more than the host. Seedlings of a susceptible and of a moderately resistant cultivar of different ages (1, 2, and 3 wk) gave the same disease reaction. The maturing pea stem apparently did not develop disease resistance.

Stem rot caused by *Rhizoctonia solani* (Kühn) anastomosis group (AG) 4 has recently been found to play an important part in the stem and root rot complex on peas (19). The stem rot pathogen alone can cause serious damage to pea plants under certain conditions (6,8). A screening technique for resistance to this disease in peas has been developed, and resistance has been reported to be nonuniform within each resistant pea cultivar and to vary with the environment (18). Although factors affecting resistance in peas to other soilborne pathogens have been studied (13,14), factors affecting resistance to stem rot caused by *R. solani* are not well understood.

The effect of temperature on disease severity caused by *R. solani* has been investigated on various crops. Optimum temperature for disease development varies with the crop, anastomosis group of the pathogen, and relationship between the pathogen and host under different environments (9,12). In general, disease severity does not correspond closely with the growth rate of either the host or the pathogen at different temperatures but is inversely related to the host/pathogen growth ratio (12). Disease incidence of *R. solani* on peas is serious when temperatures higher than 18–20 C persist (8).

High soil moisture was reported to either increase (20) or decrease (17) disease severity caused by *R. solani* in other crops. The confusion in the literature about the effect of soil moisture on *R. solani* in different crops may be due to failure to distinguish between the effects of moisture tension and aeration. Rhizoctonia tip blight on emerging pea seedlings was severe when the moisture in a sandy plant growth medium was 12% (8).

The effect of temperature on the length of the incubation period necessary to produce disease in lettuce has been investigated. At a higher temperature, the incubation period averaged 46 hr, whereas at the lower temperature, the incubation period was 84 hr (21).

Many host plants are susceptible to penetration and tissue invasion by *R. solani* during the seedling and juvenile stages of growth; then they develop disease resistance with age (5,11,17,20). However, development of resistance in the pea stem over a period of time has not been investigated.

In general, *R. solani* has the capacity to penetrate and infect the host only under certain conditions. This capacity is changed by various environmental factors as well as by nutrition (1,4,10, 15,22). Factors associated with resistance and susceptibility to *R. solani* in other crops have been documented (2,3,5,7,16). The objective of our study was to investigate the resistance of peas to Rhizoctonia stem rot as influenced by temperature, method of watering, age of inoculum, period of disease development, and age of plants.

MATERIALS AND METHODS

Three experiments were conducted in growth chambers. In the first (a factorial with three replicates) 11 genotypes were grown under two methods of watering. Little Marvel (susceptible) and Wando (moderately resistant to Rhizoctonia stem rot) (18) were used along with nine breeding lines selected from Wando. In the first watering method, seeds were planted in Jiffy Strips peat pots filled with pasteurized sand and placed in wooden flats. The plants were watered lightly several times after inoculation. Thereafter, water was applied only after the soil surface had dried.

In the second method, seeds were planted in acrylic trays (4 × 8 × 28 cm) filled with pasteurized sand. The trays were watered until the soil reached its water-holding capacity just before the plants were inoculated. No further water was applied to the soil because the acrylic trays kept soil moisture at a high level for several days. Sixteen seeds were planted 2.5 cm deep in each container. The seedlings were inoculated by the corn-kernel technique (18) and kept in the growth chamber for 4 days at 27 ± 1 C during the day and 21 ± 1 C at night.

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Plants were carefully removed from the sand. Stems were washed and rated for reaction based on a disease index (DI) of 1–5, where 1 = healthy stem and 5 = severe infection of xylem and cortex with dead plants.

In the second experiment, reactions of susceptible and moderately resistant pea cultivars (Little Marvel and Dark Skin Perfection, respectively) to Rhizoctonia stem rot as influenced by temperature and the period of disease development were investigated. Again, a factorial design with three replicates was used. Plants were grown in acrylic containers and inoculated as in experiment 1. Stem rot reaction was compared under two temperature regimes in two growth chambers (27 ± 1 C day/21 ± 1 C night and 18.2 ± 1 C day/12.6 ± 1 C night). One-week-old seedlings were inoculated and rated for disease reaction (and discarded) 5, 10, and 15 days after inoculation. Disease reaction on each plant in each period of disease development was scored once. The experiment was repeated once.

The effects of three plant ages and two ages of inoculum of *R. solani* AG4 on the stem rot reaction in Little Marvel and Dark Skin Perfection were investigated in a third experiment in a factorial design with three replicates. One-, 2-, and 3-wk-old pea plants were inoculated with 2- and 3-wk-old inoculum. Inoculated plants were then held in acrylic containers in the growth chamber as described before. Temperature was maintained at 27 ± 1 C during the day and 21 ± 1 C at night for 4 days before evaluation. The experiment was repeated once.

RESULTS AND DISCUSSION

Seedlings of all genotypes grown in acrylic containers and watered to the point of maximum water-holding capacity of the medium had more disease than seedlings grown in peat pots and watered lightly (average DI = 4.1 vs. 3.3, respectively) (Table 1). Susceptible and moderately resistant cultivars, however, were distinguished with both watering methods. The moderately resistant cultivar Wando and the nine single-plant selections derived from it did not differ in disease severity ($P = 0.05$).

Little Marvel was more susceptible than Dark Skin Perfection at both temperatures and all time periods. Disease increased with time. The moderate resistance of Dark Skin Perfection was ineffective when plants were exposed to long periods of high soil moisture at high temperatures.

A distinction between susceptible and moderately resistant plants was obvious with high temperature 5 days after inoculation or at low temperature 15 days after inoculation (Fig. 1). Under the high-temperature regime, Little Marvel and Dark Skin Perfection averaged 4.7 versus 3.5 and 5.0 versus 4.8 at the 5- and 15-day disease periods, respectively. Corresponding values were 2.8 versus 2.5 and 4.1 versus 3.3 at the 5- and 15-day periods of disease development, respectively, under the low-temperature regime.

Disease severity was increased by the high-temperature regime on both the susceptible and the moderately resistant cultivars. The greatest separation between the two cultivars was found at the 5-day period of disease development under the high-temperature treatment; most susceptible plants had collapsed as a result of stem cortex and xylem tissue damage.

Dark Skin Perfection had moderate resistance at high temperature after 5 days (DI = 3.5) but failed to maintain its resistance and most of the plants collapsed (DI = 4.8) when left in the growth chamber under high temperature and high soil moisture for 15 days. Moderate resistance to Rhizoctonia stem rot in peas may occur only under a specific environmental condition as a result of the interaction between pathogen and host environment over time. Thus, a breakdown of moderate resistance may occur when environmental conditions favor the pathogen more than the host.

No differences in disease severity were caused by age of inoculum or by age of plants at inoculation. The average DI was 4.7–4.8 for Little Marvel and 3.4 for Dark Skin Perfection for all treatments. The difference between cultivars was significant at $P = 0.01$. Pea seedlings, in contrast to common bean (5), may not develop resistance to Rhizoctonia stem rot with time.

Finally, proper control of temperature,

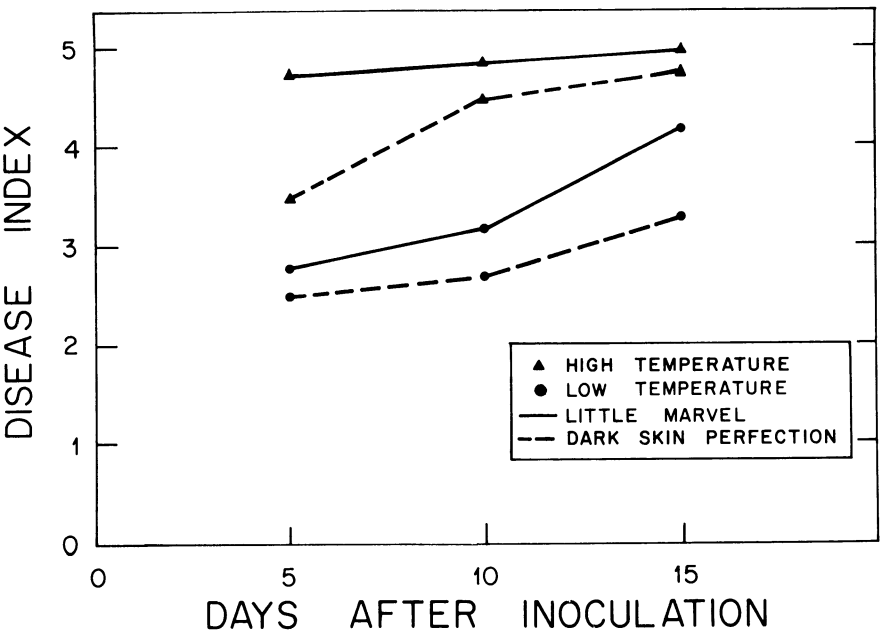

Fig. 1. Reactions of susceptible and moderately resistant pea cultivars to Rhizoctonia stem rot as influenced by temperature and period of disease development (average of two experiments).

Table 1. Reaction of 11 pea genotypes to stem rot by *Rhizoctonia solani* under two watering methods

Genotype	Heavy watering[a] (acrylic trays)	Light watering[b] (peat pots)	Genotype mean
80MF 2549	3.8[c]	2.9[c]	3.3[c]
79MG 523	3.8	2.8	3.3
80MF 2544	3.9	3.3	3.6
Wando	4.0	3.1	3.6
80MF 2545	4.0	3.4	3.7
80MF 2541	4.1	3.0	3.6
80MF 2548	4.1	2.7	3.4
79MG 525	4.2	3.5	3.8
80MF 2540	4.2	3.6	3.9
79MG 524	4.3	3.3	3.8
Little Marvel	4.9	4.5	4.7
$\bar{X}$ Disease index	4.1[d]	3.3[d]	

[a] Heavy watering was applied once to reach maximum water-holding capacity of the soil. Plants were grown in acrylic trays; hence, a high level of soil moisture was maintained for 4 days.
[b] Light watering was applied to the plants grown in peat pots placed in wooden flats and repeated when soil surface dried.
[c] Disease index: 1 = no symptoms, 5 = dead plants. Means of 12 plants in each of three replicates.
[d] The value of F was significant at the 1% level. Standard error of differences between two genotypes = 0.6. Standard error of differences between two genotypes within watering methods = 0.6.

soil moisture, and period of disease development is recommended when screening peas for resistance to this disease. It should also be noted that pea germ plasm that retains resistance under high temperature/high soil moisture conditions would logically be the best choice as a source of resistance in pea breeding.

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