Reaction of Selected Chickpea Lines to Fusarium and Thielaviopsis Root Rots

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ABSTRACT

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Forty selected chickpea (*Cicer arietinum*) cultivars or breeding lines were evaluated for resistance to root rot caused by *Fusarium solani* f. sp. *pisi* or *Thielaviopsis basicola*. Disease severity was higher in two different trials in the greenhouse at 25 ± 3 C than at 22 ± 3 C. Disease severity, rated on a 1-9 scale where 1 = a healthy plant and 9 = a dead plant, ranged from 4.1 to 9.0 at the low temperature and from 7.8 to 9.0 at the high temperature. Although none of the 40 lines was completely resistant to *F. s. pisi* at either temperature, 10 desi (small-seeded) lines were resistant (mean disease index = 3 or less) to root rot caused by *T. basicola*.

The cultivated chickpea (*Cicer arietinum* L.), also known as garbanzo bean, gram, and Bengal gram, is one of the most important pulse crops (food legumes) grown worldwide (4). Since 1982, chickpea has become a promising alternative crop for the dryland areas of the Palouse region of eastern Washington and northern Idaho, where it is grown in rotation with wheat, barley, and peas (1). The area sown to chickpeas in this region increased from 450 ha in 1982 (5) to about 4,500 ha in 1987. Two important root rot pathogens that commonly affect peas (*Pisum sativum* L.) and chickpeas in the Pacific Northwest are *Fusarium solani* (Mart.) Sacc. f. sp. *pisi* (F. R. Jones) W.C. Snyder & H.N. Hans. and *Thielaviopsis basicola* (Berk. & Broome) Ferraris (= *Chalara elegans* Nag Raj & Kendrick) (3,7,10). *Aphanomyces euteiches* Drechs. has recently become a serious root rot pathogen of peas in northern Idaho (11) but is not a serious pathogen of chickpeas (J. M. Kraft, *personal observation*). *Pythium ultimum* Trow causes seed rot and preemergence damping-off of chickpeas (5) but is adequately controlled by registered fungicides applied as seed dressings (5,6).

Because *F. s. pisi* and *T. basicola* can infect chickpeas as well as peas, rotation of chickpeas with peas will not reduce buildup of inoculum of the pathogens in the soils of the Palouse region. If chickpeas are to be grown in the Palouse, the most economical measure to control these root pathogens would be the development of resistant cultivars.

There are no previous reports on the availability of resistance in chickpea to *F. s. pisi* and *T. basicola*. In contrast, there are numerous reports on the development of chickpea cultivars with resistance to wilt caused by *F. oxysporum* Schlechtend.:Fr. f. sp. *ciceris* (Padwick) Matuo & K. Sato (10,13). Extensive disease resistance screening trials have been conducted to find resistance to *F. s. pisi* and *T. basicola* in peas (8,9,12).

The objective of this study was to screen a selected number of chickpea lines to determine if resistance to *F. s. pisi* and *T. basicola* is readily available.

MATERIALS AND METHODS

Plant material. Forty chickpea lines were evaluated for resistance to *F. s. pisi* and *T. basicola* under greenhouse conditions. Lines from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India) were designated as ICRRWN (International Chickpea Root Rot and Wilt Nursery) and lines from ICARDA (International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria) were designated as ICC. Evaluation trials were conducted twice, once during the winter with a greenhouse temperature of 22 ± 3 C and once during

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the summer at 25 ± 3 C. A 1–9 disease severity scale was used, where 1 = no visible symptoms; 3 = light root discoloration, necrotic lesions, approximately 10% of hypocotyl and root tissue covered with lesions; 5 = approximately 11–25% of hypocotyl and root tissue covered with lesions; 7 = coalescing of lesions to form large lesions affecting approximately 26–50% of the root system, considerable softening and rotting of root system; and 9 = approximately 51–100% of root system infected, severe necrosis, death of plant. Even numbers of the scale were assigned to plants showing symptoms between two odd number ratings. Percent resistance was calculated as: percent resistance = number of plants with disease index of 3 or less/total number of plants per line × 100.

All of the lines evaluated, with the exception of Surutato and UC-5, were the desi type, i.e., small seeds (100 = < 26 g) with irregularly shaped, pigmented coats. Kabuli types have large seeds (100 = > 26 g) with rounded, pale, hyaline coats (13). Seeds of all test lines were surface-disinfested with a 0.3% solution of sodium hypochlorite before planting.

Infesting soil with *F. s. pisi*. A Moxee silt loam soil (39% sand, 57% silt, and 3.6% clay) with a pH of 6.9 (determined by the water-paste method) was used. Soil was passed through a 3-mm screen, air-dried, and stored at room temperature. Soil was fumigated with methyl bromide (1.0 kg/m^3 of soil). Primary inoculum of *F. s. pisi* was obtained by placing about 20 mg of infested stock soil on Nash and Snyder's PCNB medium (14) in a petri dish. Microconidial inoculum, added to pathogen-free soil, was prepared according to procedures described previously (8,9). Populations of *F. s. pisi* were adjusted to approximately 5,000 cfu/g of air-dried infested soil (8).

Steam-sterilized wooden containers (25 × 60 cm) with removable slides were filled with infested soil. Two test lines consisting of 18 seeds each were planted about 2.5 cm deep in rows along both sides of the container. Seeded containers were placed in the greenhouse and incubated for 25 days, with soil moisture maintained in the −200 to -40 kPa range. At 25 days, the plants were carefully removed and the roots washed, and each was rated for disease severity.

Infesting soil with *T. basicola*. Aluminum trays (45 × 60 cm) were filled with an autoclaved (121 C, 1.406 kg/cm^2 pressure for 6 hr), moistened sand and perlite mix (1:1). Twenty seeds of each line were planted 2.5 cm deep in rows, six lines per tray. A hand sprayer was used to uniformly spray the potting mix and seeds with a suspension of *T. basicola* adjusted to 10^5 conidia per milliliter. Inoculated seeds were covered with the sand-perlite medium and incubated for 25 days, then harvested. The aluminum trays were watered at the rate given above. At 25 days, the plants were carefully removed and the roots washed, and each was rated for disease severity.

RESULTS

***F. s. pisi*.** Only four of the 40 lines tested showed some degree of resistance (disease index = < 3) to *F. s. pisi* at 22 ± 3 C. These were PI 273879 (81% of the plants), ICC-1437 (61%), ICRRWN-81004 (56%), and ICRRWN-3428 (44%) (Table 1). The other entries were as susceptible as the susceptible control used, ICC-4951 (JG-62). At 25 ± 3 C, no entry was rated as resistant to *F. s. pisi* (Table 1).

***T. basicola*.** Five lines (UC-5, ICC-5003, ICC-10802, ICCL-81256, and ICCL-83102) were 100% resistant to the black root rot fungus at both temperatures, and three (ICC-1437, ICC-4973, and ICCL-83104) were 100% resistant at 22 ± 3 C but susceptible at 25 ± 3 C (Table 2). Thirteen entries showed 61–89% resistance and 10 showed none at 25 ± 3 C (Table 2).

DISCUSSION

This report is the first on the reaction of chickpea breeding lines or cultivars to root rot caused by *F. s. pisi* or *T. basicola*. These two pathogens are the most important components of the root rot complex of peas in the Pacific Northwest (3,10) and could significantly impact chickpea culture in the Northwest.

In the winter trial, when the greenhouse temperature was 22 ± 3 C and day length was 10 hr, four brown-seeded desi-type chickpea lines showed 44–81% resistance to root rot caused by *F. s. pisi*

Table 1. Chickpea lines evaluated for resistance to *Fusarium solani* f. sp. *pisi* in two greenhouse tests

Entry	Origin	22 ± 3 C Disease index[a]	22 ± 3 C Percent resistance	25 ± 3 C Disease index	25 ± 3 C Percent resistance
Surutato	Mexico	6.1	0	8.6	0
UC-5	United States	7.4	0	8.0	0
PI 273879	Ethiopia	4.1	81	8.0	0
ICC-4	Ethiopia	9.0	0	9.0	0
ICC-1437	Ethiopia	5.4	61	7.8	0
ICC-2246	Iran	6.8	0	8.4	0
ICC-4951 (JG-62)	India	8.0	0	9.0	0
ICC-4973	India	7.2	0	9.0	0
ICC-5003	India	4.9	0	7.1	0
ICC-9029	Iran	9.0	0	9.0	0
ICC-9035	Iran	8.0	0	9.0	0
ICC-10802	India	8.9	0	9.0	0
ICC-11252	India	6.1	0	9.0	0
ICC-11322	India	6.3	0	7.7	0
ICC-11324	India	7.0	0	8.0	0
ICC-12244	Iran	5.8	6	7.8	0
ICCL-4928	ICRISAT	7.6	0	9.0	0
ICCL-81256	ICRISAT	8.4	0	9.0	0
ICCL-81258	ICRISAT	9.0	0	9.0	0
ICCL-82127	ICRISAT	9.0	0	9.0	0
ICCL-83101	ICRISAT	8.8	0	8.4	0
ICCL-83102	ICRISAT	8.4	0	8.6	0
ICCL-83103	ICRISAT	8.3	0	9.0	0
ICCL-83104	ICRISAT	9.0	0	9.0	0
ICCL-83105	ICRISAT	8.5	0	9.0	0
ICCL-83106	ICRISAT	8.4	0	9.0	0
ICCL-83107	ICRISAT	8.2	0	9.0	0
ICCL-83108	ICRISAT	7.5	0	7.8	0
ICCL-83111	ICRISAT	8.3	0	9.0	0
ICCL-83112	ICRISAT	9.0	0	9.0	0
ICCL-83113	ICRISAT	7.4	0	9.0	0
ICCL-83114	ICRISAT	6.5	17	8.7	0
ICCL-83119	ICRISAT	5.9	0	8.2	0
ICCL-83120	ICRISAT	6.6	0	8.9	0
ICCL-83124	ICRISAT	6.2	0	8.7	0
ICRRWN-3482	Turkey	4.9	44	9.0	0
ICRRWN-3782	Turkey	7.3	6	8.5	0
ICRRWN-11224	India	5.1	6	6.1	6
ICRRWN-81004	ICRISAT	4.8	56	7.8	7
ICRRWN-81014	ICRISAT	9.0	0	9.0	0
Mean		$\bar{x}$ 7.3		$\bar{x}$ 8.6	

[a] Based on a 1–9 disease severity scale, where 1 = no visible symptoms; 3 = light root discoloration, approximately 10% of hypocotyl and root tissue covered with lesions; 5 = approximately 11–25% of hypocotyl and root tissue covered with lesions; 7 = approximately 26–50% of hypocotyl and root tissue covered with lesions, softening and rotting of root system; and 9 = approximately 51–100% of root system infected, death of plant. Numbers 2, 4, 6, and 8 were assigned to plants showing symptoms between the appropriate odd number ratings.

(Table 1). The same lines were susceptible during summer trials when the greenhouse temperature was 25 ± 3 C and day length was 15 hr.

Five of the 14 lines completely resistant to Thielaviopsis root rot at 22 ± 3 C were also 100% resistant at 25 ± 3 C (Table 2). Twelve other entries showed a wide range (61–89%) of resistance in both trials. Most of the resistant lines were brown-seeded desi types. These results agree with those of others (5,6,13) who reported that resistance to diseases existed more often in desi than in kabuli chickpeas. Resistance in desi chickpeas is attributed to seed coat thickness, high percentage of crude fiber, and presence of anthocyanins.

If a breeding program is initiated to produce a chickpea cultivar adapted to growing conditions in the Northwest, resistance to Fusarium and Thielaviopsis root rots should be a primary objective. Apparently, usable levels of resistance will be more difficult to find for Fusarium than for Thielaviopsis root rot. That environmental factors commonly influence the rate and degree of root disease development is well established. Chickpea lines that are susceptible to root rot in tropical climates may still yield better than the local susceptible cultivars of the temperate regions if the pathogen's inoculum density is not above 5,000 propagules per gram (3). Previous results have indicated that when screening chickpea genotypes for resistance to *F. s. pisi*, the soil temperature should be above 20 C; otherwise, susceptible plants may escape. Conversely, if the temperature is 30 C or above, the disease can be so severe that valuable germ plasm may be undervalued or even lost. A temperature of 25 C and an inoculum level of 5,000 propagules per gram were required for expression of a typical disease (2). In these studies, the inoculum levels were known and can be reproduced. Therefore, we recommend that the evaluation of chickpeas for resistance to the pathogens of Fusarium or Thielaviopsis root rot be conducted at an inoculum level of 5,000 propagules per gram and at a temperature of 25 C (2). These levels are comparable to field inoculum densities of *F. s. pisi* in the soils cropped to pea in eastern Washington and northern Idaho. The population densities of *T. basicola* in the Palouse region have not been determined, however.

On the basis of the results of screening experiments, it is apparent that such factors as day length, sunlight, and temperature could have played a role in disease expression in the trials conducted during two completely different seasons of the year. This observation is in agreement with previous results that severity of chickpea and pea root rot is directly related to inoculum density and environmental stress (3,10).

Table 2. Chickpea lines evaluated for resistance to *Thielaviopsis basicola* in two greenhouse tests

		22 ± 3 C		25 ± 3 C	
Entry	**Origin**	**Disease index**[a]	**Percent resistance**	**Disease index**	**Percent resistance**
Surutato	Mexico	2.3	83	3.4	72
UC-5	United States	2.0	100	2.7	100
PI 273879	Ethiopia	4.7	0	5.0	0
ICC-4	Ethiopia	2.3	89	3.7	61
ICC-1437	Ethiopia	4.3	100	4.2	17
ICC-2246	Iran	2.0	0	3.1	78
ICC-4951 (JG-62)	India	4.8	72	4.6	11
ICC-4973	India	3.8	100	4.9	0
ICC-5003	India	1.0	100	2.2	100
ICC-9029	Iran	2.0	100	2.3	89
ICC-9035	Iran	2.0	100	3.1	89
ICC-10802	India	2.0	100	2.0	100
ICC-11252	India	4.8	0	4.4	11
ICC-11322	India	3.0	100	3.3	67
ICC-11324	India	3.6	56	4.1	6
ICC-12244	Iran	2.2	89	2.2	100
ICCL-4928	ICRISAT	5.3	0	5.4	0
ICCL-81256	ICRISAT	1.0	100	1.2	100
ICCL-81258	ICRISAT	3.4	56	3.8	44
ICCL-82127	ICRISAT	3.6	36	3.8	22
ICCL-83101	ICRISAT	4.2	40	5.4	0
ICCL-83102	ICRISAT	2.0	100	3.0	100
ICCL-83103	ICRISAT	4.0	87	3.7	67
ICCL-83104	ICRISAT	3.0	100	3.8	22
ICCL-83105	ICRISAT	3.4	78	3.6	78
ICCL-83106	ICRISAT	2.0	100	3.1	89
ICCL-83107	ICRISAT	2.0	100	2.6	72
ICCL-83108	ICRISAT	2.3	83	3.9	44
ICCL-83111	ICRISAT	4.2	28	4.8	0
ICCL-83112	ICRISAT	6.4	0	4.9	0
ICCL-83113	ICRISAT	2.0	100	3.1	78
ICCL-83114	ICRISAT	4.8	0	5.4	0
ICCL-83119	ICRISAT	4.3	0	4.4	0
ICCL-83120	ICRISAT	3.1	56	3.4	67
ICCL-83124	ICRISAT	3.4	56	3.8	56
ICRRWN-3482	Turkey	3.3	89	3.4	72
ICRRWN-3782	Turkey	3.8	22	4.0	0
ICRRWN-11224	India	4.0	0	4.1	0
ICRRWN-81004	ICRISAT	3.9	57	3.4	46
ICRRWN-81014	ICRISAT	3.9	56	3.7	44
Mean		$\bar{x}$ 3.2		$\bar{x}$ 3.6	

[a] Based on a 1–9 disease severity scale, where 1 = no visible symptoms; 3 = light root discoloration, approximately 10% of hypocotyl and root tissue covered with lesions; 5 = approximately 11–25% of hypocotyl and root tissue covered with lesions; 7 = approximately 26–50% of hypocotyl and root tissue covered with lesions, softening and rotting of root system; and 9 = approximately 51–100% of root system infected, death of plant. Numbers 2, 4, 6, and 8 were assigned to plants showing symptoms between the appropriate odd number ratings.

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