Responses of Beans and Peas to Root Pathogens Accumulated during Monoculture of Each Crop Species

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ABSTRACT

Dry beans and peas were planted two successive seasons, in fields where populations of root pathogens had previously accumulated during 15 and 6 yr of monoculture of the respective crops, and in nearby control fields of similar soil type where neither crop had been grown. *Pythium ultimum, Rhizoctonia solani,* and *Thielaviopsis basicola* infected many plants of both crop species in both previously monocultured fields; whereas *Fusarium solani* f. sp. *phaseoli* was prevalent only in the bean field, and *F. solani* f. sp. *pisi* only in the pea field. Populations of pathogens in the control fields were comparatively small. Yields of both beans and peas were high in fields previously monocultured to the other host, but were drastically reduced in their respective original fields. Activity of pathogens common to both crop species had no detectable effects on crop vigor or yields in the absence of the respective host-specific forms of *F. solani.*

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Several pathogens are involved in a disease complex causing root rots of beans (*Phaseolus vulgaris* L.) and peas (*Pisum sativum* L.). The relative importance of each pathogen varies with conditions. In the Northwest, *Fusarium solani* (Mart.) Appel & Wr. f. sp. *phaseoli* (Burk.) Snyd. & Hans. and *F. solani* (Mart.) Appel & Wr. f. sp. *pisi* (F. R. Jones) Snyd. & Hans. have been considered to be the principal pathogens in root rot of beans and peas, respectively. In a recent study (2), however, we found both bean and pea fields to be heavily infested by *Pythium ultimum* Trow. All isolates of this fungus recovered from both bean and pea fields were destructive to roots of both crops in greenhouse tests. In addition, *Rhizoctonia solani* Kuehn and *Thielaviopsis basicola* (Berk. & Br.) Ferr. were prevalent in these fields, and caused stem and root necrosis on both crop species.

We conducted a 2-yr field investigation to determine the relative effects on plant development and yield caused by the root pathogens common to both crops and by the host-specific forms of *Fusarium solani.* First-year results were reported previously (1).

MATERIALS AND METHODS.—In 1971 and 1972, beans (*Phaseolus vulgaris* L. 'Red Mexican') and peas (*Pisum sativum* L. 'Freezer Perfection'), slurry-treated with a fungicide and an insecticide, were planted in a field cropped to beans for the previous 15 yr (B) and in a field cropped to peas for the previous 6 yr (P). Beans and peas were also planted each year in a different control field (N71 and N72, respectively), where neither crop had ever been grown previously. Three plot strips of beans were alternated with three strips of peas in each field. Bean plots were four rows, 56 cm apart; and pea plots were eight rows, 28 cm apart. Plots were 90 m long. Peas were planted 6 and 5 April and beans 17 and 4 May, respectively, in 1971 and 1972.

All fields were Ritzville sandy loam and not more than 200 m apart. Phosphorous and zinc fertilizers (80 and 10 lb/a, respectively) were applied to each field to insure

TABLE 1. Incidence of infection (%) by four root pathogens (*Fusarium, Pythium, Rhizoctonia,* and *Thielaviopsis* spp.) in beans 2 wk and 6 wk after plant emergence in 1971 and 1972[a]

Postemergence time	Field					
	Bean (B)		Pea (P)		Control (N)	
Pathogen	1971	1972	1971	1972	1971	1972
Two weeks:						
F. solani	100	51	0	0	0	0
P. ultimum	90	100	98	100	0	0
R. solani	30	59	6	11	3	4
T. basicola	41	92	93	95	2	3
Six weeks:						
F. solani	100	100	6[c]	23[c]	33[c]	5[c]
P. ultimum	---[b]	100	80	100	62	100
R. solani	25	14	15	61	36	3
T. basicola	---	---	66	15	21	0

[a] As indicated by appearance of root or stem lesions on 100 plants from each of three replicate plots.
[b] Not discernible on Fusarium-damaged roots and stems.
[c] Mostly slight as compared with extensive necrosis on roots from field B.

adequate soil fertility. However, excessive bean foliage in N72 indicated high N-residues from a previous corn crop.

Two and 6 wk after plant emergence, 100 plants were dug randomly from each plot for disease observations and for fresh top- and root-weight measurements. Rhizosphere soil (3) from these same plants was collected for plate counts of the two *F. solani* f. spp. and *P. ultimum*.

Incidences of infection by *R. solani, T. basicola, F. solani,* and *P. ultimum* were based on root symptoms and stem lesions. Populations of *F. solani* and *P. ultimum* in soil from each field, and in rhizosphere soil, were estimated by plating of soil dilutions (1:200) on 6-18 replicate plates of modified PCNB agar (4) and on $P_{10}PV$ agar medium (6), respectively.

Green-pea and pea-seed yields were from three 6-m-long subplots in each plot. Green peas were harvested when they approached a tenderometer measurement of 100. Bean seed yields were from an entire plot.

RESULTS.—Disease symptoms on young plants showed that *P. ultimum, T. basicola,* and *R. solani* were prevalent in both monocultured fields, and that the latter two fungi were sparse in fields N71 and N72 (Table 1 and 2). *T. basicola* lesions were more prevalent on beans than on peas in all fields. Extensive lesions caused by *Fusarium* spp. were observed on beans and peas only in their respective monocultured fields.

In soil-dilution platings before planting, the two *Fusarium solani* f. spp. were detected only in the fields in which their respective hosts had been grown in monoculture (Table 3). In pea-rhizosphere platings, however, *F. solani* f. sp. *pisi* was easily detected in all fields, and numbers were greater at 6 wk than at 2 wk after plant emergence. This pathogen was much more prevalent in field P than in the other fields and in pea rhizospheres than in bean rhizospheres.

F. solani f. sp. *phaseoli,* on the other hand, was prevalent in both bean and pea rhizosphere platings from field B, barely detectable in rhizosphere platings from field P, and absent in those from the control field (Table 3).

Both formae speciales diminished in numbers in the rhizosphere of the opposite host, between the 2-wk and 6-wk samplings (Table 3). During this same time, *F. solani* f. sp. *phaseoli* also diminished in numbers in the bean rhizosphere, but *F. solani* f. sp. *pisi* increased pronouncedly in the pea rhizosphere.

Rhizosphere platings from peas grown in field B indicated a slightly higher incidence of *F. solani* f. sp. *pisi* in 1972 than in 1971. Rhizosphere data for *F. solani* f. sp. *phaseoli* were not obtained in 1971.

Pythium ultimum was prevalent in most soil platings from all fields, except in the preplanting sampling of control field N71. No consistent species or rhizosphere influence on numbers of this pathogen was detected.

Yields of both beans and peas were much greater, both seasons, in the field previously monocultured to the opposite host, and in the control fields, than in the field in which they had been monocultured (Table 4). Yields of both crops were reduced by flooding in control field N71. Pea yields generally were better in 1972 than in 1971.

A repetition of the experiment in 1973 demonstrated a buildup and greater activity of *F. solani* f. sp. *pisi* on peas in field B, and of *F. solani* f. sp. *phaseoli* on beans in field P, than was observed in 1971 or 1972. In fact Fusarium root rot was sufficiently severe on both hosts in both fields to significantly reduce crop yields. The disease was not yet noticeable in field N72, wherein the crops were grown for only a second consecutive year.

DISCUSSION.—Activity of other members of the "disease complex," *P. ultimum, R. solani,* and *T. basicola,* in both monocultured fields (Table 1 and 2) caused slight to severe root necrosis on both beans and peas. *P. ultimum* caused extensive necrosis. However,

TABLE 2. Incidence (%) and severity (relative to controls) of disease symptoms caused by different pathogens (*Fusarium, Pythium, Rhizoctonia,* and *Thielaviopsis* spp.) on peas, 2 wk and 6 wk after plant emergence in three fields, 1971 and 1972

Postemergence time	Field					
	Bean (B)		Pea (P)		Control (N)	
Pathogen	1971	1972	1971	1972	1971	1972
Two weeks:						
F. solani	0	0	90	56	0	0
P. ultimum	98	30	32	8	5	23
R. solani	30	2	12	3	9	3
T. basicola	6	10	0	0	0	0
Disease index[a]	1.9	0.4	1.6	0.6	0.2	0.3
Six weeks						
F. solani	0	---[b]	100	100	0	20
P. ultimum	100	100	---	---	100	50
R. solani	0	---	---	---	20	0
T. basicola	0	---	---	---	0	0
Disease index	4.3	2.8	4.8	4.9	2.8	2.0
Fresh weight of roots[c]	87		58		114	

[a] Based on a 0-5 rating of each plant, the higher the figure the more severe the disease.
[b] Lesions absent or few and obscured by general necrosis.
[c] Fresh weight in grams of roots from 100 plants, average of three replications.

TABLE 3. Incidence of pathogens in soil dilutions from fields previously monocultured to beans or peas and control fields, 1971 and 1972[a]

Field and source of soil	*F. solani* f. sp. *phaseoli*		*F. solani* f. sp. *pisi*		*Pythium ultimum*	
	1971	1972	1971	1972	1971	1972
Bean field soil before planting	285	260	0	0	200	660
Pea rhizosphere, 2 wk[b]	---[c]	233	0	40	1,112	160
Pea rhizosphere, 6 wk	---	0	126	260	906	300
Bean rhizosphere, 2 wk	---	560	---	0	---	---
Bean rhizosphere, 6 wk	---	276	---	0	---	90
Pea field soil before planting	0	0	310	340	340	180
Pea rhizosphere, 2 wk	---	0	260	200	514	240
Pea rhizosphere, 6 wk	---	0	726	6,420	206	520
Bean rhizosphere, 2 wk	---	7	---	37	---	200
Bean rhizosphere, 6 wk	---	13	---	0	---	127
Control field soil before planting	0	0	0	0	0	320
Pea rhizosphere, 2 wk	---	0	40	0	0	60
Pea rhizosphere, 6 wk	---	0	220	240	580	140
Bean rhizosphere, 2 wk	---	0	---	0	---	0
Bean rhizosphere, 6 wk	---	0	---	0	---	133

[a] Propagules per gram of air-dry soil diluted 1:200, mean counts from 6-18 replicate plates.
[b] Age of plants after plant emergence.
[c] Not determined.

TABLE 4. Yields (kg/hectare) of beans and peas in previously monocultured fields and in control fields in 1971 and 1972[w]

Year and field	Peas (kg/hectare)			Beans (kg/ha)
	Total fresh-plant weight	Green peas[x]	Dry seed	Dry seed
1971 B (bean)	23,757 a[y]	3,391 a	3,186 a	982 b
P (pea)	11,191 c	1,993 b	1,313 b	3,496 a
N71 (control)[z]	13,338 b	3,153 a	2,617 a	1,512 b
1972 B (bean)	46,934 b	7,171 b	2,990 a	1,930 b
P (pea)	27,832 c	4,479 c	1,505 b	3,369 a
N72 (control)	63,533 a	8,348 a	3,241 a	3,822 a

[w] Means of six replicate 1/325-ha plots of peas and three replicate 1/42-ha plots of beans. Beans and peas were planted in the same strips in fields B and P, both years.
[x] Peas sieved to processing grade and data adjusted to tenderometer measurements of 100.
[y] Means in each group of three followed by the same letter are not significantly different, $P = 0.05$.
[z] Plots damaged by flooding.

unless the host-specific form of *F. solani* was prevalent, yields of both crops were comparatively high and nearly equal to their respective yields in the control fields where *P. ultimum* was the only prevalent pathogen. Therefore, we must conclude that the host-specific forms of *F. solani* were essential to significant crop damage under the conditions of this experiment. Still, the possible importance of root necrosis by the other pathogens in predisposing plants to root rot by the *F. solani* could not be ruled out.

Previous studies (5, 7) have suggested various degrees of reciprocal infectivity of beans and peas by *F. solani* f. sp. *phaseoli* and *F. solani* f. sp. *pisi*. However, the two fungi, as they occur in these fields, had little, if any, effect on the opposite host. Both of the *Fusarium* formae speciales were found in rhizosphere soil from both hosts, two wk after plant emergence (Table 3). However, neither of the *Fusarium* formae speciales could be detected in the rhizosphere of the opposite host by 6 wk after plant emergence, suggesting that the rhizosphere factors as well as host tissues were selective for the respective host-specific *Fusarium* forms.

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