Determination of Bean Root Rot Potential in Vegetable Production Fields of Wisconsin's Central Sands

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ABSTRACT

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A greenhouse bioassay was developed to determine the bean root rot potential of central Wisconsin vegetable-production fields. Greenhouse and field disease severities were shown to be highly and positively correlated during 3 yr of testing in 83 commercial snap bean fields. As field and greenhouse disease severity indices increased, there was a corresponding trend toward decreased yields. This bioassay can be used by growers as part of an integrated program for bean root rot control by estimating the risk factors of fields.

Wisconsin is the nation's largest producer of snap beans (*Phaseolus vulgaris* L.) for processing, with approximately 32,000 ha planted annually. Over half of this land is located in an area of intense, irrigated vegetable production known as the Central Sands of Wisconsin. Soil types of the Central Sands are primarily sandy loams and loamy sands with nearly level terrain, which makes this area ideal for vegetable production.

Bean root rot has continued to be a severe problem on snap beans in these soils because of inadequate crop rotation. It is thought to be caused by a complex of fungal pathogens that includes *Rhizoctonia solani* Kühn, *Pythium ultimum* Trow and other *Pythium* species, and most recently, a bean strain of *Aphanomyces euteiches* Drechs. (1,4). No commercial cultivars resistant to bean root rot are available, and there is no registered chemical control.

Sampling soil to determine pathogen content has been used to determine the possible extent of infestation by fungi (5,7,8). A test to determine pea root rot potential has been successfully employed for over 20 yr as the only known method for avoiding Aphanomyces pea root rot (7).

The objectives of this study were 1) to develop a reliable greenhouse soil bioassay for assessing bean root rot potential; 2) to relate the bean root rot severity rating, based on the greenhouse bioassay, to the disease severity that develops in the field; and 3) to determine the relationship between root rot potential, as determined by our greenhouse bioassay, to ultimate yields. A preliminary report of our findings has been published (2).

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MATERIALS AND METHODS

Locations of fields intended for snap bean production were provided by processing company fieldmen. Fields ranging from 8 to 40 ha were selected by obtaining locations of 20 fields from each company and, from these, randomly selecting fields for study (Fig. 1). Soil samples were collected from each field in late April or early May, before planting, and again in October after harvest. The sampling started approximately 15 m from the edge of the field and continued along three sides of an open square pattern with 10 subsamples per side. The individual subsamples were taken, 30–40 m apart to a depth of 10 cm, with a trowel. Atypical depressions or knolls that did not conform to the major landscape or soil type of the field were not sampled. Total soil volume collected from each field was about 7.6 L.

Soil samples from each field were bulked in plastic bags, air-dried at room temperature (24 C ± 3), and thoroughly mixed and screened through 12.5-mm mesh to remove debris before being placed in three 15-cm clay pots. After randomizing on the greenhouse bench, pots were planted with six seeds of cultivar Early Gallatin beans that had been treated with captan/chlorpyrifos, formulated as Lorsban 50SL (Dow Chemical Co., Midland, MI 48640). Seeds were equidistant from each other in the pot and planted at a depth of 3 cm. Greenhouse temperature was maintained at 24 C ± 3 with a relative humidity range of 40–80% and supplemental fluorescent lighting on a 12-hr photoperiod. Light readings ranged from 105 to 140 $nEs^{-1}cm^{-2}$ at 400–700 nm, as measured with a Lambda Model LI-185 meter (Lambda Instrument Corp., Lincoln, NE 68504), 20 cm from the light bank. Soil temperature ranged from 17 to 25 C, as measured by thermocouples placed 5 cm into the soil and recorded on a CR 21 micrologger (Campbell Scientific Inc., Logan, UT 84321).

Pots were watered every other day with 150 ml^3 of water for 13 days, after which they were saturated daily to maintain high soil moisture for 10 days until 25–30 days after planting. Soil watering was stopped 2–3 days before disease rating. Controls were a highly infested soil and an uninfested soil that had never grown beans.

Plants were harvested 32 to 36 days after planting. Hypocotyl and root disease severity were determined using a 0 (healthy) to 4 (dead or dying) scale. These readings were then converted to a greenhouse disease index (GHDI) from 0 to 100% by using the following equation:

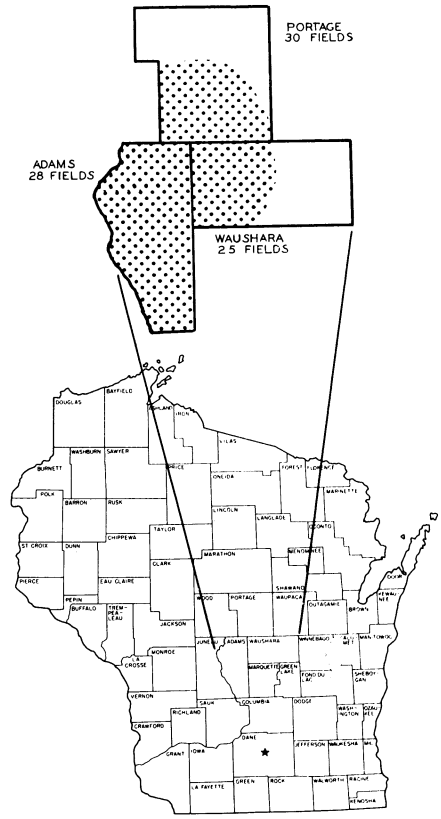

Fig. 1. Major bean-growing counties of Wisconsin's irrigated Central Sands.

Table 1. Coefficient of correlation of greenhouse and field disease indices for root rot severity

Company	1979	1980	1981
A	0.882 (4)[a]	0.668*[b] (10)	0.636* (14)
B	0.872** (9)	0.333 (10)	0.706** (14)
C	0.691* (12)	0.740* (10)	...

[a] Number of fields studied in parentheses.
[b] * Indicates $P = 0.05$ and ** indicates $P = 0.01$.

Table 2. Coefficient of correlation of bean yield and greenhouse and field root rot disease indices

	1979		1980		1981	
Company	Field	Greenhouse	Field	Greenhouse	Field	Greenhouse
A	−0.99	−0.85	−0.59	−0.57	−0.03	−0.48
B	−0.73	−0.74	−0.26	−0.34	−0.19	−0.29
C	−0.59	−0.56	−0.25	0.08	...	...

Table 3. Comparison of greenhouse disease indices from spring and fall soil sampling

Company A (1980)		Company A (1981)		Company B (1981)		Company C (1981)	
Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
64.9	62.7	54.9	57.4	54.9	60.0	70.6	62.7
64.2	54.3	54.3	55.6	53.7	63.4	66.4	62.0
60.0	60.0	48.4	58.7	53.7	62.7	63.4	62.7
43.9	62.0	44.4	62.0	52.5	65.6	62.7	80.0
53.1	65.6	41.0	58.1	51.4	60.0	62.7	56.8
50.2	53.7	40.4	62.0	51.4	55.6	59.3	62.7
46.7	53.7	35.1	30.0	48.4	56.8	59.3	50.8
43.9	62.0	30.7	51.4	38.6	60.0	58.1	43.3
30.0	62.7	27.3	56.2	34.4	58.7	51.4	62.0
27.3	51.4			42.3	60.7	49.0	54.9
Coef. corr. 0.61[a]		Coef. corr. 0.31		Coef. corr. 0.71[a]		Coef. corr. 0.39	

[a] Significant at $P = 0.01$.

$$\text{Disease index} = \left\{ \frac{\left(\text{Disease class} \times \text{Number of plants in that class}\right)}{\text{Total number of plants} \times 4} \right\} \times 100$$

The root rot severity of snap beans at 20 different sites, in the same fields from which the soil samples had come, was determined 30–40 days after planting. Plants were sampled along a diagonal transect across the field, five plants per site, and 100 plants per field. Several sites in this transect intersected the open square pattern used previously for collecting soil samples. The disease severity ratings and field disease indices (FDI) were determined in a manner similar to those used in the greenhouse. Means of disease indices in the field and greenhouse were arc sine transformed because of the binomial distribution and unequal variances of percentage data before correlation analysis, which used the Minitab method (3,6). Yield data from pods were provided by three processing companies, A, B, and C.

RESULTS AND DISCUSSION

A high, positive correlation was found between root rot severity in the greenhouse and root rot severity in the field as expressed by disease indices (Table 1). An exception was the low correlation for company B in 1980. This may have been because the results of the greenhouse bioassay were communicated to the fieldman before planting. As a result, early irrigation was reduced, which commonly decreases field disease severity, and extra nitrogen was sidedressed to increase adventitious root development in order to help the plants withstand the effects of root rot.

As the bean root disease index increased in the field or greenhouse bioassay, yield tended to decrease (Table 2), despite the fact that each processing company planted different bean cultivars and may have recommended different agronomic practices to their growers. Some growers and fieldmen dismiss bean root rot as a serious problem in the Central Sands area as long as they obtain adequate economic returns, and they only become alarmed when the entire field sustains severe yield loss or has to be abandoned. Because many factors like tillage, seeding rate, plant stand, planting date, weed competition, soil fertility, cultivar, environment, and diseases other than root rot influence yield, these data demonstrate 1) the ability of this test to estimate root rot potential; and 2) the inconsistent but real effect of root rot in reducing yield.

Disease indices were always lower in the field than in the greenhouse. This is to be expected because the test in the greenhouse was designed to provide the environmental conditions optimum for severe bean root rot development, whereas greater environmental fluctuations occur in the field.

Correlation was not consistently high between spring and fall soil sampling, as measured in the greenhouse bioassay but, in most cases, disease severity was greater in the fall than in the spring (Table 3).

The results of this study indicate that a significant positive correlation exists between greenhouse and field disease indices so one can predict the potential for bean root rot development in the field with reasonable accuracy ($P = 0.05$). This test is only a measure of the potential for bean root rot to develop if environmental conditions are favorable to the disease during the growing season. The greenhouse bioassay can serve as a guide for growers to estimate or judge the risk factor of growing beans in a particular field. It would help the grower avoid fields with a high risk factor for bean root rot if he chose, or to risk planting and hope environmental conditions favorable for severe bean root rot development would not occur.

We believe this test should become a part of an integrated program for bean root rot control. Fields where soils give an index above 65 in the greenhouse bioassay (untransformed data) should be avoided for snap bean production, but those with indices between 50 and 65 should only be used if absolutely necessary or, if used, should be planted with a tolerant root rot cultivar. Fields with an index below 50 in the greenhouse may be safely planted with cultivars currently susceptible to root rot without concern for severe disease development or great economic loss. This form of disease escape or disease avoidance should be helpful to Central Sands bean growers as an inexpensive, practical, and reliable technique for reducing losses from root rot.

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LITERATURE CITED

1. Hoch, H. C., Hagedorn, D. J., Pinnow, D. L., and Mitchell, J. E. 1975. Role of *Pythium* spp. as incitants of bean root rot and hypocotyl rot in Wisconsin. Plant Dis. Rep. 59:443-447.
2. Kobriger, K. M., and Hagedorn, D. J. 1981. Determining bean root rot potential of fields in Wisconsin's central sands. (Abstr.) Phytopathology 71:887.
3. Little, T. M., and Hills, F. J. 1978. Agricultural Experimentation. John Wiley & Sons, New York.
4. Pfender, W. F., and Hagedorn, D. J. 1982. *Aphanomyces euteiches* f. sp. *phaseoli*, a causal agent of bean root and hypocotyl rot. Phytopathology 72:306-310.
5. Reiling, T. P., King, T. H., and Fields, R. W. 1960. Soil indexing for pea root rot and the effect of root rot on yield. Phytopathology 50:287-290.
6. Ryan, T. A., Joiner, B. L., and Ryan, B. F. 1976. Minitab. Wadsworth Publishing Co., Belmont, CA.
7. Sherwood, R. T., and Hagedorn, D. J. 1958. Determining root rot potential of pea fields. Wisc. Agric. Exp. Stn. Bull. 531. 21 pp.
8. Wilhelm, S. 1957. Determining the inoculum potential of Verticillium in soil and predicting subsequent wilt losses in strawberry. Phytopathology 47:37.