Yield loss conversion factors for fusarium root rot of pea[1]

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A method for relating the severity of root rot caused by ***Fusarium solani*** f. sp. ***pisi*** to yield losses in green pea (***Pisum sativurn)*** was developed from experimental plots at Ottawa and from commercial crops in five provinces. On the basis of 3 years results with several pea cultivars, severely affected plants showed an average yield loss of 57%. Moderately affected plants showed an average yield reduction of 35% in experimental plots, but a similar severity-loss relationship for the moderate severity level was not confirmed in commercial fields. It is suggested that a conservative estimate of yield loss in growers' fields may be obtained by multiplying the percentage of severely affected plants by a factor of 0.57.

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On a mis au point une methode permettant d'etablir un rapport entre la gravite du pourridié fusarien cause par ***Fusarium solani*** f. sp. ***pisi*** et les baisses de rendement des petits pois (***Pisum sativurn)*** a partir de parcelles experimentales a Ottawa et de cultures commerciales dans cinq provinces differentes. D'après les résultats de trois ans obtenus de plusieurs cultivars de pois, les plants gravement atteints ont montre une baisse de rendement moyenne de 57%. Les plants moyennement touches ont montré une baisse moyenne de 35% dans les parcelles experimentales, mais il a ete impossible de confirmer un rapport gravite de la maladie-baisse de rendement semblable pour une infestation modéree dans les cultures commerciales. Toute porte a croire qu'il est possible d'obtenir une estimation prudente des baisses de rendement des plantations commerciales en multipliant le pourcentage de plants gravement atteints par un facteur de 0.57.

In Canada ***Fusarium solani*** f. sp. ***pisi*** is considered to be the primary causal agent of root rot of green pea (***Pisum sativurn*** L.), although ***F. oxysporum*** f. sp. ***solani*** and species of ***Ascochyta, Rhizoctonia,*** and possibly ***Aphanomyces*** also may be involved (1,3,4,5,10,11). Attempts to establish a relationship between levels of ***Fusarium*** propagules in soil and disease development have been inconclusive (2,8,9). Johnson (8) developed a useful method for estimating the hazard of planting peas in infested soil but it could not be used for predicting yield losses. In some fields, root rot has caused partial (9) to complete loss of pea crops (1,4,11), but it has also been shown experimentally that pea plants can recover from the disease when root development continues beyond the zone of infested soil (3). In our previous survey (1), no consistent relationship was found between the percentage of plants affected by root rot and the bulk yield of shelled peas from growers' fields.

The aim of the present work was to find if a consistent relationship between the severity of root rot and yield loss could be established by comparing the yield of healthy plants with that of diseased plants in field plot experiments and in commercial fields.

Materials and methods

Disease severity rating and yield

Preliminary attempts to measure the severity of pea root rot in greenhouse-grown plants showed that a quantitative estimation of the percentage of the root system damaged was not feasible. In this study severity was judged primarily on the length of the brown to black discoloration of the lower stem and primary root region (epicotyl and hypocotyl). Field grown plants were dug carefully at a stage of development suitable for processing, and the following root rot categories were adopted to classify them according to the overall disease symptoms:

Root rot categories

0 No discoloration of roots, plants apparently healthy but may have few (4 to 6) lower leaves chlorotic or dry due to natural senescence

1 A trace to 2 cm brown to black discoloration of the lower stem and tap root region, lateral roots not discolored, plants apparently healthy

2 Up to 4 cm brown to black discoloration of the lower stem and tap root region, lateral roots not discolored, plants apparently healthy

3 Up to 5 cm brown to black discoloration of the lower stem and tap root region, lateral roots turning brown; plants showing slight yellowing of leaves apart from normal senescence

4 Six cm or more brown to black discoloration of the lower stem and tap root region, most lateral roots decayed, most leaves yellowed; plants often stunted, wilted, moribund, or killed

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Table 1. Yield[a] of Jade pea plants grown in root rot infested field plots, 1972; plants grouped in five severity categories

	Root rot severity category[b]				
Plot no.	0	1	2	3	4
1	4.16	3.21	2.42	1.14	1.56
2	6.30	4.05	5.00	2.82	2.46
3	4.96	3.99	2.77	3.06	1.76
Mean yield[c]	4.85	3.67	3.05	2.48	1.84
Yield loss (%)[d]		24.00	37.00	49.00	62.00
Plants/category (%)[e]	50.10	24.10	3.10	3.40	19.30

[a] Avg yield of shelled green peas (g/plant), oven-dry basis.

[b] 0 = healthy, 4 = severe root rot.

[c] Means underscored by the same line are not significantly different by the Duncan's multiple range test at P = 0.05.

[d] Based on the mean yield of plants in healthy (0) category.

[e] Based on 1,677 plants sampled from the 3 plots.

Yield of shelled peas from plants of each root rot category was expressed as the average oven-dry weight of seeds per plant unless otherwise stated. The yield loss in the diseased categories was based on the yield of healthy plants.

Field plot experiments

At Ottawa the relationship between root rot severity and yield loss was studied during 1972-74 in a 0.28 ha field that had been artificially infested in 1971 with propagules of *Fusarium* solani (Mart.) Sacc. f. sp. ***pisi*** (Jones) Snyder and Hansen. The viability of the pathogen was checked annually in spring and fall by a dilution plate method (12). The field was subdivided into plots and pea seed obtained from commercial processors or seed companies was sown at the usual spacing, 5 cm **x** 18 cm, with a grain drill in early June each year. Plants were harvested when most of the green pods were filled, 60 to 70 days after planting. Earlier studies (P.K. Basu, unpublished) indicated that it was not possible to maintain Fusarium-free plots within the test area to serve as controls because of cross contamination. Hence, plants without root rot symptoms were used as controls.

In 1972 the cultivar Jade was grown in 3 large plots, each 12.8 m x 66.1 m. In each plot 50 consecutive plants of a row were sampled at each of 10 equally spaced sites located along a W pathway, discarding a 2-m-wide border; the plants were rated for root rot using the five categories described. In 1973 the cultivars Jade and Thomas Laxton were grown in a randomized block design with six replicated plots. A total of 300 plants (10 per site) were sampled from each plot at 30 predetermined sites; 10 of the sites were selected along a W, 10 on a diagonal, and 10 at random. These plants were placed in three instead of five root rot categories by combining categories 1 to 3. In 1974, 10 pea cultivars, Anoka, Charger, Dark Skin Perfection, Jade, Mars, Nugget, Trojan, Venus, Asgrow XPF 3007, and Asgrow 4683 were grown with four replications of each in a randomized block design. A stand count was made after emergence. At harvest, the number and yield of all plants showing symptoms of root rot category 4 in each plot were recorded. The percentage and yield of plants belonging to categories 0 (healthy) and 1-3 (moderately affected) were estimated from 2-3 groups of 100 plants taken from one-half of each plot, divided diagonally; plants from the other half **of** each plot provided the bulk fresh weight yield of shelled peas.

Sampling in growers' fields

Based on previous records (1), root rot affected fields were chosen for sampling in 1972, 1973, and 1974 in the main pea growing areas of British Columbia, Ontario, Quebec, Nova Scotia, and Prince Edward Island. Samples were taken when the crop was ready fo machine-harvesting for freezing or canning. In 1972 a systematic sampling procedure was adopted; 100 successive plants in a row were removed from each of 10 sites located equidistantly along the arms of a **W** pattern (1) in each field. Plants were placed in the appropriate root rot categories, and the average seed yield (oven-dry basis) per plant was recorded for each category. In 1973 and 1974, yield comparisons were based on a paired sample of 100 severely affected (root rot 4) and 100 "healthy" (root rot 0-3) plants from each field. Usually the severely affected plants were found in distinct patches containing yellow to brown plants; the apparently healthy plants were taken from nearby green areas.

Results

Field plot experiments

In the 1972 experiment with the cultivar Jade, plants of root rot categories 1, 2, 3, and 4 yielded 24%, 37%, 49%, and 62% less, respectively, than the plants classed as healthy (Table 1). These results suggested that there was a direct correlation between yield loss and root rot severity. However, the mean yields of adjacent disease categories were not significantly different. In these samples the numbers of plants in each category were not equivalent, and hence the values of categories 2 and 3 may have received undue weight because they contained relatively few plants. These results further indicated that mildly to moderately affected plants may be grouped into one category (root rot 1-3), thus eliminating many borderline plants and saving considerable time in judging severity.

In the 1973 experiment with the cultivars Jade and Thomas Laxton (Table 2), significant yield differences occurred among the three (0, 1-3, and 4) root rot categories. Plants in the latter two categories showed losses of 26% and 58% in Jade and 45% and 69% in Thomas Laxton. The loss values of the most severely affected plants in both 1972 and 1973 were similar, e.g. 62% and 58% in Jade and 69% in Thomas Laxton

Table 2. Yield[a] of Jade and Thomas Laxton pea plants grown in root rot infested field plots, 1973; plants grouped in three severity categories[b]

	Jade			Thomas Laxton		
	Root rot severity category			Root rot severity category		
Plot no.	0	1-3	4	0	1-3	4
1	2.82	2.78	1.67	2.75	1.92	1.68
2	3.97	3.15	1.84	4.94	2.84	1.74
3	4.40	3.04	1.57	5.67	3.13	1.76
4	5.16	3.80	2.06	2.92	2.17	1.01
5	4.63	3.33	1.77	2.78	3.20	1.55
6	5.16	3.30	2.03	9.20	2.16	0.94
Mean yield[c]	4.36	3.23**	1.82**	4.71	2.57*	1.45*
Yield loss (%)[d]		26.00	58.00		45.00	69.00
Plants/category (%)[e]	9.70	65.10	25.20	6.60	56.50	36.90

[a] Avg yield of shelled green peas (g/plant), oven-dry basis.

[b] 0 = healthy, 4 = severe root rot.

[c] Mean yields indicated by * and ** are significantly different at $P = 0.05$ and 0.01, respectively.

[d] Based on the mean yield of plants in the healthy (0) category.

[e] Based on 1,800 plants of each cultivar from the 6 plots.

(1973 only). Whether or not a common loss factor could be applied to all cultivars was considered further the following year.

In the 1974 field plot experiment, losses were estimated for 10 pea cultivars on the basis of yield per plant and percentage of plants in the three root rot categories (Table 3). In all cultivars the yield of healthy plants was significantly higher than that of severely affected ones; the yield of moderately affected plants (root rot 1-3) was significantly different from that of healthy plants in 6 of 10 cultivars and from that of severely affected plants in 3 of 10 cultivars (Table 3). The yield loss per plant within the moderately infected group ranged from 6.6% to 48.8% with an average of 27.4% ± 2.6%. Per plant yield loss of severely infected plants ranged from 25% to 66.6% with an average of 44.9% ± 1.8%. The standard error values, 2.6 for the moderate and 1.8 for the severe categories, were less than 10% of the respective grand means (Table 3, cols. 4 and 5). The low SE values afforded some justification for averaging the loss values of different cultivars to obtain a common loss factor for the two levels of disease severity. In this experiment, the majority of the plants belonged to the moderately diseased category (62.1%) followed by those in the healthy (32.7%) and those in the severely diseased (5.2%) categories. The percent yield loss per plant of a category, expressed as a fraction, multiplied by the percentage of plants in that category resulted in a loss value for the category; the sum of losses from the disease categories represented the total loss for each cultivar. On average, the yield loss for all cultivars was estimated at 19.9% (Table 3). However, despite an overall loss of about 20%, the average bulk fresh weight of shelled peas from the plots was 5042 kg/ha (over 2 tons/acre), which was comparable to the average pea

Table 3. Estimated yield losses in 10 pea cultivars grown in root rot infested field plots, 1974, plants grouped in three severity categories; 0, 1-3 and 4

Cultivar	Avg yield (g) per plant[a]			Yield loss (%) per plant[b]		% of total plants in each category			Yield loss (%) per category		Total loss (%) per cultivar
	0	1-3	4	1-3	4	0	1-3	4	1-3	4	
Anoka	8.4	4.3	4.1	48.8 p	51.2 pqr	19.1	70.4	10.5	34.3	5.4	39.7
Charger	2.4	1.9	1.8	20.8 qrs	25.0 rst	37.4	59.2	3.4	12.3	0.9	13.2
Dark Skin Perfection	2.0	1.6	1.4	20.0 qrs	30.0 st	41.2	56.0	2.8	11.2	0.8	12.0
Jade	4.6	2.8	2.6	39.1 pqr	43.5 qrs	35.7	60.2	4.1	23.5	1.8	25.3
Mars	3.0	2.5	1.0	16.6 rs	66.6 p	21.5	70.5	8.0	11.7	5.3	17.0
Nugget	1.3	1.2	0.9	7.7 s	30.8 rst	42.0	53.5	4.5	4.1	1.4	5.5
Trojan	5.9	3.8	2.0	35.6 pqrs	66.1 p	30.5	65.5	4.0	23.3	2.6	25.9
Venus	5.0	3.3	2.4	34.0 pqrs	52.0 pqr	33.0	62.5	4.5	21.2	2.3	23.5
XPF 3007 (Asgrow)	4.2	2.3	1.8	45.2 pq	57.1 pq	29.3	63.5	7.2	28.7	4.1	32.8
#4683 (Asgrow)	1.5	1.4	1.1	6.6 s	26.6 st	37.7	59.3	3.0	3.9	0.8	4.7
Grand mean	3.8	2.5	1.9	27.4 ± 2.6[d]	44.9 ± 1.8[d]	32.7	62.1	5.2	17.4	2.5	19.9

[a] Based on oven-dry weight of seed from a total of 400 plants in each severity category, figures underscored by the same line are not significantly different by the Duncan's multiple range test at P = 0.05.

[b] Values followed by the same letters in each column are not significantly different by the Duncan's multiple range test at P = 0.05.

[c] Rased on 2-3, 100-plant samples in each of 4 replications.

[d] Standard error of the grand mean.

Table 4. Yield[a] of pea plants qrown in 10 commercial fields affected by root rot, 1972; plants qrouped in five severity categories

Field no.[b] and Cultivar	Root rot severity category[c]				
	0	1	2	3	4
1 Early Sweet	0.44	0.66	0.50	0.46	0.19
2 Early Sweet	2.62	3.68	3.31	2.61	1.33
3 Lark	0.06	0.17	0.14	0.18	0.07
4 Lark	0.12	0.28	0.21	0.37	0.26
5 Lark	0.51	0.90	0.87	0.76	0.39
6 Lark	0.67	0.57	0.60	0.48	0.34
7 Delmar	0.05	0.50	0.77	0.84	0.28
8 Delmar	0.68	0.84	1.00	0.58	0.15
9 Mars	1.35	1.25	1.37	1.14	0.52
10 Pride	1.57	1.28	1.22	1.33	0.93
Mean yield	0.81	1.01	1.00	0.88	0.45
Yield loss (%)[d]					51.00
Plants/category (%)[e]	5.40	11.30	25.90	22.10	35.30

[a] Yield of shelled green peas (g/plant), oven-dry basis.

[b] Fields 1-8 and 9-10 were in Ontario and Nova Scotia, respectively

[c] 0 = healthy, 4 = severe root rot.

[d] Based on the combined average yield of root rot categories 0 to 3 (underscored), which were not significantly different by the Duncan's multiple range test at P = 0.05.

[e] Based on a total of 9,815 plants from 10 fields.

yield in growers' fields reported earlier (1). The actual fresh bulk yields (kg/ha (over 2 tons/acre), which was comparable to the average pea yield in growers' fields reported earlier (1). The actual fresh bulk yields (kg/ha) of the 10 pea cultivars at Ottawa were: Anoka, 3933; Charger, 6688; Dark Skin Perfection, 6550; Jade, 5139; Mars, 3679; Nugget, 5897; Trojan, 5944; Venus, 5388; Asgrow XPF 3007, 4343; and Asgrow 4683, 2802. These fresh weights were on average five times greater than the corresponding oven-dry seed weight (1 kg of freshly shelled peas yielded approximately 200 g dry matter). It is also noteworthy that the population of *Fusarium solani* in the field plots ranged from 400 to 1600 propagules per gram of soil. Similar levels of inoculum were observed in root rot affected fields elsewhere (2,8).

Samples from growers' fields

During these studies, samples were also taken from growers' fields to determine the per plant yield loss associated with different root rot categories.

In 1972 plants were placed in five root rot categories but there were no significant differences among the mean yields of categories 0 to 3, (Table 4). However, plants in the severely affected category (root rot 4) showed a significant yield loss of 51%. In these fields, healthy plants constituted only 5.4% of the total number of plants sampled; therefore the estimate of yield loss for plants in the severe category was based on the combined yield of categories 0 to 3. It was evident that securing sufficient numbers of healthy plants in some root rot affected fields posed a problem. Therefore in 1973 and 1974, yield data were obtained for equal numbers of plants in only two severity categories (root rot 0-3 and 4), constituting paired samples of apparently healthy and severely affected plants (Tables 5 and 6). These data illustrate the range of yield and corresponding yield losses for several pea cultivars grown in different regions of Canada. It should be noted that the yield of the same cultivar varied from field to field even

Table 5. Yield loss from severe root rot (category 4) based on yield of apparently healthy plants (categories 0–3) in 31 commercial pea fields, 1973

Field no.[b] and cultivar or line	Avg seed yield[a] (g/plant, oven-dry)		
	Apparently healthy (categories 0–3)	Severe root rot (category 4)	Yield loss (%) in severe category
1 Venus	1.12	0.50	55.4
2 Venus	0.80	0.53	33.8
3 Venus	0.76	0.28	63.2
4 Venus	0.68	0.36	47.1
5 A-45 (Asgrow)	0.75	0.11	85.3
6 A-45 (Asgrow)	0.81	0.24	70.4
7 A-45 (Asgrow)	0.75	0.54	28.0
8 A-45 (Asgrow)	0.77	0.44	42.9
9 scout	0.79	0.73	7.6
10 scout	0.76	0.62	18.4
11 Dark Skin Perfection	0.81	0.60	25.9
12 Dark Skin Perfection	0.66	0.36	45.5
13 Dark Skin Perfection	0.85	0.46	45.9
14 Early Sweet	0.91	0.07	92.3
15 Early Sweet	0.57	0.19	66.7
16 Early Sweet	0.31	0.12	61.3
17 394 (Asgrow)	0.36	0.32	11.1
18 394 (Asgrow)	0.51	0.33	35.3
19 4683 (Asgrow)	0.48	0.18	62.5
20 4683 (Asgrow)	0.65	0.17	73.8
21 4683 (Asgrow)	0.60	0.30	50.0
22 4683 (Asgrow)	0.60	0.26	56.7
23 4683 (Asgrow)	0.93	0.81	12.9
24 Lilaska	0.54	0.20	63.0
25 Lilaska	0.55	0.15	72.7
26 Early Sweet	1.19	0.46	61.3
27 Early Sweet	0.94	0.36	61.7
28 Nugget	0.64	0.44	31.3
29 Nugget	0.58	0.23	60.3
30 Pride	0.88	0.14	84.1
31 Pride	1.25	0.35	72.0
Mean yield and standard error	0.74 ± 0.04	0.35 ± 0.03	
Mean yield loss (%) calculated from mean yield difference[c]			52.7

[a] Based on avg yield of 100 plants in each of the two categories (0-3 and 4).

[b] Fields 1–13, 14–23, 24–27 and 28–31 were in British Columbia, Ontario, Quebec and Nova Scotia, respectively,

[c] Mean yield difference was significant by paired *t* test at P = 0.01.

Table 6. Yield loss from severe root rot (category 4) based on yield of apparently healthy plants (categories 0–3) in 36 commercial pea fields, 1974

Field no.[b] and cultivar or line		Avg seed yield[a] (g/plant, oven-dry) Apparently healthy (categories 0-3)	Severe root rot (category 4)	Yield loss (%) in severe category
1	Dark Skin Perfection	0.71	0.53	25.4
2	Dark Skin Perfection	0.83	0.11	86.7
3	Dark Skin Perfection	0.61	0.27	55.7
4	scout	1.35	0.28	79.3
5	scout	1.05	0.21	80.0
6	scout	1.46	0.10	93.2
7	scout	1.55	0.38	75.5
8	scout	3.30	0.28	91.5
9	scout	1.46	0.31	78.8
10	scout	2.53	0.62	75.5
11	scout	1.62	0.34	79.0
12	4683 (Asgrow)	1.47	0.42	71.4
13	4683 (Asgrow)	0.72	0.13	81.9
14	4683 (Asgrow)	1.01	0.53	47.5
15	4683 (Asgrow)	0.86	0.22	74.4
16	Trumpet	1.04	0.62	40.4
17	Trumpet	0.42	0.18	57.1
18	A-45 (Asgrow)	0.72	0.31	56.9
19	A-45 (Asgrow)	1.14	0.48	57.9
20	Early Sweet	1.38	0.60	56.5
21	Early Sweet	1.07	0.43	59.8
22	Early Sweet	0.93	0.32	65.6
23	Dash	0.54	0.33	38.9
24	Lark	0.96	0.21	78.1
25	Medalis	1.02	0.44	56.9
26	Medalis	1.00	0.30	70.0
27	Early wilt resistant Perfection	1.79	0.93	48.0
28	Early wilt resistant Perfection	0.51	0.31	39.2
29	Sparkle	2.04	1.17	42.6
30	Sparkle	1.36	1.04	23.5
31	Sparkle	2.68	0.68	74.6
32	Sparkle	1.69	1.39	17.8
33	Anoka	4.89	4.29	12.3
34	Anoka	2.52	0.78	69.0
35	Anoka	3.19	0.58	81.8
36	Anoka	1.25	0.51	59.2
Mean yield and standard error		1.46 ± 0.15	0.57 ± 0.11	
Mean yield loss (%) calculated from mean yield difference[c]				60.9

[a] Based on avg yield of 100 plants in each of the two categories (0-3 and 4).

[b] Fields 1-11, 12-24, 25-26, 27-28, and 29-36 were in British Columbia, Ontario, Quebec, Nova Scotia, and Prince Edward Island, respectively.

[c] Mean yield difference was significant by paired *t* test at P = 0.01.

in the same geographic region, indicating the influence of local climatic and edaphic conditions. Also, the critical timing of assessment in relation to maturity of the crop presented some practical problems in conducting such a wide ranging survey and this may have contributed to some of the variation observed. However, yield variation expressed as standard error was less than 20% of the mean yield for each category of plants in both years, and thus the derivation of a mean yield loss value for different cultivars seems reasonable, provided we allow for about 20% error due to natural variability.

Loss factors

An average loss value of 55% was obtained for severely affected plants in the 3-year field plot experiments with the cultivar Jade. In 11 pea cultivars tested similarly in field plots the average loss for that severity category was 58.4%. Similar results were obtained in commercial fields, where the average per plant yield loss for the severely affected category was 51%, 52%, and 60.9% in 1972, 1973, and 1974, respectively. Based on the results of the experimental and field observations, a loss factor of 0.57 seems appropriate for estimating the effect of severe root rot on pea yield.

Plants classed as moderately affected by root rot (categories 1-3) showed an overall average yield loss of 34.7% as compared to the yield of healthy plants (category 0) in experimental field plots. However, in commercial fields a comparable estimate of loss for moderate levels of root rot was not obtained. In those fields very few healthy (category 0) plants appeared in the samples and they were combined with those of categories 1 to 3 in evaluating the loss due to severe disease.

On the basis of these results we propose, as a working model, the use of a loss factor of 0.57 for estimating yield loss from this disease; i.e. % yield loss % severely affected plants × 0.57. Until further information is available on the effects of moderate levels of root rot on pea yield in growers' fields, this formula should provide a useful, conservative estimate of yield loss in cultivars of green pea presently grown in Canada.

Discussion

Difficulties involved in studying yield losses from root diseases have been recognized (7) and there are few examples (6) of well defined methods for measuring disease severity, for producing controlled epidemics, and for relating severity ratings to yield loss. We have chosen what is in effect a critical point system (7) in which disease assessment is made only once, as close to harvest as possible. In this study the effects of early or late infections and of climatic or edaphic factors on pea yield were not specifically considered, and there are obvious dangers in drawing conclusions from samples collected from a wide geographical area involving different pea cultivars. For the purpose of this study it was assumed that green pea producing areas share similar cultural methods and that the pea cultivars commonly grown do not differ appreciably in symptom expression and in yield response to this disease.

In this work we have attempted to relate various levels of root rot severity to pea yield to provide a working model for estimating loss in commercial crops. Percent yield loss for the severe disease level was reasonably consistent over a 3-year period in both growers' fields and experimental plots. Although moderate levels of root rot showed a substantial yield loss (35%) in experimental plots, similar detectable loss could not be confirmed in the commercial crops sampled. Consequently a conservative estimate of yield loss due to root rot over a large area can be obtained by multiplying the percentage of severely affected plants by a factor of 0.57.

The percentage of severely affected plants can be estimated by suitable sampling procedures (1) or by other methods. Since severely affected plants often appear in visually discernible patches in a field, aerial photography may be useful in determining the area of crop severely affected by the disease.

These results clearly indicate that severe levels of fusarium root rot result in a large measurable loss in yield of green peas. Reducing the incidence of severely affected plants in infected fields by the development of resistant cultivars or by chemical or cultural means, should have a significant effect in increasing yield.

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