Soil compaction effect in clay soils on common root rot in canning peas3

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Root rot problems in canning peas (*Pisum sativum*) were observed during the growing season of 1979 on 12 farms located near the St-Jean and Rougemont regions of southwestern Quebec. Root rot is caused mainly by *Fusarium solani* f. sp. pisi, a fungus that tends to increase root damage under soil compaction.

A soil dry bulk density increase of *26* percent was observed for farms using higher powered tractors with tire contact pressures ranging from 38 kPa to over 50 kPa.

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Durant l'été 1979, les dommages causes, sur le pois de conserverie (*Pisum sativum*) par le pourridie fusarien. furent evalues sur *12* fermes situees au sud-ouest du Quebec dans la region de St-Jean et de Rougemont. La cause de cette maladie est d'origine fongique, soit principalement le *Fusarium* solani f. sp. *pisi.* Une augmentation de la densite apparente du sol favorise cette maladie.

Un accroissement de la densite apparente du sol de 26% fut observe sur des fermes utilisant des trarteurs à haute puissance dont la repartition de charge par pneu variait de 38 kPa a plus de 50 kPa.

Introduction

The common root rot of peas (*Pisum sativum* L.), is a complex disease, primarily incited by the fungus, *Fusarium solani* (Mart.) Sacc. f. sp. *pisi* (F.R. Jones) Synd. & Hans. (1). Results of experimental and field observations show that severe root rot can cause a 57% loss in pea yield (2). Natural root obstruction in compacted and stoney soils is an important factor in the root rot problem, according to Burke *et al.* (3). Later Burke *et al.* (4) gave field results showing non-existence of root rot in plots where pea roots could easily penetrate the soil; whereas, compacted or hard soils increased pea root rot by delaying root extension out of the pathogen infested plowed layer into the sparsely infested subsoil.

Soil types with high water retaining capacities, such as clay soils, were shown by Temp and Hagedorn (9) to have a slower decrease in root rot potential over years of cropping; and heavy clay soils are more favourable to the development of root rot than lighter soils as shown by Jones *et al.* (5). This study was undertaken to assess the effects of soil compaction on the severity of root rot in peas in southwestern Quebec.

Materials and methods

During the growing season of 1979, twelve fields were selected in two regions of southwestern Quebec, namely St-Jean and Rougement, on clayey soil types of Ste. Rosalie soil series with improved drainage (Table 1). Pea varieties were selected according to heat units: 843°C and over were referred to late season varieties. All fields had a minimum of five years rotation with grain crops to reduce residual effect of pea root rot.

Table 1. Pea variety, soil texture, soil series[b] and soil dry bulk density for investigated fields.

Farm[a] No. Pea variety	Surface soil texture (0 to 20 cm)	Mean Soil Dry Bulk Density (15 to 20 cm Zone) (kg/m^3)	C.V. (%)[c]
1. Trojan	Clay†	1203	10.2
2. Medalist	Silty clay loam†	1418	5.2
3. Trojan	Silty clay†	1494	4.9
4. Medalist	Silty clay loam†	1427	4.4
5. Medalist	Silty clay loam†	1527	2.9
6. Trojan	Clay loam†	1289	6.7
7. Champ	Silty clay §	1136	8.6
8. Champ	Clay†	1287	9.6
9. Champ	Silty clay loam†	1203	9.6
10. Champ	Clay §	1266	17.6
11. Perfection 5c	Clay†	1420	5.3
12. Champ	Clay §	1546	5.1

[a]Fields 1-6 and 7-12 were located in Rougemont and St-Jean areas, respectively.
[b]All Ste Rosalie except no. 7, Richelieu.
Ref. Quebec Agriculture Department 1942. Soil Map, scale 1:5280.
[c]C.V. = coefficient of variation.
†Subsurface drainage
§Surface drainage only.

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Severity of pea root rot in field grown plants was judged in four categories ranging from zero to three using a method reported by Basu *et al.* (1) and a disease index was computed from this data to assess damage severity, using the following equation:

$$RRDI = \frac{[\Sigma \text{ (no. plants per category)} \times \text{(no. of category)}] \times 100}{\text{(number of categories - 1)} \times \text{(total no. of plants)}} \qquad (1)$$

where, RRDI = root rot disease index. Soil preparation varied slightly from one field to another with a fall plowing followed by two discings and one harrowing in the spring, and rolling after seeding. The differences in tractor sizes used for soil preparation resulted in different levels of soil compaction. Tractor weight, power and rear tire size were recorded to assess soil compaction: each region had three farms having 45kW (60 hp), 63 kW (85 hp) and 75 kW (100 hp) tractors, whereas the remaining three farms had 134 kW (180 hp) tractors, as shown in Table 2.

Table 2. Tractors' model weight[t] and contact pressures related to engine power and tire size.

Field No.	Engine Power (kW)	Weight per Rear-tire (kg)	Tire Width X Diameter (cm)	Contact Pressure (kPa)
1	45	1474	39.4 X 96.5	38.3
2	134	2310	46.7 X 96.5	50.1
3	134	2310	-	50.1
4	134	2310	-	50.1
5	63	2023		44.2
6	75	2051	-	45.1
7	45	1474	39.4 X 96.5	38.3
8	75	2051	46.7 X 96.5	45.1
9	63	2023	-	44.2
10	134	2310	-	50.1
11	134	2310	-	50.1
12	134	2310	-	50.1

[t] Based on Nebraska Tractor test.
Ref. Agricultural Engineers Year **Book,** 1975-79.

Data were collected from a sampling plot of 5 m X 5 m located near the centre of each field. Average soil dry bulk density from the surface to depths of 5, 10, 15 and 20 cm was determined using a single probe Troxler density gauge (7). Soil samples were collected for gravimetric soil moisture-content determination (7). There were 4 replications per plot. Data were transformed into soil dry density at four consecutive depths, 0 to 5, 5 to 10, 10 to 15 and 15 to 20 cm according to equations reported by Taylor *et al.* (8).

Root rot was evaluated at the plant flowering stage. In each plot 50 plants were sampled from five different places. Data on plant population and yield of shelled peas over a 1 m X 1 m subplot per field at harvest time were also collected.

Results and discussion

Pea cultivars, soil series, soil texture, surveyed farms identification and soil dry bulk density are listed in Table 1 for both Rougemont and St-Jean regions.

Table 3. Yield results.

Field No.	Fresh yield[a] per m^2 (g)	Fresh yield[b] per ha (kg)	Dry yield[c] per m^2 (g)	Plant population per m^2
1	-	-	-	-
2	305.3	4092	56.5	128
3	363.0	4549	60.6	120
4	449.4	3759	86.9	100
5	349.3	3403	78.3	92
6	191.3	-	38.3	60
7	100.1	-	18.7	100
8	259.5	3005	43.9	100
9	175.3	836	26.6	68
10	361.1	1469	72.6	108
11	101.9	1086	20.0	160
12	133.6	1469	26.1	108

[a] Fresh yield of shelled peas, based on 1 m^2 sample.
[b] Overall fresh yield of shelled peas given by processors.
[c] Dry yield of shelled peas, based on 1 m^2, over-dry basis.

In both regions there is an increase in soil dry bulk density of 26 percent in the depth range of 15 to 20 cm attributed to the use of higher contact pressures of the tractors (Tables 1 and 2). The relation between tractor contact pressures and soil dry bulk density is linear and significant at 0.05 level with a coefficient of determination (R^2) of 48% for the 12 farms.

A correlation between soil dry bulk density and root rot disease index (RRDI) was established. The results are shown in Figure 1 for the St-Jean and Rougemont areas. There is a linear relation between root rot disease index and soil dry bulk density. The equation of the line is given by:

$$RRDI = -70.86 + 0.07 (\gamma \text{ dry}) \qquad (2)$$

where, γ dry = Soil dry bulk density (kg/m^3) in the depth range of 15 to 20 cm whose coefficient of determination (R^2) is 37 percent (significant at 0.05 level) for the 11 farms. The farm no. 9 shown in Figure 1 does not fit the equation (2) shown above, because the field was waterlogged by heavy rainfalls after seeding and this resulted in a poor germination rate and a high level of root rot on remaining plants. The equation of the line strongly indicates that soil compaction could promote root rot severity. The effect of compaction on yield was investigated using an estimate of yield loss caused by root rot. The following equation developed by Basu *et al.* (2) was used:

Estimated yield loss percentage

= (Percentage of plants in root rot category no. 3) X (0.57) (3)

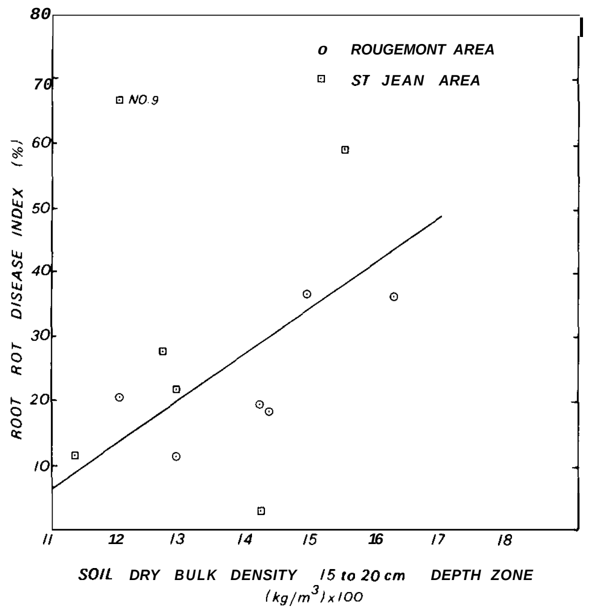

Figure 1 Root rot disease index plotted against soil dry bulk density for both Rougemont and St-Jean areas

Results gave a maximum yield loss of 4.5 percent and did not correlate with soil compaction. However, these estimated yield loss figures are not in accordance with the 78 percent difference observed in actual fresh yield per m^2. Yield information was also obtained by the processors on an hectare basis, for the 9 farms out of the 12 farms under study and this data correlated well with the yield samples collected ($R^2 = 0.523$ at 0.05 level) indicating that the sampling procedure is in fact a good representation of total field yield (Table 3) and yield variation. Low yield losses obtained with the equation (3) might be biased because of the early root rot severity evaluation which was done at the flowering stage, 10 or 12 days prior to harvest. It is possible that disease might have developed during this period and created more damage than what was estimated. However, soil compaction has been reported to reduce corn silage yields up to 50 percent in Ste. Rosalie clay soil, Raghavan *et al.* (6).

This phenomenon might occur with pea production which is often in rotation with corn on this same soil series. Further studies are required to assess yield loss predictions with soil compaction.

Conclusions

In this study the effects of soil compaction on pea root rot infection were specifically considered. Root rot disease index varied from 3 to 59 percent on both regions where disease index response was found to be dependent on soil dry bulk density. Soil dry bulk density increment was found to be dependent on tractor contact pressures in both regions investigated. Therefore, an increase in dry bulk density resulting from soil compaction can promote root rot damage. Further research in this field is necessary to establish the full impact of soil compaction on canning peas yield loss.

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Literature cited

1. Basu, P. K.; R. Crête; A. G. Donaldson; C. O. Gourley; J. H. Haas; F. R. Harper; C. H. Lawrence: W. L. Seaman; H. N. W. Toms; S. I. Wong and R. C. Zimmer. 1973. Prevalence and severity of diseases of processing peas in Canada, 1970, 71. Can. Plant Dis. Surv. 53:49-57.
2. Basu, P. K.: N. J. Brown; R. Crête; C. O. Gourley; H. W. Johnston; H. S. Pepin and W. L. Seaman. 1976. Yield loss conversion factors for fusarium root rot of pea. Can. Plant Dis. Surv. 56:25-32.
3. Burke, D. W.; D. J. Hagedorn and J. E. Mitchell. 1969. Aphanomyces and fusarium root rot of peas with partial vs total exposure of roots to infested soil Phytopathology 59:1261-1266.
4. Burke, D. W.; D. J. Hagedorn and J. E. Mitchell. 1970. Soil conditions and distributions of pathogens in relation to pea root rot in Wisconsin soils. Phytopathology 60:403-406.
5. Jones, F. R. and M. B. Linford. 1925. Pea disease survey in Wisconsin. Wis. Agr. Expt. Sta. Res. Bul. 64:31 pp.
6. Raghavan, G. S. V.; E. McKyes; G. Gendron: B. K. Borglum and H. H. Le. 1978. Effects of tire contact pressure on corn yield. Can. Agr. Eng. 20:34-37.
7. Raghavan, G. S. V.; E. McKyes; I. Amir; M. Chasse; R. S. Broughton. 1976. Prediction of soil compaction due to off-road vehicle traffic. Trans. Amer. Soc. Agr. Eng. 19(4):610-613.
8. Taylor, F.; E. Douglas; S. Negi; G. S. V. Raghavan and E. McKyes. 1980. The effects of minimum tillage on corn growth in Eastern Canadian Agricultural soils. Final report. Engineering and Statistical Research Institute Research Branch, Agriculture Canada, Ottawa (Ontario) File no. 07SZ.01843-9-0904:29-30.
9. Temp, M. V. and D. J. Hagedorn. 1967. Influence of cropping practices on Aphanomyces root rot potential of Wisconsin pea fields. Phytopathology 57:667-670.

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