EFFECT OF COMPACTION AND ROOT ROT DISEASE ON DEVELOPMENT AND YIELD OF PEAS

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Green peas were grown in plots subjected to wheel traffic of known contact pressures. Measurement of plant parameters showed that the plants were damaged by increased levels of soil compaction. Root rot index correlated well with degree of compaction. Measurement of dry bulk density of the soil showed that most of the effect of compaction was in the top 0.075 m and allowed relationships to be established to predict yield from soil bulk density and root rot index. Soil bulk density increases had more effect on yield than high root rot indices.

INTRODUCTION

Green peas (Pisum sativum) are one of the major vegetable crops in the Province of Quebec. They are, however, very susceptible to root rot and other diseases. Root rot, principally caused by Fusarium solani (Mart.) Appel + Wr.f.sp.pisi (F. R. Jones), can reduce yields by up to 57% (Basu et al. 1976). Root rot has been found to be more prevalent and to have more effect on plants in compacted soils; the organisms can survive in the soil for many years.

Soil compaction has been shown to significantly hamper the performance of various crops (Weaver and Crist 1922; Taubenhaus et al. 1931; Adams et al. 1960; Phillips and Kirtham 1962; Saini and Lantagne, 1974; Morris 1975; Raghavan and McKyes 1977; Raghavan et al. 1978), and it has become a serious problem with increased use of large machinery and more intensive cultivation. The effects of traffic on soil physical properties, particularly on changes in the soil-air-water matrix, have been studied by various researchers (Soehne 1958; Barnes et al. 1971; Chancellor 1976; Soane 1970, 1973; Davies et al. 1973; Amir et al. 1976; Raghavan et al. 1975, 1976; Soane et al. 1977; McKyes et al. 1977).

Many studies have been done on the occurrence of root rot and its effect on the pea plant (Reinking 1942; Walker and Hare 1943; Sherwood and Hagedorn 1958). It appears that root rot increases in compacted soils, because the roots are unable to penetrate the infested upper layers and grow down into deeper areas of the soil (Burke 1968; Burke et al. 1969a; Miller and Burke 1974). It has been found that even if infestation levels are high, the plants are not as severely affected in less compact soil as they are in a denser soil (Burke et al. 1969b; Burke and Kraft 1974). This could be attributed to two things: either the level of infestation in the deeper soils is much lower or the plants are more able to compensate for the root damage because their root surface area is increased (Miller and Burke 1974).

The present experiment was designed to study the effects of measured levels of compaction on the growth and yield of green peas grown in a field with a known history of root rot. At the same time, a companion experiment in a field where peas had never been grown was performed.

EXPERIMENTAL METHODS

The two sites selected for field trials were at David Lord Ltd., St. Jean, having a clay-loam soil with a history of pea root rot which had been in pasture and corn for the past 2 yr and at Emile A. Lods Research Centre, Macdonald Campus, a clay soil which had been seeded to corn in 1976 and 1978, alfalfa in 1977 and was used for weed trials in 1979. No peas had ever been grown at the latter site.

In both fields, 2-m x 5-m plots were set up as a randomized complete block design and were subjected to measured ground contact pressures ranging from 0 to 690 kPa, using tractors exerting ground contact pressures per pass of 34, 41 and 46 kPa. The plots were seeded mechanically with Dark Skin Perfection peas at the rate of 32 seeds/m following hand raking and rotary tilling, depending on the condition of the seedbed after compaction treatments. Both fields had 250 kg/ha of 8–32–16 NPK and herbicide (2.2 kg/ha of Gesagard in 340 L of water) applied.

The percentage of seedlings emerged, root rot index, and vine length were measured after 28 days, 67 days and 55 days, respectively. Also, the soil bulk density from 0 to 0.30 m in 0.05-m increments was measured three times using a nuclear density gauge. This gauge measures an average soil bulk density from the surface to the depth of measurement. Using these values, soil bulk density was calculated for each layer of 0.05 m and indicated at its mid-depth. Therefore, the values in Fig. 1 are shown at 0.025 m, 0.075 m, etc. These data were used to relate the performance of the crop and the development of root rot to soil condition and traffic treatment. This information was also used to determine the effect of bulk density and root rot on crop yield.

RESULTS AND DISCUSSION

The overall percentage emergence of peas was low at both locations (Table I). The clay-loam field had a maximum percentage of seedlings emerged of 59% observed in the 1R (34-kPa) treatment. The minimum of 26% seedlings emerged was in the 15Q (690-kPa) treatment. The clay soil had even lower rates with 23% and 29% seedling emergence, respectively, in compacted and uncompactcd plots.

The root rot index, calculated according to Basu et al. (1976), was highest in the heavily compacted plots of both soils. Moderate compaction, 1R and 5Y treatments showed the lowest root rot indices which were 60 and 48 in the clay loam and clay soils, respectively. The maximum values of 89 were observed in the 10R and 15R treatment plots of clay-loam soil. The results of Duncan's new multiple range test are in Table I for both soils.

Vine length generally decreased with increasing compaction level. The longest vines in both soils were in the uncompacted plots. The vines on the clay soil were longer, reaching a treatment average.
TABLE I. AVERAGE VALUES FOR PERCENTAGE SEEDLING EMERGENCE, ROOT ROT INDEX, VINE LENGTH AND DRY YIELD

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cumulative contact Pr. (kPa)</th>
<th>% plants emerged</th>
<th>Root rot index</th>
<th>Vine length, (m)</th>
<th>Dry yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay-loam soil</td>
<td>000 0</td>
<td>54 a</td>
<td>72 ab</td>
<td>0.462 a</td>
<td>560 a</td>
</tr>
<tr>
<td>1Q‡</td>
<td>46</td>
<td>54 a</td>
<td>72 ab</td>
<td>0.321 b</td>
<td>342 b</td>
</tr>
<tr>
<td>1R</td>
<td>34</td>
<td>59 a</td>
<td>66 b</td>
<td>0.316 b</td>
<td>328 b</td>
</tr>
<tr>
<td>5Q</td>
<td>230</td>
<td>44 ab</td>
<td>82 a</td>
<td>0.214 cd</td>
<td>0 c</td>
</tr>
<tr>
<td>5R</td>
<td>170</td>
<td>36 bc</td>
<td>76 ab</td>
<td>0.270 bc</td>
<td>40 c</td>
</tr>
<tr>
<td>10Q</td>
<td>460</td>
<td>30 bc</td>
<td>84 a</td>
<td>0.194 d</td>
<td>0 c</td>
</tr>
<tr>
<td>10R</td>
<td>340</td>
<td>27 c</td>
<td>89 a</td>
<td>0.195 d</td>
<td>0 c</td>
</tr>
<tr>
<td>15Q</td>
<td>690</td>
<td>26 c</td>
<td>84 a</td>
<td>0.184 d</td>
<td>0 c</td>
</tr>
<tr>
<td>15R</td>
<td>510</td>
<td>31 bc</td>
<td>89 a</td>
<td>0.215 cd</td>
<td>0 c</td>
</tr>
</tbody>
</table>

| Clay soil | 000 0 | 29 a | 52 a | 0.666 a | 185 a |
| 5Y | 206 | 23 a | 48 a | 0.561 ab | 161 a |
| 15Y | 618 | 23 a | 52 a | 0.444 b | 79 a |

†Number of passes.
‡Contact pressure: Q = 46 kPa; R = 34 kPa; Y = 41 kPa.

Yield results showed the most dramatic decreases. On the clay-loam soil, contact pressures of (i) 46 kPa with passes of greater than one and (ii) 34 kPa with passes greater than five resulted in virtual elimination of pea yield. The yields in the clay soil were all very low. Figure 1 shows the profiles of soil bulk density related to depth for all the treatments. Most of the effect of compaction was in the top 0.075 m for both soils. On the clay-loam soil one pass of the tractor resulted in the largest increase per pass. The increases in soil bulk density between 5, 10 and 15 passes of 0.666 m, whereas on the clay-loam the maximum length was only 0.462 m. Higher compaction levels caused a 58% reduction in vine length in the clay loam, whereas the reduction in the clay soil was 34%.

Soil bulk density actually had more effect on yield in both fields than did the degree of root rot. In the clay-loam field, however, yield could be related to both root rot disease and soil bulk density in the top 0.10 m. This relationship was:

\[ Y_2 = 1899 - 3019 \ln(y_{0.10}) - 7.490(R_D) \]  

where,

\[ Y_2 = \text{dry yield of peas in clay-loam field (kg/ha)} \]

\[ y_{0.10} = \text{soil bulk density in top 0.10 m depth (Mg/m}^3\text{)} \]

\[ R_D = \text{root rot index} \]

Figure 2 shows plots of these relationships assuming root rot indices of 0, 50 and 90. Soil bulk density actually had more effect on yield in both fields than did the degree of root rot. In the clay-loam, the effect of the root rot increased slightly with increasing soil bulk density. Table II shows the yield losses resulting from increases in bulk density and root rot index. As the soil bulk density increased from 1.0 to 1.7 in the clay-loam soil the yield fell from a potential of 1899 kg/ha to 0 kg/ha, meaning a 100% reduction, but with a root rot index of 90, the maximum loss in yield was only 36%.

The results of this study showed that peas are a sensitive crop, susceptible to...
Figure 2. Plot of yield of peas vs. soil bulk density for increasing levels of root rot index.

Percentage of plants emerged, vine length and yield were shown to decrease with increasing levels of compaction. Root rot index increased with increasing compaction. Plots of soil bulk density versus depth for all the treatments showed that most of the effect of compaction was in the top 0.075 m; that most of the damage in the clay loam field was done by the first pass of the tractor; and that the effect of higher number of passes went deeper in the clay soil. When yield was related to root rot and soil bulk density, increases in soil bulk density did more harm than did increases in root rot. On the clay-loam soil, 100% decreases in yield were attributed to increased bulk density, whereas with a root rot index of 90 a maximum of 36% yield loss was seen.

Soil management to reduce soil bulk densities as much as possible coupled with a proper program of crop rotation would likely increase pea yields in the Province of Quebec.

SUMMARY AND CONCLUSIONS

Green peas were grown on two soils, a clay and a clay-loam. The clay had no history of root rot, whereas the clay-loam was known to have a high root rot potential. Plant growth and development parameters, as well as root rot development and soil properties, were monitored over the growing season.

TABLE II. YIELD LOSSES RESULTING FROM INCREASES IN SOIL BULK DENSITY AND ROOT ROT INDEX

<table>
<thead>
<tr>
<th>Dry density (Mg/m³)</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.20</td>
<td>1340</td>
<td>29</td>
<td>965</td>
<td>49</td>
<td>666</td>
<td>65</td>
</tr>
<tr>
<td>1.30</td>
<td>1108</td>
<td>42</td>
<td>733</td>
<td>61</td>
<td>434</td>
<td>77</td>
</tr>
<tr>
<td>1.40</td>
<td>885</td>
<td>53</td>
<td>510</td>
<td>73</td>
<td>211</td>
<td>89</td>
</tr>
<tr>
<td>1.50</td>
<td>676</td>
<td>64</td>
<td>301</td>
<td>84</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>1.60</td>
<td>480</td>
<td>75</td>
<td>105</td>
<td>95</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1.70</td>
<td>296</td>
<td>84</td>
<td>0</td>
<td>100</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

Clay-loam soil

<table>
<thead>
<tr>
<th>Dry density (Mg/m³)</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
<th>Yield (kg/ha)</th>
<th>Yield loss due to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>221</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.10</td>
<td>165</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.20</td>
<td>113</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.30</td>
<td>66</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clay soil

†No yield loss expected at γ = 1.0 Mg/m³ and potential yield → 1899 kg/ha for David Lord Ltd., and 221 kg/ha for Emile A. Lods.
‡Net effect for both γ and root rot.

REFERENCES


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