Clubroot development in resistant and susceptible canola cultivars affects soil populations of Plasmodiophora brassicae

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Clubroot, caused by Plasmodiophora brassicae, has become a serious threat to canola (Brassica napus) production in western Canada. The pathogen induces the formation of galls on infected roots that impair growth and nutrient uptake, leading to wilting or death of the infected plants and yield losses of 30–50% or more. Clubroot management options that are used in vegetable crop production, such as drench application of fungicides and amendment with lime to increase soil pH, are not practical or cost effective for use in the extensive production of field crops.

Clubroot-resistant spring canola cultivars have recently been developed and released for the Canadian market, but it is unknown what effect that cultivation of these crops will have on spore populations in the soil. The incidence of primary infection of canola by P. brassicae was assessed using microscopic examination of root hair infection in plants of cvs. 45H26 (susceptible) and 45H29 (resistant) across a range of resting spore densities (0, 1×10^3, 1×10^5 and 1×10^7 spores/mL), created by inoculation with resting spores or by 0:1, 1:8, 1:1, or 1:0 dilutions of infested soil: soil-less mix. The progress of infection was monitored at 2-day intervals from 4 to 14 days after seeding. The proportion of infected root hairs was 2- to 3-fold higher in the susceptible versus the resistant cultivar. Root hair infection in the susceptible cultivar peaked between 6 and 8 days after seeding and then declined as the pathogen completed the primary stage of infection. Infection in the resistant cultivar increased slowly but steadily over the 14-day duration of the study (Fig. 1). The incidence of infection in both lines increased with increasing inoculum density, but the relationship was substantially stronger and more consistent in the susceptible versus the resistant cultivar. Inoculum density was strongly and positively correlated with clubroot severity and negatively correlated with plant height and seed yield in the susceptible genotype (Figs. 2, 3 and 4).

Two trials were also conducted to determine the effects of repeatedly growing the same resistant cultivar, and mixtures of resistant and susceptible cultivars, on resting spore populations in soil and subsequent clubroot severity. Although resistant cultivars are available, susceptible volunteer canola plants and cruciferous weeds will continue to be present in infested fields for many years. In one experiment, a susceptible and a resistant cultivar were grown in infested soil-less mix (1×10^6 spores/g soil) for three 6-week cycles.

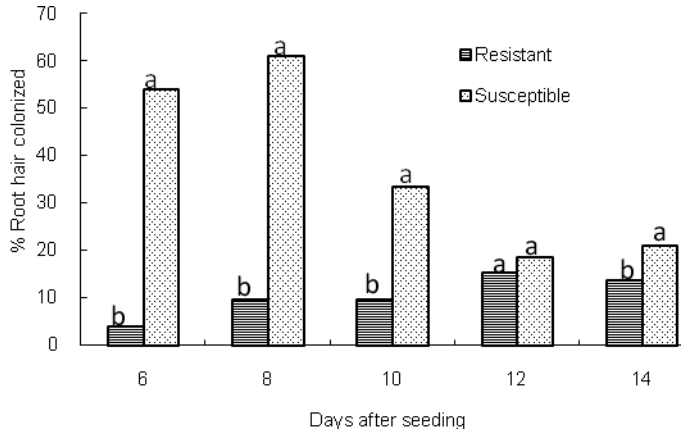

Figure 1. Root hair colonization by Plasmodiophora brassicae in resistant and susceptible canola cultivars over 14 days.

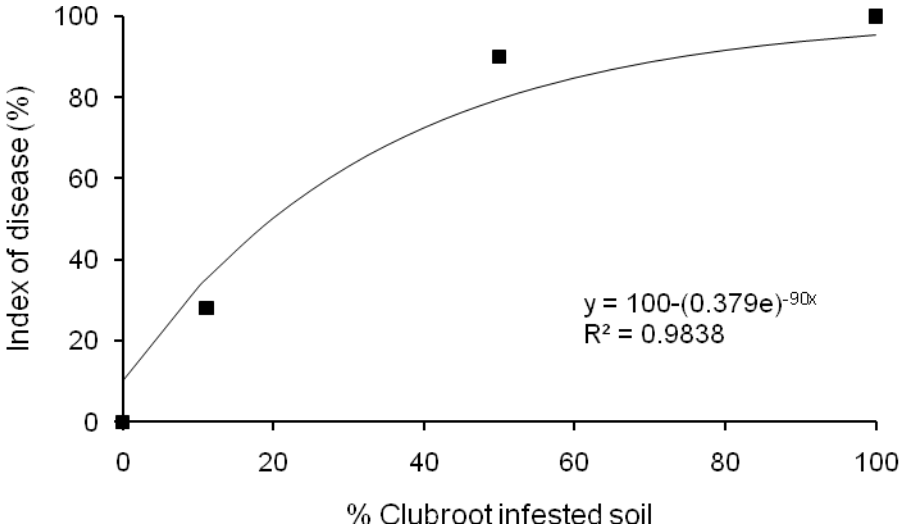

Figure 2. Effect of Plasmodiophora brassicae inoculum density on disease severity in a clubroot-susceptible canola cultivar.

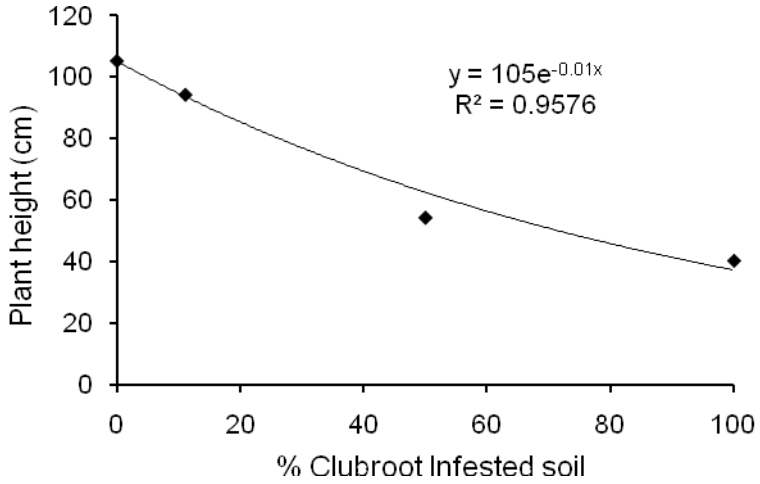

Figure 3. Effect of Plasmodiophora brassicae inoculum density on plant height in a clubroot-susceptible canola cultivar.

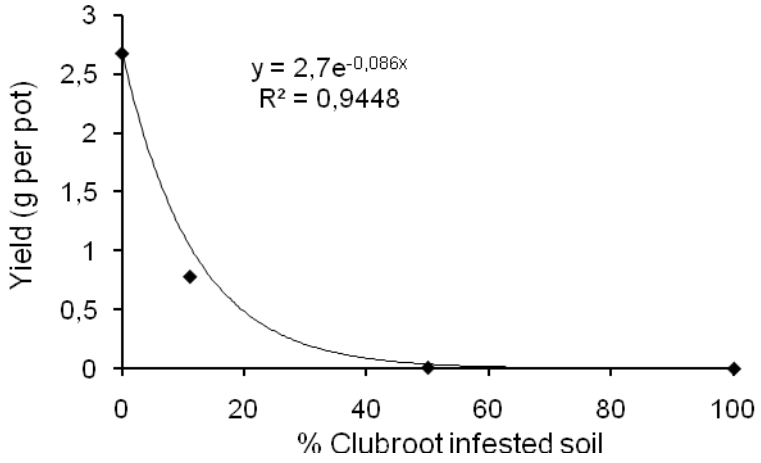

Fig. 4. Effect of Plasmodiophora brassicae inoculum density on seed yield in a clubroot-susceptible canola cultivar.

The inoculum potential was estimated by planting the susceptible cultivar in the soil-less mix and assessing the disease index after each cycle. The disease index for the susceptible cultivar increased in each successive cycle (data not shown). In another experiment, the impact of various proportions of resistant and susceptible cultivars in the crop was assessed. The two cultivars were grown in ratios of 1:0, 3:1, 1:1, 1:3, and 0:1 (resistant: susceptible) in infested soil-less mix (1×10^8 spore/ g soil) for 6 weeks. Data on root mass, plant height, clubroot incidence and severity were recorded. The roots then were macerated and incorporated into the soil, which was reseeded for two additional 6-wk cycles. Root mass and clubroot severity increased with increasing proportions of susceptible canola (Fig. 5). In subsequent cultivation of the susceptible cultivar, disease and root mass were lower in soil where only the resistant cultivar had been grown, higher where only the susceptible cultivar had been grown, and intermediate where resistant and susceptible cultivars were grown in a mixture (Fig. 6). Root mass increased while top growth declined as metabolic resources were diverted to the roots. In the resistant cultivar, 15-20% of the root hairs became infected and 11% of plants developed visible galls. This may indicate that repeated cultivation of the resistant cultivar will result in selection for pathogen phenotypes that can overcome this source of resistance.

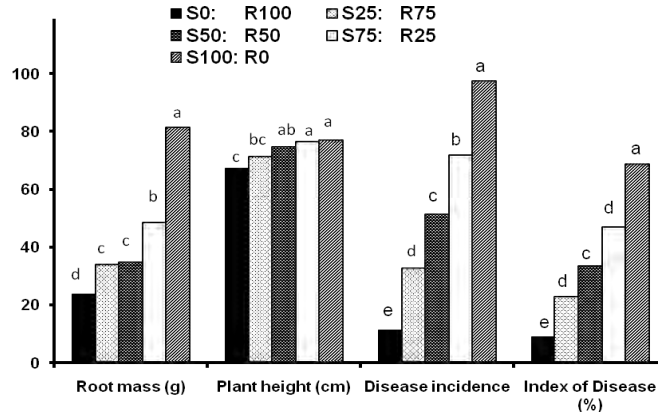

Figure 5. Growth and disease symptoms in various proportions of susceptible and resistant canola cultivars grown in clubroot-infested soil.

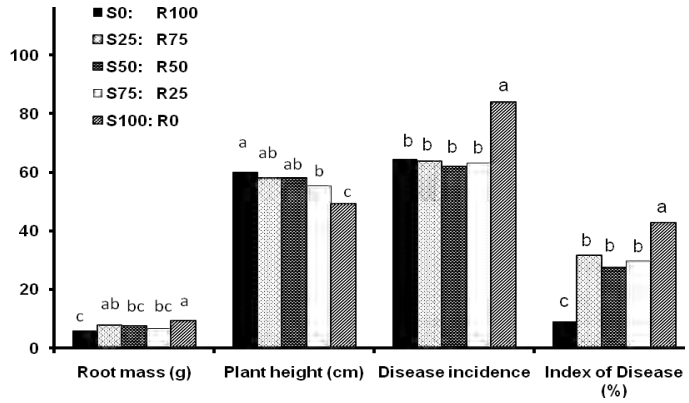

Figure 6. Growth and disease symptoms in a clubroot-susceptible canola cultivar after cultivation of various proportions of susceptible and resistant canola cultivars in the same soil.

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