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Effect of Co-inoculations with *Spongospora subterranea* (Powdery Scab) and *Meloidogyne chitwoodi* (Columbia Root-knot Nematode) on Potato Health

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Introduction

Powdery scab of potato is caused by the protozoan pathogen *Spongospora subterranea*. Powdery scab signs on susceptible potato cultivars are sponge-like galls on roots and stolons, and lesions on tubers. These signs become visible generally at tuber initiation stage. The powdery scab pathogen is an endoparasitic slime mold. It is an obligate parasite with infectious activity at temperatures between 55-65°F when soils are wet. Infection initiates from resting spores known as sporeballs, which can be in the soil and/or on the tuber's surface. Following infection a plasmodium forms inside the roots and/or the tubers, which produces motile spores (zoospores) that continue to infect the roots, stolons and tubers multiple times. Eventually, a new generation of sporeballs is formed in masses in the root galls and the tuber lesions giving the disease its name, powdery scab. The spore balls that are the primary source of inoculum and can survive in soil or on the surface of tubers for many years. Powdery scab impairs tuber appearance due to lesions on the epidermis and reduces tuber quality. Infection of roots may cause young plants to wilt and die, and possibly disturb the uptake of nutrients and water, affecting photosynthetic translocation to tubers. Hence, the disease can potentially reduce yields. Field observations in the Columbia Basin of Washington State have indicated that potato plants infected with the pathogen developed necrosis on the roots, which affected the development of large (>280 g) tubers needed for processing. Root rot may be an important contributor to economic damage in the crop aside from blemishes on tubers.

The Columbia root-knot nematode (CRKN), *Meloidogyne chitwoodi*, is another serious pest of potato in the Pacific Northwest. CRKN is a sedentary endoparasite that remains permanently attached to the root and tuber tissues at the feeding site once feeding initiates. Plants infested with the nematode may demonstrate poor shoot growth, foliar chlorosis, small tubers and internal tuber browning. Roots invaded by the pest demonstrate knots at the feeding sites, and tubers demonstrate sub-epidermal swellings (bumps) and discoloration of the flesh. The damage caused to tubers is unacceptable by the fresh market and the processing industries, resulting in price reduction penalties or rejection of harvested tubers.

The powdery scab pathogen and the CRKN are major concerns to the potato production in the Columbia Basin of central Washington and north central Oregon. Field observations point towards an increase in their incidence in fields throughout the region. The majority of the potato cultivars grown in Washington, Idaho or Oregon are susceptible to both. In the present study we tested whether or not the two organisms can interact to cause greater levels of disease and reduce potato health.

Materials and Methods

The experiments were conducted in a controlled environment growth chamber in half-liter pots, and were two months in duration. A soil mixture composed of 84% sand, 10% silt, and 6% clay that was previously treated

with methyl bromide (0.3 kg/m³) was used. This soil is similar to the soil in most potato fields in the Columbia Basin region. The soil temperature was kept at 60°F, which supports powdery scab and CRKN development. The following treatments were tested: 1) powdery scab + CRKN; 2) powdery scab alone; 3) CRKN alone; and 4) non-inoculated control plants.

Results and Discussion

In this study, the severity of root galls due to powdery scab infection was not increased in the presence of the CRKN. In the same manner, the number of CRKN (females, juveniles and total nematode count) was not increased in the presence of the powdery scab pathogen (Table 1). Interestingly, in the presence of the powdery scab pathogen the nematodes were mostly aggregated in large numbers around the root galls, and not spread out in the root system (Fig. 1). The nematodes however were rarely recorded inside the root galls. In relation to plant health, the results indicated that in the presence of the powdery scab pathogen root rot was increased. Root rot severity was higher in the presence of powdery scab than in its absence (Table 1 and Fig. 2). In conclusion, a synergistic interaction between the powdery scab pathogen and the CRKN, which reduced potato health, was not substantiated in this study.

Table 1. Effect of co-inoculations with *Spongospora subterranea* and *Meloidogyne chitwoodi* on powdery scab severity, Columbia root-knot nematode colonization of roots, and on potato health.

Treatment ^a	Root galls (0-8) ^b	Fresh root weight (g)	Root rot (0-3) ^c	CRKN nematode / gram fresh root		
				Females with egg masses embedded in roots	Juvenile (J2)	Total
PS + CRKN	7.2 a	1.5 ab	1.6 b	140 a	147 a	287 a
PS alone	6.8 a	0.8 b	2.75 a	0.4 b	0.5 b	0.9 b
CRKN alone	0.7 b	1.9 a	0.7 c	121 a	69 a	190 a
Non inoculated control plants	0.9 b	1.5 ab	1.0 c	0 b	0 b	0 b
<i>P</i>	<.0001	0.09	<.0001	<.0001	<.0001	<.0001

Statistical analysis was carried out in SAS at 5% significance level. Different lower-case letters within a column indicate different statistical differences among the treatments.

^a PS = Powdery scab pathogen present in soil; CRKN = Columbia root-knot nematode present in soil.

^b Powdery scab root galls scored using a 0 to 8 visual scale, where: 0 = no galls, 2 = 1 galls, 4 = 2 or 3 galls, 6 = 4 to 10 galls and 8 = more than 10 galls.

^c Root rot severity was scored using a 0 to 3 visual scale, where: 0 = no rot, 1 = low (yellow to 30% of roots with light brownish root discoloration), 2 = medium (light brown to 30% of root with dark brown discoloration), 3 = high (more than 50% of the root with dark brown discoloration).

Figure 1. Aggregation of CRKN females in a 3 mm root section removed from near a powdery scab root gall. There are about 10 females in this root section.

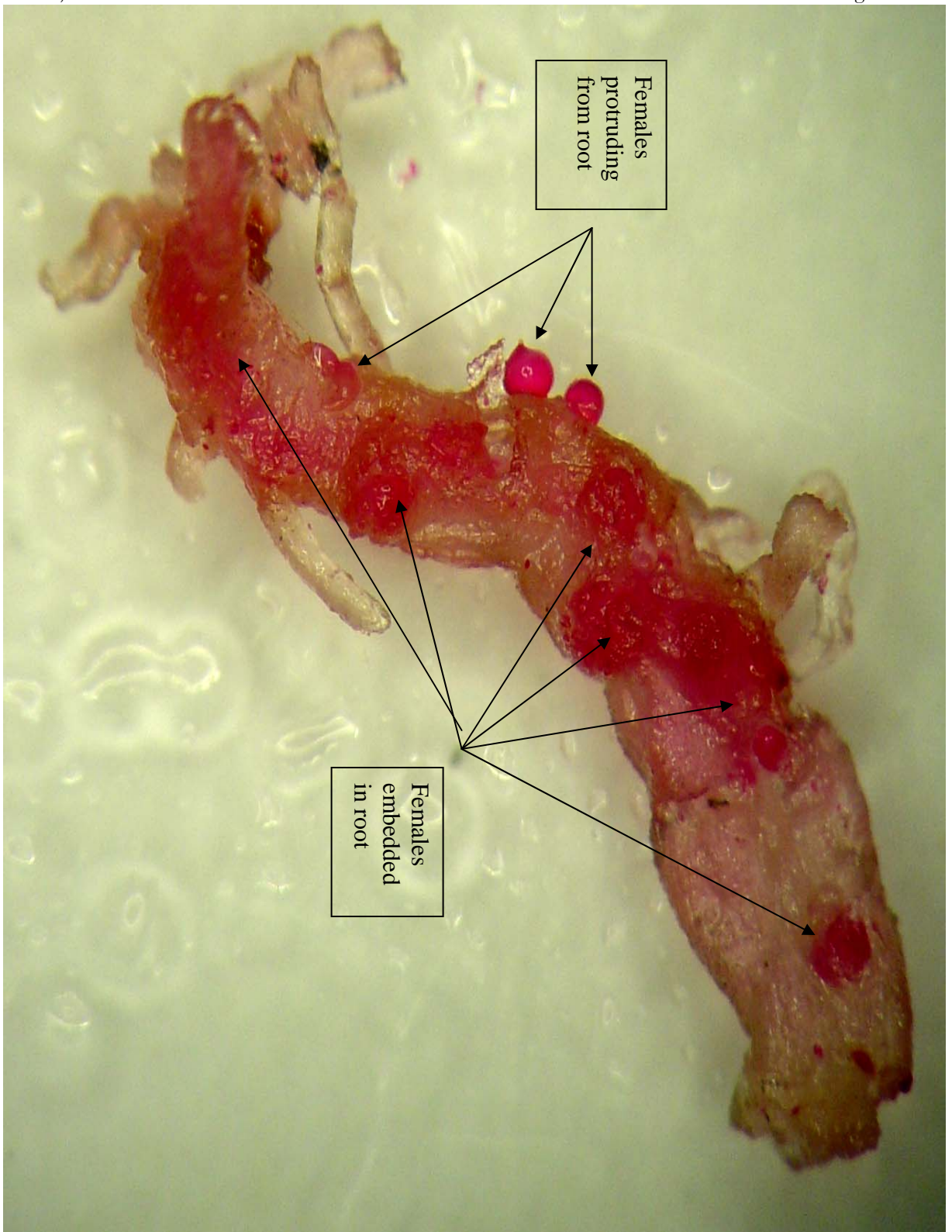




Figure 2. Reduction of root size and increased root rot on plants inoculated with the powdery scab pathogen compared to non-inoculated control plants.