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Short communication

Relative susceptibility of selected potato cultivars to feeding by two wireworm species at two soil moisture levels

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ABSTRACT

Tubers from six potato (*Solanum tuberosum* L.) cultivars were exposed to the wireworms *Melanotus communis* (Gyllenhal) and *Glyphonyx bimarginatus* (Schaeffer) under no-choice conditions in the laboratory to determine the relative susceptibility of these cultivars to wireworm feeding under high and low soil moisture conditions. Feeding injury by *G. bimarginatus* was not affected by soil moisture but differed by cultivar. Percent injury, mean number of feeding holes, and volume of tuber consumed were significantly higher in Yukon Gold than all other cultivars. Neither head capsule width nor larval weight affected any of the feeding parameters measured for *G. bimarginatus*. Injury incidence and number of feeding holes caused by *M. communis* were significantly higher in high soil moisture conditions; soil moisture had no effect on the volume of tuber consumed. *Melanotus communis* consumed more tissue from Dark Red Norland and Yukon Gold than all other cultivars. Size of *M. communis* larvae did not affect any of the feeding parameters measured. This study provides evidence of host plant resistance in commercial potato cultivars and suggests planting less susceptible cultivars could be a viable strategy for integrated pest management of wireworm in potato.

1. Introduction

Wireworms, the larval form of click beetles, are subterranean polyphagous insects that attack many cultivated crops worldwide. Wireworms feed on planted seeds and roots of most crops and are particularly pestiferous in root and tuber crops such as sweetpotato, *Ipomoea batatas* (L.) Lam. and potato, *Solanum tuberosum* L. Up to 100 wireworm species are known to attack potato (Vernon and van Herk, 2013). Market tolerance for insect damage to potato tubers is low and as a result, growers use prophylactic soil applied, broad spectrum insecticides. It is well understood that insect management based solely on insecticide use can result in insecticide resistance, disruption of biological control, and/or outbreaks of secondary pests (Seal et al., 1992). Host plant resistance offers an additional approach to integrated wireworm management in potato that could minimize losses while reducing the environmental impact of pesticide use and mitigating the risk of resistance development to traditional synthetic insecticides (Kwon et al., 1999).

Two wireworm species routinely collected in agricultural fields throughout the southeast USA are *Melanotus communis* (Gyllenhal) and *Glyphonyx bimarginatus* (Schaeffer) (Cherry, 2007; Deen and Cuthbert, 1955; Hall, 1988; Herbert et al., 1992; Willis et al., 2010a; Langdon, 2012). *Melanotus communis* is a pest of many agricultural crops in the eastern and central USA including potato (Jansson and Lecrone, 1989, 1991; Kuhar et al., 2003; Riley and Keaster, 1979). Although *G. bimarginatus* is abundant in many areas of the southeast, little is known about its biology and ecology or whether it is of economic importance in potato production systems (Hall, 1988; Cherry and Stansly, 2008).

Host plant resistance can be an effective component of an integrated pest management strategy that provides economic and environmental benefits. Investigations of host plant resistance to wireworm in some potato cultivars have been completed (Johnson et al., 2008; Kwon et al., 1999; Strickland et al., 1962), but no studies have been conducted to identify susceptibility of potato cultivars commonly grown in the southeastern USA to wireworm species

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found in the region. A no-choice laboratory feeding bioassay was conducted to determine the relative susceptibility of six potato cultivars commonly grown in the southeastern USA to the wireworms *M. communis* and *G. bimarginatus* under two soil moisture conditions.

2. Materials and methods

2.1. Wireworm collection

Wireworm larvae were collected from commercial potato fields in Washington, Tyrrell, Hyde, and Pasquotank Counties in North Carolina using oat baits in April and May 2011. Approximately 78 g of steam crimped oats, *Avena sativa* L. (Purina Mills, St. Louis, MO) were placed in a hole (7.5 cm diameter by 12 cm deep) and covered with 2 cm of soil. A golf course cup cutter was used to remove baits from the field after 14 d. Each 1300 cm^3 bait/soil matrix was placed in a resealable plastic bag, transported to the laboratory at North Carolina State University, Raleigh, North Carolina, and stored at 4 °C until wireworms were removed. Wireworm larvae were identified to species under a dissecting microscope using the keys of Rabb (1963), Riley and Keaster (1979), and Seal (1990). Live wireworms were stored individually in 57 g plastic containers with soil from the sample; soil was wetted to approximately 0.3 g/g mass water content, and 2 g dry steam crimped oats were added. Larvae were held in the dark in a laboratory refrigerator at 7 °C. Seven days prior to initiation of the study, containers were removed from refrigeration and placed on a laboratory bench at 23 °C with a photoperiod of 10:14 L:D. Wireworm larvae were starved for 7 d prior to use in experiments.

2.2. Tubers

The following potato cultivars commonly grown in the southeastern USA were selected for use in the feeding assay: Atlantic, Dark Red Norland, Frito Lay 1867, Snowden, Superior, and Yukon Gold. Potato tubers were harvested by hand from commercial potato fields in northeastern North Carolina in June 2011. Tubers were transported to the laboratory at North Carolina State University, Raleigh, North Carolina and washed thoroughly to remove soil and organic material. Tubers were air dried and stored at 23 °C for approximately 55 d until initiation of the study. Tubers used in the study ranged in size from 6.5 to 8.5 cm diameter.

2.3. Soil collection

Soil was collected from a commercial potato field in North Carolina where no insecticides had been applied in the preceding 14 months. Soil was sterilized using aerated steam (LINDIG Model 150 Steam Generator, LINDIG Manufacturing Corporation, St. Paul, Minnesota) at 74 °C for approximately 1 h. A subsample of the soil was used to quantify soil texture. Organic matter was removed from the subsample prior to measuring particle size; the soil was determined to contain 26% organic matter. USDA soil texture classification was determined to silt loam with 40.6% sand, 50.3% silt, and 9.1% clay.

2.4. Experimental design

A single feeding arena consisting of one 20 ml polypropylene liquid scintillation vial (Wheaton Science International, Millville, New Jersey) with the bottom removed was fixed to each potato tuber with a bead of hot melt glue. Sterilized soil was wetted to 0.400 g/g mass water content (high moisture) and 0.156 g/g mass water content (low moisture) and used to fill the appropriate feeding arenas. A subsample of soil at each moisture level was weighed and oven dried at 105 °C for 24 h. Mass water content was then calculated using the following formula: mass water content= (mass wet soil (g) − mass dry soil (g))/mass dry soil (g).

The feeding assay was arranged in a randomized complete block design with 24 treatments and 8 replications. Treatments consisted of all combinations of six potato cultivars, two soil moisture levels, and two wireworm species. The developmental stage of individual larvae used in the experiment was unknown. The head capsule width and weight of each wireworm was recorded at the start of the experiment. A single wireworm larva was released into each soil-filled feeding arena, and the cap was loosely attached to prevent wireworm escape or asphyxiation. Each tuber/arena unit was placed into a 15 cm diameter plastic pot and oriented such that the length of the vial was horizontal with the lab bench to control for gravitational effects (Campbell, 1937). The tuber/arena was covered with soil to control for lighting effects. Soil temperature was recorded each hour (WatchDog Data Logger Model 100, Spectrum Technologies, Inc. Plainfield, Illinois). Mean laboratory temperature during the study was 21.29 °C (19.0–26.0 °C) well within the optimum developmental temperature range reported for *M. communis* (17 - 29 °C) (Fulton, 1928; Villani and Wright, 1990). Tubers were exposed to wireworm herbivory for 25 d. Potato tubers with at least one wireworm feeding hole were considered injured. The incidence of feeding injury (percent of tubers with at least one feeding hole) to tubers in each treatment was recorded. Cumulative tuber volume consumed and severity of injury (number of feeding holes) were also recorded for each tuber in the study. The total volume of potato consumed by each wireworm was quantified to the nearest microliter by injecting glycerol into each feeding hole using a 50 μl microsyringe as described in Johnson et al. (2008). Percent wireworm mortality was calculated at the end of the experiment for each treatment as: percent mortality = total dead/(total dead + total alive)*100.

2.5. Data analysis

Cumulative volume and number of feeding holes data were subjected to square root transformation, and all percent data were subjected to arcsine square root transformation to achieve homogeneity of variance prior to analysis. Fixed effects included wireworm species, cultivar, and soil moisture; replicate was treated as a random effect. All potential interaction effects were included in the models. Nevertheless, because of the large differences in feeding activity of *G. bimarginatus* and *M. communis* observed in this study and the putative limited economic importance of *G. bimarginatus*, analysis of injury is presented for each species individually. Transformed data were analyzed using Proc Mixed in SAS v9.2 (Proc Mixed, SAS Institute, 2008). Least squares means are presented in all figures, and error bars represent a 95% confidence interval (CI). Mean separations were based on Fisher's least significant difference (LSD), where treatment means differed significantly at $\alpha \leq 0.05$. Wireworm head capsule width and weight data were analyzed using Proc Reg in SAS v9.2 to determine the effect of larva size on injury severity (Proc Reg, SAS Institute, 2008).

3. Results and discussion

Although *G. bimarginatus* is widespread in the southeastern USA and is one of the most abundantly collected wireworm species in northeastern North Carolina (Langdon, 2012), little is known about the biology of the species (Hall, 1988; Cherry and Stansly, 2008). In this study, a small number (ca. 10%) of *G. bimarginatus* larvae