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Factors influencing monitoring of *Agriotes* spp. wireworms

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Abstract: Wireworms tunneling into potato tubers cause quality decline to the product. Due to the short time between initial wireworm presence in the topsoil in spring and the moment of potato planting, decisions whether or not to control wireworms based on monitoring in spring are insecure. Increased knowledge on temperature and soil moisture may help enhance a succesful monitoring strategy. Two trials performed in climate chambers showed wireworms to be increasingly active between 5°C and 25°C. The preferent soil moisture level was 20%, ranging from 10 to 25%.

Key words: potato, *Solanum tuberosum*, wireworms, *Agriotes* spp., monitoring

Introduction

Wireworms occur throughout the world as pests in many crops, including potatoes, where as many as 39 species and 12 genera have been recorded (Parker & Howard, 2001). Although cultural control options may be effective (Schepl & Paffrath, 2005), wireworm control is mainly achieved by incorporating an insecticide or biological into the soil or by seed treatment (Blaser *et al.,* 2004; Huiting & Ester, 2009). In contrast to many other crops where wireworms cause plant loss, damage is a quality issue in potato production. Wireworms tunneling deep into the tubers' flesh render a potato batch unfit for sale causing substantial financial losses. Consequently, growers are particularly keen on the control of this soil dwelling insect. Decisions to apply insecticides are made after risk assessment based on the site's cropping history and wireworm population estimation. In the Netherlands wireworm monitoring consists of digging potato tubers into the soil in spring prior to planting, and assessing wireworm presence or tuber damage after ten days to a fortnight. Presence of either means that control measures are recommended. Absence however does not necessarily imply that damage at harvest is prevented: since even low population densities (< 100,000/ha) can result in economic loss (Parker & Howard, 2001), presence may not be recorded due to the heterogenic distribution in the field or unsuitable soil circumstances. Simultaneously, field observations indicate that heavy rainfall during the growing season may reduce wireworm feeding activity, underlining the difficulty to link population density prediction to levels of attack at harvest (Parker & Sweeny, 1997). Especially in high value crops as potatoes, this combination makes growers tend to apply an insecticide anyway. Increased costs and increased consumer awareness should however enhance a tendency towards better targeting of control measures, contributing to a more sustainable solution.

A better understanding of meteorological factors influencing wireworm behaviour helps improve monitoring this pest. As wireworms presence in the topsoil is induced by temperature increase in spring, many potato sets are planted too early for accurate monitoring prior to planting. For a better understanding of the factors influencing wireworm behaviour, thus increasing reliability of a monitoring system, experiments were carried out focusing on soil temperature and moisture as well as increased attraction at monitoring in the field.

Material and methods

In two climate chamber multi factor experiments, in 2007 and 2008, influence of varying soil moisture and temperature on wireworm behaviour was tested (Table 1). Plots consisting of PVC cylinders (∅ 30cm, 60cm high, c. 42l.) with closed bottoms were filled with marine loam soil (c. 5% clay, homogenised). Wireworms used were kept at 4°C after collection at the Applied Plant Research station (PPO) in Lelystad, the Netherlands. Soil moisture levels, chosen in a range for marine loam soils between moisture deficiency for plants and soil saturation under field conditions, were adjusted after drying the soil to 5% moisture content. Experiment temperatures were selected to fit to soil temperatures in spring and autumn. Cylinders were filled gradually. Twelve *Agriotes* wireworms were released at various depths in 2007 and all at the same depth in 2008. At -15cm four half potatoes were placed as an attractant to wireworms. Resulting from the temperature gradient a split-plot design with two (2007) and three replicates was chosen. Assessments focussed on location of the wireworms and numbers of wireworm attack marks on the tubers. In 2008, each time one replicate was assessed, after incorporating assessment intervals, to answer questions on monitoring interval.

Table 1. Factors and levels included in two multi factor experiments in 2007 and 2008 to establish effects on wireworm behaviour.

Factor	Level	2007	2008
Temperature	5°C	x	X
	10°C	-	X
	15°C	x	X
	20°C	-	X
	25°C	x	X
Moisture	10%	x	X
	15%	x	X
	20%	x	X
	25%	x	X
Placing wireworms	-15cm	x	-
	-30cm	x	-
	-45cm	x	-
	-60cm	-	X
Assessment	1 week	-	X
	2 weeks	x	X
	3 weeks	-	X

Results and discussion

Regardless of temperature and soil moisture level, wireworm activity increased greatly after one week experiment interval. After two weeks only tuber damage increased, in contrast to wireworm division in the plots. Measured by both damage to the tubers and wireworm location in the plots after two weeks, the wireworms were most active at 20% soil moisture, coinciding with optimal moisture conditions for plant growth (Figure 1). Both at 20 and 25% moisture content over 70% of the wireworm were retrieved in the top half of the plots. Campbell (1937) obtained similar soil moisture responses using *Limonius californicus* after only four days. Apart from temperature and soil moisture, gravity was discussed by Campbell, although Lees (1943) suggested that vertical movement is either coincidal or induced after release of wireworms above soil in such experiments. In our experiments four half potato tubers per plot were used as a wireworm attractant to obtain information on monitoring situations in the field. Several baiting techniques and baiting products have been tested (Parker, 1996; Horton & Landolt, 2002; Vernon *et al.*, 2003), mostly not including half potato tubers. A particular wireworm monitoring benefit of half potato tubers is the easy assessability of damage symptoms, making actual wireworm presence at the baiting station at assessment redundant. Since cultivar differences in wireworm damage have been established however (Johnson *et al.*, 2008: Kwon *et al.*, 1999), cultivar selection may influence monitoring efficacy.

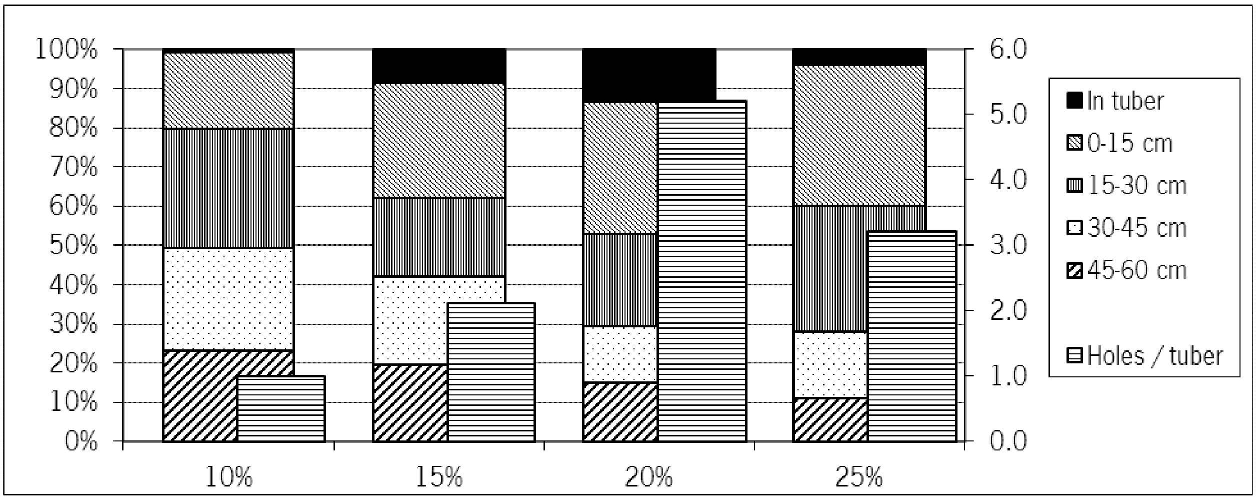

Figure 1. Percentage division of wireworms per soil layer and numbers of holes per tuber – division per soil moisture content level, 2007.

Wireworms responded strongest to 25°C in terms of tuber attack but at 10°C migation to the top layer was the highest (Figure 2). At 5°C wireworms showed virtually no damage to the tubers was found and over 70% was retrieved in the -45 to -60cm zone, justifying the conclusion that the critical temperature for adequate wireworm monitoring is above 5°C. In contrast to our experiments using fixed temperature levels, at temperature gradient experiments of Campbell (1937) 5°C was the lowest temperature at which wireworms were retrieved, suggesting preference for higher temperatures. Lafrance (1968) established 3°C to be the critical temperature inducing *Agriotes mancus* movement to the topsoil.

In our experiments marine loam was chosen as a soil type to closely fit to the main potato growing field conditions. Depending on soil moisture content wireworms may anticipate on organic matter in the soil thus not attacking potato tubers (Lees, 1943). Behaviour may be different though if sand were used as experiment medium, implicitly influencing organic matter content, and water saturation levels for instance.

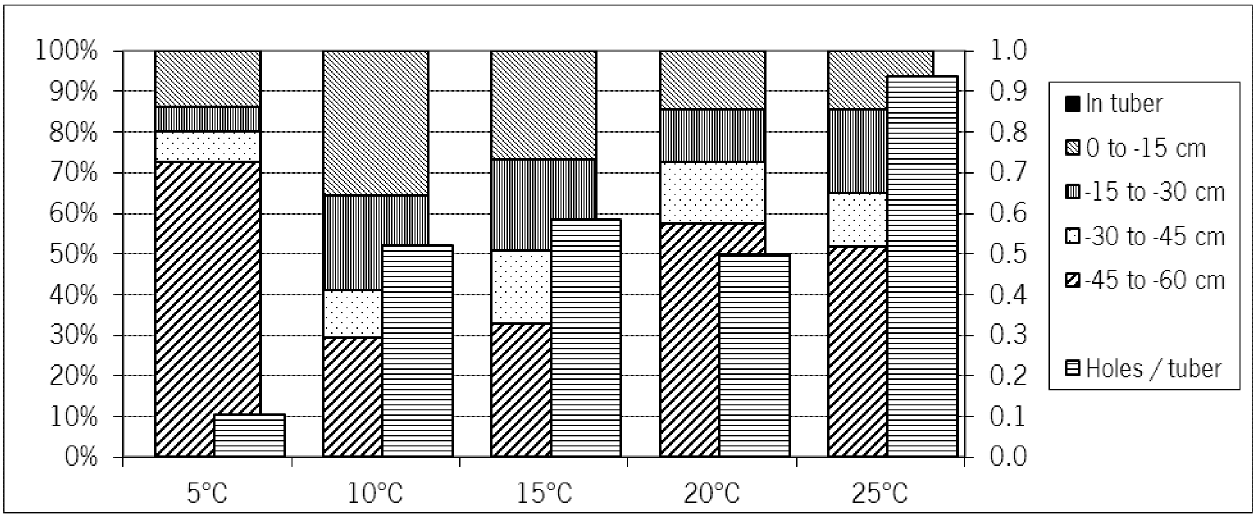

Figure 3. Percentage division of wireworms per soil layer and numbers of holes per tuber – division per temperature level, 2008.

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