Integrated control of the potato tuberworm, *Phthorimaea operculella* (Zeller): The ecological background

THESIS

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ABSTRACT

The potato tuberworm, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), is an oligophagous pest of cultivated solanaceous plants and potato is its preferred host plant. The potato tuberworm is found in all parts of Israel, but is most common in the south. In this region, the damage is severe because two potato crops are grown annually.

To control the pest, commercial fields are routinely treated with insecticides, sometimes up to 11 times per season. It is likely therefore that there is an excessive use of harmful chemicals against the pest. In the present study information was collected about pest population level, time of infestation and within field and within plant pest distributions. These distribution patterns could be used to design cost effective sampling protocols and spot treatments. Additionally, the study examined the influence of ridging, roller pressing, potato variety, chemical control, and irrigation frequency on pest and damage levels. Finally, the importance of volunteer potato plants for pest and natural enemies was studied. The overall goal of the study was to gather information needed for the development of an integrated control program for the potato tuberworm in potato fields.

For three seasons, the pest was studied in two systems in the western Negev in Israel: 'Kara' and 'Mondial' varieties in sandy soil and 'Desire' and 'Mondial' varieties in loess soil. Adult moth populations were studied using pheromone traps. Adult catches were low in February-March, they increased between April-May, and peaked between May-June. Throughout most of the season (all three years of the study taken together), adult population level was higher in sandy than loess fields. Apparently, females were attracted to oviposit in sandy soil because of the low water content in this soil compared to loess soil. An increase in moth numbers was recorded toward the end of the season, in the middle of June. At that time, in the absence of foliage, more tubers were exposed to the ovipositing moths, particularly in loess soil that tend to crack. Additionally, it is possible that moths migrated into loess fields from nearby harvested sandy fields.

The density of the larvae was monitored by sampling stems from the edge of the field and from its center. Weekly samples continued from sprouting to defoliation. The

first larvae were found in the foliage in April and larval population peaked in May. Most of the larvae were found in the younger foliage at the upper parts of the plants. Larval density in the foliage was significantly by higher in sandy than loessial soil and in edge rows of the field (up to 11m from field margin) than the center. This within field infestation pattern suggests a migratation habit of the pest between fields. Additionally, larval survival was probably higher in sandy soil because of the drier, more favorable conditions in this soil.

The tubers were sampled three time during the season: before defoliation, after defoliation and before harvest. Overall, infestation level throughout the 3 years of study was 6.72%. Eighty seven percent of the infested tubers were green (exposed to light). The highest infestation rate in the green tubers was found before harvest time and in loess fields. It seems that the high tendency of the loess soil to crack as it drys allows the larvae to reach the tubers in higher numbers than in sandy soil. Contrary to the green tubers, infestation levels in white tubers were similar in both soils. Apparently, the white tubers are found deep in the ground and out of larval reach. It was found that frequent irrigations are effective in reducing tuber infestation. It seems that high soil moisture reduces cracking and larval access to the tubers. Also, treatments with roller press were important in reducing tuber infestation, presumably by sealing the cracks in the soil. Additionally, high soil moisture causes high larval mortality and hinders oviposition. Because the average weight of a white tuber is 1.5 times that of a green tuber and because yield in determined by weight, the economic loss to the pest is relatively low.

Apparently, pheromone traps provide reasonable information on the timing of pest first appearance in the field and on the dynamics of its population. Yet, traps were not reliable in predicting larval infestation levels in the foliage and in the tubers. In sandy soil, a significant positive correlation was found between adult catch and larval density in the foliage and between larval density in the foliage and tuber infestation level. The non-significant correlation that was found in loess soil could suggest high levels of larval mortality (because of high soil moisture).

Contrary to the expectations, a positive correlation was found between the number of insecticide applications (Insect Growth Regulators (IGR) and Organophosphates, such as 'Prodex) and larval density in the foliage and in tubers in sandy soil. In contrast, no such correlation was found in loessial soils. Therefore, data indicate that these chemical treatments are ineffective against the pest (both adults and larvae). Additionally, the organophophates are harmful to natural enemies and retard their ability to suppress pest populations. Furthure, the lower efficiency of the insecticides in loessial soil may be due to their airial application, unlike the ground application in sandy soil. Finally, larvae could be protected from sprays in loess soil, because they are concealed in solid cracks and in the tubers.

A significant variation was found in tuber infestation level in different potato varieties. Moreover, a single variety often suffered higher infestation level when grown in loessial than contrary sandy soil. Therefore, crop variety should be carefully selected also in respect to its susceptibility to the pest.

Larval density was higher in volunteer than in cultivated potato plants. Therefore, volunteer plants may serve as a source of tuberworm infestation in commercial fields and as such their removal could reduce infestation levels. The population density of natural enemies were also higher in volunteer (untreated with insecticides) than cultivated potato plants. This difference may be the result of a positive response of the enemies to pest densities, which were higher on volunteer plants. It may also be the result of negative effect of chemical treatments on natural enemy populations in commercial fields. In a laboratory experiment, all predators that were collected on potato plants in the field were able to prey on tuberworm larvae. In a field trail, half of the plants that were infested with pest larvae were caged to exclude enemies, whereas the other half were left uncaged. Only 16.6% of the released larvae were found on the exposed plants in contrast to a 100% recovery in protected plants. Thus, it seems that natural enemies have an important role in suppressing tuberworm populations and limiting the use of harmful insecticides should conserve these enemies.

In conclusion, results indicate that several cultivation practices may be used to reduce tuberworm infestation. Because chemical treatments appear ineffective against the pest, limiting their use should enhance the activity of natural enemies. Additionally, the pest could be monitotred more intensively in the edges of fields, where it reaches higher numbers. For the same reason, the effectiveness of selective treatment of field edges against the pest should be tested. Carefull timing of roller treatment, frequent irrigations and use of suitable potato varieties should decrease tuber infestation level, particularly in loess fields. Finally, the removal of volunteer plants near commercial fields is highly beneficial.