# Potato tuberworm: impact and methods for control – Mini Review

**Yulin Gao**

## Abstract

The potato tuberworm, *Phthorimaea operculella* Zeller, is one of the most economically significant insect pests of potato in both field and storage worldwide. The biology of the pest and various management strategies such as cultural practices, biological, and chemical control and other control methods are reviewed.

**Keywords:** *Phthorimaea operculella*, Potato, Pest management, IPM

## Origins, Distribution and Impacts

Potato tuberworm, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae), which probably originated in the tropical mountainous region of South America, is currently a cosmopolitan potato pest. It is considered to be the most damaging insect pest of potatoes in the developing world of the tropics and subtropics in both field and storage. This moth is distributed over a wide range of tropical and subtropical countries in South, Central and North America, Africa, Australia and Asia. In the mid 1800, *P. operculella* was reported as a potato pest when tuber damage was first reported in Tasmania. In South Central Asia, *P. operculella* was first introduced to Bombay, India in 1906, but by the mid-1900s, *P. operculella* became widely distributed in all potato regions in India. In China, *P. operculella* was first reported in Guangxi Province in 1937, at present, *P. operculella* is widely distributed mainly in Yunnan, Guizhou and Sichuan provinces. All these provinces are key potato production areas. In the mid-1970s, *P. operculella* was introduced to Iraq and by the early 1980s it was found in Russia. In 1913, *P. operculella* was first reported in the USA. From 2002, *P. operculella* has emerged as a problem in the Bologna providence in northern Italy.

The potato tuberworm has four life stages: adult (Figure 1), egg, larva (Figure 2) and pupa (Figure 3). Adults are small moths with a wingspan of 1.27 cm. Eggs are $\leq$0.1 cm spherical, translucent, and range in colour from white or yellowish to light brown. Female usually preferred exposed tubers, particularly damaged tubers for oviposition to foliage in fields. The eggs might be deposited on the surface of exposed tubers or on the ground of the tubers. Adult female moths lay 150–200 eggs on the underside of leaves, on stems and in tubers. Larvae are usually light brown with a characteristic brown head. Mature larvae may have a pink or greenish colour. Larvae close to pupation drop from infested foliage to the ground and may burrow into the tuber. Ultimately, larvae will spin silk cocoons and pupate on the soil surface or in debris under the plant.

Although the potato tuberworm host range includes a wide array of Solanaceous crops such as tomatoes, peppers, eggplants, tobacco and weeds such as nightshade, the pest has been recorded as the most important insect pests on potato and tobacco in the Southwest region of China. Tuberworm larvae behave as leaf miners. They can also live inside stems or within groups of leaves tied together with silk. The most important damage is to tubers, also a food source for the larvae, especially exposed tubers, or those within centimeters of the soil surface. Larvae can infest tubers when foliage is vine killed or desiccated right before harvest. Tunnels left by tuber worms in tubers can be full of droppings or excrement that can be a potential source for secondary infections.

## Control Methods

Several methods for the development of an integrated pest management system for potato tuberworm are available. However, the use of chemicals is still the main foundation of potato tuberworm control worldwide including in China. A thorough knowledge of the distribution, host range, biology, ecology and economic effect of a pest is necessary before developing management practices. It is difficult to achieve effective control by a single method when the infestation is very high. When populations are low, any individual component may be effective.

*Cultural Control* Cultural practices for potato tuberworm control may include prevention of soil crack with regular irrigation, setting tubers deeply (at least 2 inches deep), prompt harvesting and sanitation of the garden through removal of volunteer plants, crop rotation, clean storage practices, plantation of uninfected seed pieces and destruction of culling piles. Any of these practices may reduce the exposure of the potatoes to egg-laying female moths, thus reducing potato tuberworm damage and aiding in preventing tuberworms in potato crops.

*Biological Control* Controlling potato tuberworm via an organic method of eradication is accomplished utilizing

**Figure 1** Potato tuberworm adult.

**Figure 2** Potato tuberworm larva.

**Figure 3** Potato tuberworm pupa.

parasitoids and predators. Beneficial nematodes may also be introduced and are an environmentally friendly method of potato tuberworm control. These nematodes seek out and kill soil inhabiting potato tuberworm larvae without harming beneficial insects, such as ladybugs or earthworms. They can be found for sale online. Our recent results indicated that *Beauveria bassiana* strain SD is highly virulent to potato tuberworm and significantly reduces survival of potato tuberworm larvae. The SD strain caused higher mortality than observed in laboratory trials for other strains of *B. Bassiana*. The cage experiment further supports our laboratory studies regarding the virulence of the SD strain. Furthermore, we found that B. *bassiana* not only has high pathogenicity to potato tuberworm larvae, but also cause sub-lethal effects, which include shortening the development period of one generation, reducing the fecundity of female of offspring and affecting their population parameters. In addition, attract-kill technique, the behavioural manipulation techniques including uses of sex attractant, oviposition deterring semiochemicals and food lure etc, also a good biological control strategy.

*Chemical Control* When all else fails for potato worm control, there are pesticides that may be applied to aid in their eradication. Additionally, the use of pheromone traps can detect potato tuberworm moth activity and help to pinpoint the correct timing for insecticide control. A simple pan of soapy water with a lid for hanging the pheromone bait can be placed among the potato crop in the garden, or a sticky trap may be used to capture the moths. Insecticide must be used before vine kills or it will have no efficacy. Insecticides for controlling potato tuberworm should be used in the evening during the moths' most active time and can be found at one's local garden center. Utilizing cultural methods for preventing tuberworms in potato crops such as irrigation to prevent soil cracks, planting uninfected seed pieces and deep seating of tubers before attempting to use an insecticide for controlling potato tuberworm.

*Plant Resistance* Host plant resistance factors, both natural and engineered, would augment current pest management practices. Natural host plant resistance factors from the Solanum species can be introgressed into the cultivated potato through traditional breeding. *Solanum berthaultii* 'Hawkes', *Solanum commersonii* 'Dunal', *Solanum. sparsipilum* 'Bitter', *Solanum sucrense* 'Hawkes' and *Solanum tarijense* 'Hawkes' have reported resistance to potato tuberworm. Combine avidin with natural host plant resistance factors against potato tuberworm also report. Combining avidin with other resistances factors, including natural host plant resistance factors, such as leptines or glandular trichomes, or other transgenes, such as Bt-Cry proteins, may provide strong and broad-spectrum plant protection. For example, combining avidin with a stronger natural host plant resistance factor from *S. berthaultii*, *S.commersonii*, *S. sparsipilum*, *S. sucrense* or *S. tarijense* may provide superior protection against insect pests.

## Conclusions

A thorough knowledge of the distribution, host range, biology, ecology and economic effect of a pest is necessary

before developing management practices. It is difficult to achieve effective control by a single method when the infestation is very high. When populations are low, any individual component may be effective. Other actions such as deeper seed planting, hilling the rows, irrigation, the release of parasitoids in the early stage of the crop should be practised. In later stages, the selective use of recommended insecticides and mass trapping with sex pheromones or yellow cards should be put into practice. In storage, it is necessary to remove damaged tubers before storing. Sex pheromones may be used for monitoring and mass trapping with water traps. Screening of germplasm may be practised in endemic areas to identify resistance in the field and in storage. This will provide a base for long-term management to reduce the pest incidence in a continuous cropping system.

## Acknowledgements

This work was supported in part by the National Key Research and Development Program (2018YFD0200802). Thanks to Prof Runzhi Zhang (CAS-IOZ) for preparing the pictures in the current version.

## Bibliography

Gao YL. Potato tuberworm: a threat for China potato. Entomology, Ornithology & Herpetology: Current Research 2018;7:e132.

Yuan HG, Wu SY, Lei ZR, Rondon SI, Gao YL. Sub-lethal effects of *Beauveria bassiana* (Balsamo) on field populations of the potato tuberworm *Phthorimaea operculella* Zeller in China. Journal of Integrative Agriculture 2018;17:911–8.

Yuan HG, Lei Z, Rondon SI, Gao YL. Potential of a strain of *Beauveria bassiana* (Hypocreales: Cordycipitaceae) for the control of the potato tuberworm, *Phthorimaea operculella* (Zeller). International Journal of Pest Management 2017;63:352–4.

Rondon SI. The potato tuberworm: a literature review of its biology, ecology, and control. American Journal of Potato Research 2010;87:149–66.

Kroschel J, Zegarra O. Attract-and-kill: a new strategy for the management of the potato tuber moths *Phthorimaea operculella* (Zeller) and *Symmetrischema tangolias* (Gyen) in potato: laboratory experiments towards optimising pheromone and insecticide concentration 2010;66:490–6.

Kroschel J, Zegarra O. Attract-and-kill: a new strategy for the management of the potato tuber moths *Phthorimaea operculella* (Zeller) and *Symmetrischema tangolias* (Gyen) in potato: evaluation of its efficacy under potato field and storage conditions 2013;69:1205–15.

### About the author

Dr. Yulin Gao is an insect ecologist/entomologist working in Institute of Plant Protection, Chinese Academy of Agricultural Sciences (CAAS) in Beijing, China. Currently, he is Horticultural Entomology Professor and Chair for the Department of Research Extension in IPP-CAAS. He serves as the Executive Editor of *Pest Management Science*. He is on the scientific advisory board for the 26th International Congress of Entomology 2020 Finland; committee member of International Branch of Entomological Society of America (ESA); committee member of Division of Bacteria of Society for Invertebrate Pathology (SIP); committee member of the second International Congress on Biological Invasions and the Vice President of the Asia Pacific Regional Section-International Organization for Biological Control (APRS-IOBC). His research has focused on the IPM of agricultural insect pests for many years. Specifically, his scientific interests cover the fields of IPM of thrips and potato tuberworm. Currently he is in State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China. Email: gaoyulin@caas.cn

doi: 10.1079/PAVSNNR201813022

The electronic version of this article is the definitive one. It is located here: http://www.cabi.org/cabreviews