POTATO TUBER MOTH

potatoes aartappels SA

Compiled and published by Potatoes South Africa (Department: Research and Development Department) June 2015

Proposed amendment: Potatoes South Africa. 2015. Factsheet: Potato tuber moth. www.potatoes.co.za/research/factsheets

POTATO TUBER MOTH

The **potato tuber moth**, *Phthorimaea operculella*, is originally from South America and has been a pest in South Africa on potatoes for more than 100 years. It occurs in all production regions and is especially problematic during hot years and in areas with low rainfall.

Moth larvae mainly attack the plant foliage, but the most damaging period is at the end of the season when the tubers below ground are also attacked. The potato plant is the primary host, but tobacco, tomato and eggplant are also affected. Several broadleaf weeds also serve as alternative hosts.

Although the potato tubermoth has several natural enemies, control is mainly chemical. Monitoring by means of pheromone traps is one way of determining the pest pressure in farmlands.

DAMAGE

Foliage Potato tuber moth larvae are leaf miners that tunnel into the plant tissue (foliage and tubers). Mines are mainly formed in the leaves (between the two epidermal layers), but sometimes growth points are also attacked. Larvae will not, however, tunnel down through the stems to the tubers below ground. Leaf mines are mostly inconspicuous "window-like" marks that can be recognised as those of the potato tuber moth by holding them up against the light (see photos). The damage to the above-ground parts of the plant does not necessary lead to economic loss, since moth infestations during the growing season do not usually occur in such high numbers that plants are completely stripped of foliage. If large numbers of moths colonise a field early in the season, very small or young plants will be negatively affected. Moth infestation of the above-ground parts of plants can put subtle stress on the plant and possibly cause wounds through which pathogens can access the plant.

Tubers below ground When the first instar larvae reach a tuber below ground, the tuber is immediately penetrated (not necessarily at an eye), after which the larvae eat small tunnels under the skin. Older larvae will then go on to create larger and deeper tunnels. Since the first instar larvae are so small, there is usually no sign of where the larvae have penetrated the tuber. The tunnels created under the skin will later collapse, decay and darken in colour, which gives the tuber the characteristic symptoms of potato tuber moth damage.

Although above-ground infestation does not necessarily lead to losses, it plays an extremely important role in the build-up of populations, which can lead to serious crop losses later in the season. Without adequate pest control, the moth population will be extremely high at the end of the season. Thousands of moths will be flying around and continue to lay eggs, while the amount of foliage and green plant matter becomes less. Even after foliage die-back, most moths will continue to lay eggs on dead plant matter and on the ground. This means that hundreds of thousands of first instar larvae can occur in a field and penetrate cracks in the soil while looking for food. Enlargement of tubers prior to foliage die-back results in numerous microscopic cracks in the soil, which serve as ideal access points to the tubers. The infestation of tubers during foliage die-back can lead to serious crop losses – up to as much as 80%.

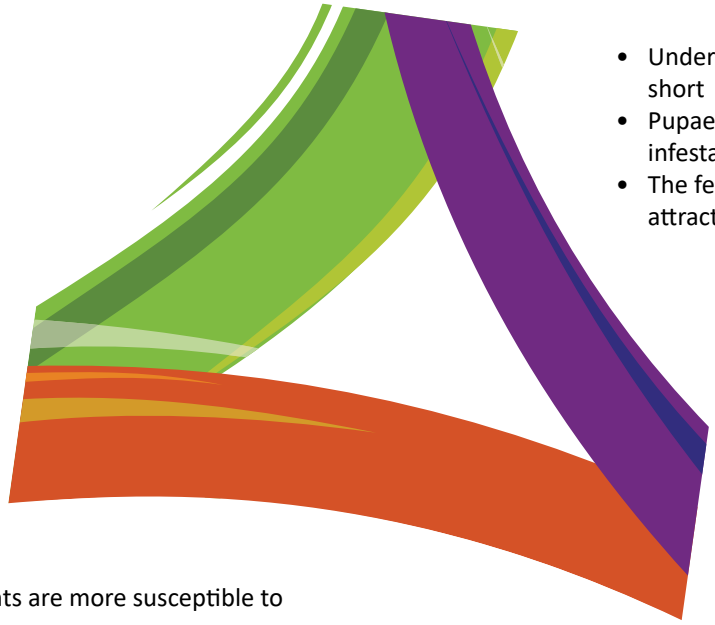
Tubers in storage If a second or third generation is allowed to develop, the entire contents of the storage shed can be destroyed within two months. The first instar larvae penetrate the tubers mainly at the eyes, after which they tunnel under the skin. Deeper tunnels are formed in the tuber over time.

The damage symptoms differ in tubers taken from the ground compared to tubers in storage. Tubers that are attacked while in storage display fewer characteristic tunnels, but they have clearly visible excreta, mainly at the eyes.

RISK MANAGEMENT

	RISK	MANAGEMENT
PLANTING TIME	Hot, dry season	Hot, dry conditions are not only highly favourable for the development of the potato tuber moth, but also cause stress that weakens the plant. - If possible plant during the cooler months.
CHOICE OF LAND	Source of pupae near a field	- Limit sources of initial infestation, namely 1) recently harvested fields where pupae are constantly hatching from the soil, 2) nearby volunteer plants and tubers, 3) dumping sites and 4) alternative host plants. - Plant as far away as possible from recently harvested fields in order to limit infestation from pupae hatching from the soil in those fields. - Bury or destroy waste tubers and plant rests from previous plantings.
CHOICE OF CULTIVAR	The potato tuber moth infests certain cultivars	No meaningful differences have been found amongst cultivars in South Africa. However, there are indications that Vanderplank is slightly less susceptible if the moth has a choice of cultivars.
SEED POTATOES	Infested seed potatoes	Seed potatoes can be a source of eggs or latent infestation by first instar larvae, especially where the seed potatoes have been left out of cold storage for long periods of time to sprout. - Plant certified seed potatoes as it lowers the risk of moth infestation. - Examine seed potatoes for symptoms of infestation on arrival and again just before planting, if they have been stored on the farm for a long period of time. If the infestation exceeds the level accepted by the South African Seed Potato Certification Scheme when it is delivered on the farm, the seed potatoes may be refused. - If a permitted level of infestation does occur, implement a suitable spraying programme as early as possible.
CROP MAINTENANCE	Heavy infestation early in the season	The origin of early infestation is usually a nearby source, e.g. volunteer plants, recently harvested fields, rubbish heaps and to a lesser extent, infected seed potatoes. - Insure that all sources are removed before planting commences.
	Spraying programme does not control potato tuber moth	Nearby sources of infestation and unusual weather conditions with long periods of hot and dry weather can lead to population “explosions”, reducing the effectiveness of any spraying programme. - Preventative control is recommended. If preventative control programmes give inadequate control, consideration should be given to 1) the correct use and alternation of chemicals, 2) sufficient leaf wetting, and 3) any factor that favours the breeding ability of moths.
	Dry soil forms cracks	Even microscopically small cracks give access to larvae. - Ridge furrows to reduce cracks.
HARVESTING	Large-scale infestation of tubers in the ground after foliage die-back	The longer the crop is left in the ground, the greater the chance of infestation. - Limit cracks in the soil, if possible by irrigation or ridging. - Control the moth at the end of the season to prevent late-season infestation.
STORAGE	Infestation of seed potatoes	Stored potatoes that are not cooled, and seed potatoes put out for sprouting, are highly susceptible to moth infestation. There are insecticides available for the protection of seed potatoes against the potato tuber moth. - See to it that there is no source of the moth inside or near the storage shed. - Start early with a spraying programme if infestation in seed potatoes is suspected.

INFESTATION



Insect pest

- Under favourable conditions, the lifecycle is short
- Pupae in the soil are a source of ongoing infestation
- The female moth excretes pheromones that attract the male

Planting

- Weakened plants are more susceptible to infestation
- Foliage, tubers in the ground and tubers in storage are affected
- All cultivars are susceptible to infestation
- The host range is primarily from the Solanaceae family

Environment

- Temperatures of 26-30°C is optimal
- Dry, hot weather is favourable for infestation of tubers

When moths colonise a potato field, the above-ground parts of plants are usually their first target. The moth does not always lay her eggs on the plant only, but also anywhere near the plant. The larvae will then move around until reaching the plants or the tubers below ground.

Unless potatoes are planted alongside a field that is heavily infested, the potato moth will usually enter farmlands in low numbers. These numbers must first grow to a much larger population before the larvae will have any effect on the crop. Four to five generations of the moth will usually breed during one season in the summer.

Moths that enter storage sheds from outside, as well as infected tubers that are brought into sheds, can both lead to the infestation of tubers in storage sheds.

LIFECYCLE AND DESCRIPTION OF STAGES

Moth and eggs The adult potato tuber moth is 8 to 10 mm in length. The moth is nocturnal and usually active just after sunset.

The male moth locates the female through pheromones excreted by the female. Mating occurs immediately, and the female lays all her eggs within two to three days. A single female lays approximately 200 eggs on plants or on the ground beneath plants.

In warm weather, the eggs will hatch within three to five days. The moth has a lifespan of one to two weeks and it does not need to feed, but it is able to live for a few days longer if it has access to liquids.

Larvae The first instar larvae that hatch are approximately one millimetre in length. They will actively move around in search of a place where they can penetrate the plant. They mine into the leaves between the upper and lower layers of the leaf. In the process, window-like tunnels are formed.

Larvae will also sometimes tunnel downward from the growth points. The larvae eat and live in this protective environment – so they are usually never observed on the plants. In hot weather the larvae will be fully grown within two weeks, but in colder conditions this process can take months.

Pupae The final instar larvae (approximately 12 mm in length) leave the plant and move towards the ground surface (downwards from the above-ground parts of plants, and upwards if the tubers were infested), where they spin a cocoon in which they pupate.

The cocoon, which is reinforced and camouflaged with sand particles, offers protection against natural enemies and is not normally visible with the naked eye. Where there is no sand available, e.g. in storage sheds, the larvae will use dust particles, and where there are no dust particles, cocoons are simply spun from silk in cracks and crevices.

The larva will transform into a pupa in the cocoon within two days, and after seven days the moth will emerge from the cocoon.

Effect of temperature on life cycle Temperature plays an important role in the potato moth's development rate. However, it is important to be aware that at no stage does the moth hibernate. All stages (eggs, larvae and pupae) will continue to develop, even in the coldest winters, with daytime temperatures above 10°C. It is only at temperatures below freezing and during long periods of temperatures above 33°C that mortality will set in.

The following guidelines apply for the duration of the lifecycle stages at temperatures between 26 and 30°C:

- eggs – as few as three days
- larvae – as few as nine days
- pupae – as few as five days
- moths – one to two weeks, but with eggs being laid within four days.

The lower the temperature (below 26°C), the longer the duration of lifecycle stages, as indicated above. Under conditions of 26 – 30°C, a new generation can thus develop within three weeks. Under field conditions (cool nights), this usually takes four to five weeks.

ASPECTS OF MANAGEMENT

Insecticides More than 130 insecticides are registered for use against the potato tuber moth in South Africa. They are represented by approximately 29 active ingredients, with some being combinations of active ingredients. The older products are mainly organophosphates, pyrethroids and carbamates. However, several new groups have been registered since the nineties. The producer can now alternate between a wide range of pesticides. Alternating between different chemicals is one of the most important strategies for the prevention of immunity in insect populations.

How to alternate between chemicals. Make a list of the insecticides you have or which you want to use. Each insecticide (active ingredient) is classified into one of 28 resistance groups – the group should be indicated on the label. If you are unable to identify the resistance group, you can download a publication from the website "http://www.irac-online.org/countries/south-africa/publications/". This publication lists most of the active ingredients and the groups into which they are classified. The resistance groups are categorised in such a way as to give the producer an indication of which groups are interrelated regarding their effect on pests. It is therefore recommended that pesticides falling into the same group are not alternated with one another (they will have the same effect, which will accelerate the building of resistance to them).

The most common means of alternating is to use a different group of insecticides for each spray application. A method that is sometimes used is "block spraying", where the same chemical (or the same group of chemicals) is used for two to three consecutive applications (at the recommended intervals), after which it is not used again for the rest of the season. Alternating in this way is recommended only for pests with a lifecycle longer than the duration of the "block". For the potato tuber moth, with a lifecycle of approximately four to five weeks, this means that block spraying with one particular chemical should not be done for longer than four weeks (two to three applications). The labels of some insecticides give more information on block spraying, as well as the maximum number of times the particular chemical may be used in a single season.

A study recently conducted amongst 15 moth populations found no evidence that any of those moth populations had built up resistance to any insecticide. Although the study was conducted under laboratory conditions, even reduced doses (up to as low as 25% of the recommended dose) gave effective control. The reason for poor control still being reported by farmers is likely a combination of factors, namely: environmental conditions (hot and dry weather), nearby sources of inoculum (rubbish heap or recently harvested field), and sub-optimal application practices.

When to commence with application. Most integrated pest-control programmes recommend that spraying commences as soon as certain threshold values (number of insects or symptoms of damage) are reached. The labels of some insecticides also give an indication of when spraying should commence. The leaf mines created by the potato tuber moth larvae are not always visible or conspicuous. Moreover, there is no scientifically founded threshold value available to determine when spraying should commence. For these reasons, and because the potato tuber moth is one of the most

destructive potato pests, most producers start spraying about two weeks after emergence.

Spraying programmes There is no standard spraying programme against the potato tuber moth. Of course, some chemical companies and also chemical representatives in specific regions have devised their own programmes over the years for recommendation to their clients. Such programmes are adjusted regularly as new chemical groups come onto the market.

Broad guidelines include the following:

- Ensure that equipment is calibrated and in good working order, and see to it that chemicals are used and alternated correctly (follow the directions on the label carefully).
- Ensure sufficient leaf wetting.
- Do not spray under unfavourable conditions, e.g. at the hottest time of the day and/or when there is a strong wind blowing.
- Systemic or translaminar chemicals work best when plants are still actively growing (before the second half of the season).
- If the population pressure is high, or if conditions are favourable for the moth (long periods of hot and dry weather), use the shortest spraying interval as indicated on the label.

Tank mixtures The mixing of different pesticides in a single tank (including chemicals to control plant diseases) may only be done on recommendation of the relevant suppliers or manufacturers. Some mixtures may be detrimental to plants, while some mixtures/additives must be added to the spray tank in a particular order.

Other host plants include tobacco, tomato and eggplant. Weeds of the Solanaceae family are also susceptible. In the off season, the potato tuber moth may survive on these crops in low numbers, but not as a major source of infestation.

Monitoring with pheromones Pheromones are the volatile excretions of the female potato tuber moth, which attract males over long distances for purposes of mating. These days the pheromone is commercially available in the form of rubber capsules, for monitoring in pheromone traps. The only way to accurately determine moth numbers, or to determine whether moth numbers are rising, is through the use of pheromone traps. Potatoes South Africa is currently conducting research on the correct use and placement of pheromone traps in farmlands. The current, untested recommendation is for the placement of one trap per quadrant of farmland (large farmlands), on top of furrows and at least 15 metres in from the closest edge of the farmland. Although commercial traps and pheromone capsules are available in South Africa, most farmers make their own traps.

Ridging Regular ridging will seal cracks that are formed during the growing season and will also protect exposed tubers. Ridging is often scaled down towards the end of the season, and it is precisely then that the moth larvae burrow down to the tubers under the ground.

Sanitation is the process of reducing or eliminating sources of moth infestation. Such sources include:

- Volunteer plants and tubers that remain behind after harvesting.
- Dump sites.
- Infected seed.
- Alternative host plants.

Of these, volunteer plants and tubers that remain behind in nearby fields after harvesting are the most important.

Rotation Crops belonging to the Solanaceae family should not be used in a rotation programme. If possible, new fields should be located as far away as possible from recently harvested fields.

Seed potatoes Certified seed potatoes reduce the risk of early infestation.

Seed potatoes are susceptible to the potato tuber moth after certification, and especially during storage. The longer the storage period, the greater the risk. When seed potatoes are inspected on arrival at the farm, particular attention must be paid to eye damage.

The maximum allowable percentage of seed potatoes with symptoms of potato tuber moth is as follows:

Type of damage	G0	G1-3			G4-6			G7 and G8		
		Elite	Class1	Std*	Elite	Class1	Std	Elite	Class1	Std
Eye damage	0	0.2	0.5	3.0	1.0	2.0	3.0	1.0	2.0	3.0
Surface damage	0	0.2	1.0	4.0	2.0	3.0	4.0	2.0	3.0	4.0
Both	**0**	**0.2**	**1.0**	**4.0**	**2.0**	**3.0**	**4.0**	**2.0**	**3.0**	**4.0**

• *Standard Grade*

Natural enemies The potato tuber moth has several known natural enemies. These include predators that catch and eat moths, as well as tiny wasp-parasitoids that infect and kill the eggs and larvae. There are primarily two imported parasitoids, namely *Copidosoma koehleri* and *Apanteles subandinus*, which are responsible for a very high mortality rate amongst the potato tuber moth in South Africa. However, both these parasitoids are highly susceptible to insecticides and are usually found in very low numbers in areas where spraying programmes are followed. Potatoes South Africa is currently conducting a project to investigate the effect of so-called "softer chemicals" on these parasitoids.

Resistant cultivars Resistant cultivars are not an option, since most cultivars are equally susceptible to moth infestation. There are indications, however, that the "Vanderplank" cultivar is less susceptible to moth infestation where the moth has a choice of cultivars. Genetically manipulated potatoes that are 100% resistant to moth larvae do exist, but they are not commercially available in South Africa.

Planting and harvesting schedules A planting schedule that results in a crop that grows mainly during the cooler months of the year, will lower the risk of infestation. The longer it takes before the crop is harvested, the greater the chances of tuber infestation.

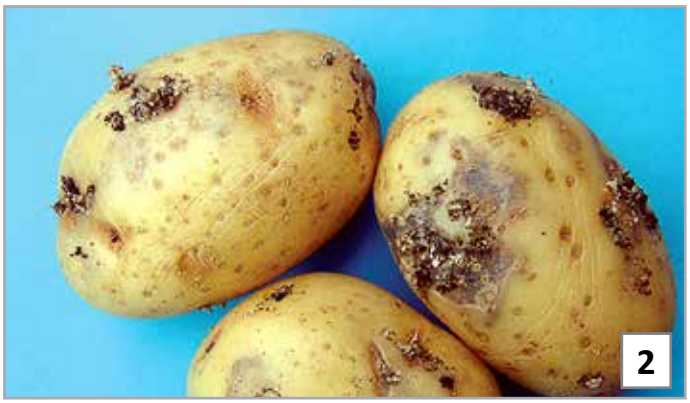
DO NOT CONFUSE DAMAGE CAUSED BY POTATO TUBER MOTH AND POTATO LEAF MINER

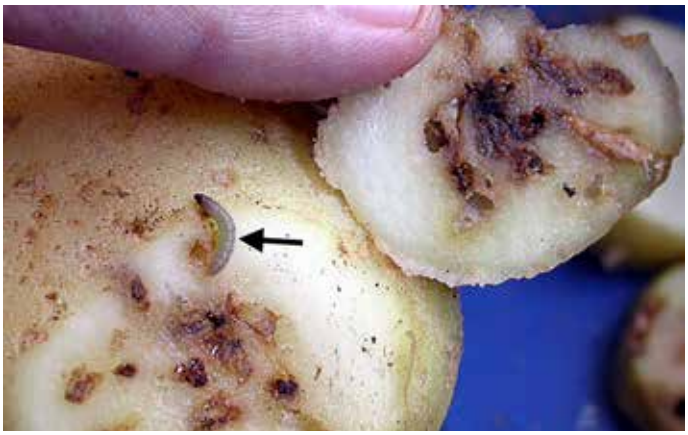
Potato leaf miner damage

potatoes aartappels SA

Private Bag X135, Pretoria, 0001, South Africa
Tel: +27 (0) 12 349 1906 | Fax: +27 (0) 12 349 2641
www.potatoes.co.za

POTATO MOTH LIFECYCLE STAGES AND SYMPTOMS OF DAMAGE





ACKNOWLEDGEMENTS: Technical information and photos: Dr Diedrich Visser, Agricultural Research Council