PIP

GUIDE TO GOOD PLANT PROTECTION PRACTICES

FOR THE PRODUCTION OF POTATO (*SOLANUM TUBEROSUM*) IN ACP COUNTRIES

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In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Notice

The Guide to Good Plant Protection Practices (fruit or vegetable) details all plant protection practices and recommends primarily the active substances supported by pesticides manufacturers in the framework of european Regulation 1107/2009, for organic production those allowed for usage by the EC Regulation 834/2007 and 889/2008, that must comply with standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with MRLs. The information given on the active substances suggested is therefore changeable and will be adapted on an ongoing basis in accordance with the new information collected by PIP.

It is, of course, understood that only those products legally registered in their country of application are authorised for use. Growers must therefore check with the local regulatory authorities to see whether the product they wish to use is included on the list of registered products.

The PIP's crop protocols and guides to good phytosanitary practices are regularly updated. For further information, see the PIP website www.coleacp.org/pip

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DISCLAIMER

Ongoing regulatory reviews and the implementation of stricter standards have led to many changes to authorisations of plant protection products (PPPs) and maximum residue limits (MRLs), both within the European Union (EU) and at international level. This has a direct impact on producers, who often must change their production practices (good agricultural practices, GAP) to comply with the new rules. Any non-compliances can lead to the interception and destruction of produce, causing significant financial losses as well as reputational damage.

Please note that this document has not been updated since 2013, and information it contains regarding the status of PPP authorisations and MRLs may not be up-to-date. This document is currently under revision.

Before applying any PPP, it is advisable to consult the latest regulatory changes. Producers may supply diverse markets that follow different regulations. EU approval of active substances and MRLs can be consulted in the **EU Pesticides database**[1]. For domestic and regional markets, a list of PPPs registered for use is usually provided by the national competent authorities. African, Caribbean and Pacific (ACP) countries generally apply the MRLs set by the **Codex Alimentarius**[2].

Keeping track of PPP authorisations and MRL changes is complex and time-consuming, but is essential to ensure regulatory compliance. COLEACP has responded to requests to provide a PPP information service that keeps members up-to-date with the changes that are most critical for the ACP fruit and vegetable sector. This includes a database (**e-GAP**) for COLEACP members and partners, which lists EU and Codex Alimentarius MRLs for key horticultural crops in ACP countries. It also provides the GAP (dose rate, intervals between treatments, pre-harvest intervals) that ensure compliance with these MRLs. Additional information is also offered – type of pesticide, r egistration s tatus o f active substance in the EU and in ACP countries, classification recommended by the World Health Organization, and resistance group (FRAC code for fungicides; IRAC classification for insecticides. The e-GAP database can be accessed via COLEACP's e-services website: eservices.coleacp.org.

1 https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN

2 http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/pesticides/en/

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1. Main pests and diseases, and their importance

This guide deals with the protection of potatoes, a crop produced for its tubers.

1.1 Impact on quantity and quality of production

The main pests and diseases discussed in this guide are listed below. This section presents, for each, the:

- level of economic importance generally observed in ACP countries, rated on the scale (+) **low**, (++) **average**, (+++) **high**, (++++) **very high**;
- parts affected and how they are attacked;
- resulting types of loss, all of which decrease the yield of marketable produce and consequently cause a loss of income. The presence of pests and diseases can reduce yield and cause losses at different levels:
  - fewer plants per hectare,
  - fewer tubers per plant,
  - smaller size of tubers,
  - lower quality product.

Quarantine organisms in Europe are followed by the abbreviation "**QO**".
As regulations can change, the status of quarantine organisms should be checked on the websites of the European Union (http://europa.eu/legislation_summaries/food_safety/plant_health_checks/f85001_en.htm) and EPPO (www.eppo.org/QUARANTINE/quarantine.htm).

INSECTS						
Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
LEPIDOPTERA						
Noctuidae						
Defoliating caterpillars *Spodoptera exigua, Spodoptera littoralis* « QO », *Helicoverpa armigera* « QO »						
The economic importance of these pests varies considerably according to the degree of infestation and the plant's phenological stage.						
+ to ++	The caterpillars devour the parenchyma of the leaves. The dried epidermis is all that remains. The crop seems to be burned out after a sustained attack.				Possible reduction in tuber size if major infestation on leaves at first potato stages.	Reduction in the size of marketable tubers.
Cutworms *Agrotis ipsilon, A. segetum*						
+	The caterpillars shelter in the surface layer of the soil. They devour the foliage and cut the stems flush with the soil as they feed.		Number of young plants reduced by the death of cut stems.	Reduced number of young plants per unit of surface and therefore of the tuber yield. Their size also suffers as a result of defoliation.		

INSECTS - cont.						
Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Sphyngidae						
Death's-head hawkmoth *Acherontia atropos*						
+	The leaf has irregular holes or is consumed entirely except for the petiole			The size and number of tubers can be reduced if there is major proliferation causing significant defoliation.		Dominance of small tubers with little commercial appeal.
Gelechiidae						
Potato tuber moths *Phthorimaea operculella, Tecia solanivora*						
Moths cause occasional damage in the field as well as when storing and preserving tubers. *Tecia solanivora* is found in the Caribbean (and Central America).						
++ to ++++	The larvae undermine the lowest, widest leaves and create silvery stains.	The larvae dig mines inside tubers. These mines pave the way for fungi and bacteria, which increase the risk of rotting.	A very severe attack then causes the young plants to wither and die, thereby reducing their numbers.			The affected tubers are not fit for consumption. Tubers rot after a short storage period.
ORTHOPTERA						
Grillidae						
Cricket and mole cricket (polyphagous) *Brachytrupes membranaceus, Gryllotalpa africana*						
+ to ++	The larvae and adults section the stems flush with the ground and devour the leaves during the night.		Reduced following direct damage to the stems.			
Pyrgomorphidae						
Stinking grasshopper (polyphagous) *Zonocerus variegatus*						
+ to ++	Taking food from leaves, stems and flowers. Sometimes total destruction of the leaf blade.		Reduced by direct damage to the leaves and stems.			
ISOPTERA						
Termitidae						
Termites *Microtermes* spp.						
++to +++	Inner tissues of the stem collar attacked		Reduced due to weakened stems and plant death.			

INSECTS - cont.						
Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
HOMOPTERA						
Aleyrodidae						
White fly (cosmopolitan) *Bemisia tabaci* « Q0 »						
+ to ++	The larvae and adults live on the underside of leaves and tap the intracellular fluids.			Loss of plant fluids weakens young plants. Main damage caused by the transmission of viruses which can cause considerable weight loss of tubers.		Reduction in the size of tubers.
Aphididae						
Aphids *Myzus persicae, Aphis gossypii, Aulacartum solani, Macrosiphum euphorbiae*						
+ to ++	The larvae and adults pierce the leaves and suck out the plant fluid.			Possible reduction (number and size) if major infestation on the leaves. Main damage caused by the transmission of viruses, which exacerbate yield reduction.		
HEMIPTERA						
Cicadellidae						
Leafhopper *Jacobiasca lybica*						
+ to ++	The larvae and adults feed on the stems and leaves, piercing them to suck out the sap.		Possible reduction if major infestation on the young plants.			
Coreidae						
Brown bug (tropical Africa - very polyphagous) *Anoplocnemis curvipes*						
+ to ++	The larvae and adults suck out the sap by piercing the petioles and young stems.		Reduced as a result of the withering and death of injured organs, above all the young stems.			
COLEOPTERA						
Chrysomelidae						
Andrector ruficornis						
+ to ++	Larvae and adults eat the leaves.			High reduction due to reduced photosynthesis.		

MITES

Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Foliage mites *Polyphagotarsonemus latus, Aculops lycopersici, Tetranychus* spp.						
+ to ++	Pitting from larvae and adults feeding on the leaves.			Possible reduction if major infestation on the leaves.		
Root mites *Rhizoglyphus echinopus*						
+		These are hollowed out and present corridors filled with a granular flour.				The tubers rot and are not fit for consumption.

NEMATODES

Extent	Organs attacked		Types of loss			
	Roots	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Nematodes *Meloidogyne* spp., *Pratylenchus* spp., *Helicotylenchus* spp.						
+ to ++	The larvae penetrate the roots.		Dieback of young plants.	Reduction if roots severely attacked.		Deformed tubers.

VERTEBRATES

Extent	Organs attacked		Types of loss			
	Roots	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Rats *Rattus rattus, R. norvegicus, Myomys daltoni, Cricetomys gambianus*						
+ to ++		Gnmawing serves as a point of entry for numerous pathogenic micro-organisms.		Reduction in the number of whole tubers.		

DIPLOPODA

Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Millipedes						
+ to ++		Eaten by millipedes mainly after attacks by weevils.				Reduction in the quality of tubers.

MOLLUSCA

Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Giant African land snail *Achatina* spp.						
+ to ++	Gnawed leaves and stems.		Reduction possible in an early attack.			

FUNGAL DISEASES of leaves

Extent	Organs attacked		Types of loss			
	Leaves	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Early blight *Alternaria solani*						
+ to ++	The spores survive in the residues of the infected crop, the soil and the contaminated tubers. The spores germinate in the presence of water and penetrate the leaf surface causing lesions which remain limited between the veins.	Occasional necrosis of stems and lesions on the tubers serving as a point of entry for other moulds.		The attacks are severe during the rains, causing major defoliation with reduction in yields of table tubers.		The tubers can develop brown injuries during storage which, although only superficial, can affect their appearance.
Leaf mould *Cladosporium fulvum*						
+	Leaf rust or mould.			Major reduction in foliage in cool, damp weather, affecting tuber formation.		Formation of small tubers in a late attack.

FUNGAL DISEASES of leaves - cont.

Extent	Organs attacked		Types of loss			
	Leaves	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Late blight of potato *Phytophtora infestans*						
++ to +++	The mycelia develop on the underside of infected leaves and produce sporangia which propagate the disease.	They cause damp or dry rot on the tubers.	Young plants die due to significant defoliation.	Reduction in the foliar system, death of stems and little tuber formation in an early attack.		Rotting, mummy disease, hard tubers with a bitter taste when cooked.

FUNGI DISEASES of stems and tubers

Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Rots *Sclerotium rolfsii, Rhizoctonia solani*						
++	*R. solani is* transmitted by seed potatoes as scelerotia. Its filaments penetrate and grow in favourable conditions. The fungus produces a growth-regulating toxin.		Reduction through death of young plants. Can occur at all stages.	Early attacks can have a major impact on yield (low tuber formation and drop in tuber weight).		Drop in quality of the visual appearance: small, misshapen tubers, cracked sometimes with superficial impairment.
Fusarium wilt and verticillium wilt *Fusarium oxysporum* « QO », *Verticillium albo-atrum*						
+ to ++	*F. oxysporum* invades vascular tissues. Young plants are infected by V. *albo-atrum* mainly through the absorbent hairs. The hyphae grow across to the xylem vessels and impede water circulation.		Reduction through death of young plants.	Reduction through the withering and death and/or weakening of young plants.		Possible rot in the tubers, making them unfit for consumption.

BACTERIA						
Extent	Organs attacked		Types of loss			
	Leaves	Stems and tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Brown rot of potato *Ralstonia solanacearum* « QO »						
+++ to ++++	The bacterium penetrates the plant through natural or artificial injuries or via nematodes. It multiplies rapidly in the plant tissues and colonizes the vascular system, propagating throughout the plant.	Runners and tuber conducting tissues turn brown.	Reduction through death of young plants.	Early attacks in contaminated or heavy soils (often poorly drained) show a high rate of young plant mortality that can go as far as the entire loss of the harvest.		Possible tuber rot, making them unfit for human consumption.
Soft rots (tubers) / blackleg (stems) *Pectobacterium carotovorum, P. atrosepticum, Dickeya* spp.						
+ to ++	These bacteria develop by vegetating on the foliage or tubers. In all cases, the attacked organs show vessel destruction.	Soft rot of tubers with a strong odour.	Reduction in the number of young plants following withering and death.	In favourable conditions (hot, damp weather), the disease causes high mortality of young plants and a reduction in density.		Soft, viscous rot of tubers, making them unfit for human consumption (in storage).
Common scab *Streptomyces scabies*						
+ to ++	*Streptomyces* invades the tubers via the breathing pores. After penetration, the pathogen colonizes a few layers of cells, which die, and it survives as a saprophyte in the damaged tissues.	"Corky" injuries on the surface of tubers, which can be superficial or deeper.				Depreciation of tuber appearance (presentation).

VIROSIS						
Extent	Organs attacked		Types of loss			
	Leaves and stems	Tubers	Number of plants	Number of tubers per plant	Size/weight of tubers	Quality of tubers
Potato leaf roll virus (PLRV)						
+	This virus is introduced into the plant by vector insects (aphids). The viral particles destroy the vessels of attacked organs and the starch can no longer be conveyed, giving rise to symptoms.			Little tuber formation due to dwarfed plants.	Tubers with reduced size and weight due to dwarfed plants.	Small tubers of little commercial value and unsuitable for use as seed.
Virus X, A and Y						
Potato virus X (PVX)						
+ to ++	The virus is transmitted solely through contact with the foliage during cultural practices. It stays infectious for 6 hours on various supports. It spreads in the whole plant.			Reduction due to reduced photosynthesis.		Small tubers of little commercial value and unsuitable for use as seed.
Potato virus A (PVA)						
+ to ++	The virus is transmitted mainly by aphids, but also through contact between injured plants, for instance in case of strong winds or by agricultural tools. It spreads in the whole plant.			Reduction due to reduced photosynthesis.		Small tubers of little commercial value and unsuitable for use as seed.
Potato virus Y (PVY)						
+ to ++	This virus is transmitted by various species of aphids which are the main vector, but it can also remain latent in tubers used as seed. It spreads in the whole plant.			Yeld reduction due to reduced photosynthesis. Strains of PVY may interact with other viruses like potato virus X (PVX) and potato virus A (PVA) and lead more important losses.		Small tubers of little commercial value and unsuitable for use as seed. Necrotic spots in the tubers cause potatoes with no commercial value.

1.2 Identification and damage

This section contains information and illustrations to facilitate identification of the main pests and diseases.

INSECTS

Insects attacking the aerial parts: leaves and stems

LEPIDOPTERA

Noctuidae

***Spodoptera* spp.**

This genus includes several species. The most significant for potatoes in a hot tropical climate are *S. exigua* and *S. littoralis*. The eggs are usually laid in clusters and covered by scales and hairs detached from the abdomen of the female. These clusters are easy to identify and are very important in controlling these species mechanically.

S. exigua: widespread worldwide, this is a polyphagous species.

Description

An adult moth measures approximately 14 mm with a wingspan of anything up to 35 mm when fully spread. The forewings are grey-brown with two characteristic brown-yellow spots. The caterpillars vary widely in colour but are generally green during the first instars, subsequently turning brown. The mature caterpillars can measure up to 4 cm and are normally black, with dark brown spots generally on their heads and pale yellow stripes on their backs. They are initially gregarious, becoming solitary at a later stage.

Damage

Damage is characteristic: during the early stages, only the upper epidermis of the leaves is chewed and then the whole leaf is devoured apart from the mid-vein. Large numbers of these caterpillars are gregarious, moving around in groups.

S. littoralis: found in Africa.

Description

The adult moth has a whitish body tinged with red. It has narrow, creamy-brown to grey forewings with a complex pattern of whitish stripes and whitish hindwings. The wingspan measures 30 to 40 mm when fully spread. In the early stages, caterpillars are bright green with a black head and prothoracic plate. They gradually turn brownish-black with white spots and a brownish-red median dorsal line.

Adult

Damage

On hatching, the caterpillars remain in clusters on the underside of the leaves and eat the parenchyma. The species sometimes behaves like a cutworm. The caterpillars emerge only at night, hiding in cracks in the ground during the day.
Highly polyphagous, *S. littoralis* is a potentially dangerous pest of potatoes.

Caterpilar

Noctuidae **- cont.**

Cotton bollworm, ***Helicoverpa armigera*** (= *Heliothis armigera*)

Caterpilar

Description

The adult moth has a large body about 20 mm long and a wingspan of 40 mm (wings fully spread). The buff- or tan-coloured forewings have a dark spot in the middle with another dark mark near the base of the wing. The hindwings are pale, edged with a dark marginal stripe with two paler spots.

The caterpillars vary in colour between greenish, yellowish, pinkish and brownish and are covered with short hairs. They have a brownish-black head and prothoracic plate, spotted in the early stages. They often have pale and dark side stripes lengthwise, especially a wide white line on the sides. They can be up to 40 mm long when fully developed.

Damage

The caterpillars gnaw the potato plant foliage, leaving large holes. The damage is most apparent in cropping plans where potatoes grow side by side with other hosts such as tomatoes or corn, or when these crops are grown before potatoes and harvest residues are left in the potato fields.

Agrotis **spp.**

This genus also includes two species of economic significance in potato cultivation: *Agrotis ipsilon* and *A. sepedecum*.

Agrotis ipsilon : found throughout the African continent.

Damage by *Agrotis* spp. (Potato plants cut at ground level (Dalaba, Guinea))

Description

The moth measures about 20 mm with a wingspan of 40 to 45 mm (wings spread fully). The body is greyish-brown. The forewings are brown with a broken line enclosing small black triangles along the outer edge and, towards the middle of the wing, an orbicular spot extended, outwards, by another black cuneate stripe. The hindwings are white with a well marked dark brown marginal stripe.

The caterpillars can be up to 50 mm long when fully developed. They are pale green at birth, with small setiferous tubercles, before turning brown-grey, hairless with a pale ventral side and, dorsally, two pale lines lengthwise either side of a darker mid-line. Each of the caterpillar's body segments has four brown spots on the side.

Agrotis ipsilon – various colours of caterpillars

Damage

Before dispersing, the young caterpillars gnaw the leaves around those areas where the eggs have been laid. When older, they section the stems flush with the ground during the night. The moth is found in a wide variety of plant species, including cereals, legume crops, sweet potato, cotton, tobacco and vegetable crops.

Noctuidae - cont.

Agrotis segetum

Agrotis segetum caterpillars

Description

The moth has a 40 mm wingspan. Fine brown lines cross the wing at its fore third and tip. The forehead has a small jagged bump with raised edges, which can be seen when the covering scales are removed.

The neonate caterpillar is brown-yellow with a slightly reddish back. It measures 40 to 45 mm long when fully developed. Its general colouring becomes lead grey and ochre in individuals entering the nymph moulting stage.

Damage

The caterpillar attacks the crown, roots and tubers. It thus destroys the leaves being formed completely sections the stems of young plants. It is a polyphagous insect, which attacks miscellaneous market garden, forage and floral crops.

Sphingidae

Potato hawkmoth (= death's-head hawkmoth), ***Acherontia atropos*** (L.)

Adult, caterpillar and chrysalid

Description

This large caterpillar is greenish or yellowish in colour, with blue lateral lines. It can be up to 15 cm long. It has an S-shaped horn on the rear of the body.

Damage

Like the sweet potato hawkmoth, the caterpillars feed on leaves, making irregularly shaped holes. They can consume the entire leaf, leaving only the petiole. The sphingidae do not normally cause much damage in potato crops.

COLEOPTERA

Chrysomelidae

Andrector ruficornis

Adult

Larvae and adults can destroy the leaves completely.

ISOPTERA

Termites are social insects, some species are harmful to agriculture. They have mouthparts designed to shred and grind plant tissues. The damage is caused in various ways, including:

- entering the plant stem, a few centimetres below the soil surface and emptying the inside of the collar and the main root, resulting in the weakening of stems and death of the plant (*Microtermes* spp.) ;
- feeding on the plant (*Trinervitermes* spp.) ;
- digging tunnels and building galleries along the stems (destabilization of the plant).

The inventory of termites on potato in the tropics has received little attention although the damage is often significant. However, several harmful species from different genera have been reported on other root/tuber plants such as cassava and sweet potato. The same polyphagous species may be found on potato: *Hodotermes mossambicus* (East and Southern Africa); *Microtermes subhyalinus* (tropical Africa); *M. thoracalis* (Sudan, Central Africa); *Trinervitermes geminatus* (Senegal); *Amitermes evuncifer* (Nigeria) and *Eutermes parvulus* (Senegal).

ORTHOPTERA

Grillidae

Gryllotalpa africana, mole cricket

Description

This insect with a robust, cylindrical body varying in colour from brown to buff lives in the ground most of the time. The adult is 35 to 45 mm long. The head is partially covered by the prothorax and carries highly developed grinding mouthpieces and short antennae, making it extremely visible. It has short, fossorial front legs (specialized for digging). The large, transparent forewings are partly covered with hyaline elytra. The end of the abdomen has two long cerci.

Adult

Damage

The damage is caused either by the movements of the mole crickets on or slightly below the surface, which lift the soil and destabilise the young plants; or by snapping off above-ground organs (leaves and stems) which they take into their burrows to feed on.
The mole cricket also feeds on earthworms (Lumbricidae spp.), underground insect larvae, and roots of vegetable and ornamental plants and various grasses. The mole cricket prefers light, cool soils (easy to dig) with plenty of organic matter and potential food.

Brachytrupes membranaceus

Description

This bright black cricket is 45 to 60 mm long, with a lighter section on the rear of the head. The back leg tibia are armed with powerful spurs. The adult lives in sprawling mines, sometimes fairly deep, opening up to the surface through a huge aperture.

Adult

Damage

The adults section the potato plant stems flush with the ground and devour them on the spot or carry the leaves into their burrows to feed the young crickets.

Pyrgomorphidae

Variegated grasshopper, ***Zonocerus variegatus***

Description

The adult measures 40 to 48 mm. The mid-section is olive green, yellowish on the edges, whilst the head and the rest of the body are black, sprinkled with white, yellow and orange spots. The elytra are green-yellow. The larva is similar to the adult except that its dominant shade is black flecked with yellow.

Larva of *Zonocerus variegatus*

Damage

The variegated grasshopper can damage young potato plants at any stage of their development, but the losses are more acute when the emerging plants are attacked early. The damage is similar to that of numerous other species of cricket encountered in miscellaneous crops in a tropical environment. The larvae and adults devour the leaflets, leaving only the main vein.

HOMOPTERA

Aleyrodidae

Tobacco whitefly, ***Bemisia tabaci***

Description

The adults are small (1 to 2 mm) but can easily be seen on the underside of the leaves because of their white colour. Very mobile, they rapidly take flight. The eggs are laid in the plant tissues. The larvae are oval and flat. The very short biological cycle (28 to 35 days) accounts for the extremely rapid rise in infestation.

Damage

The larvae and adults feed on the sap, creating chlorotic spots on the upper side of leaves. The huge amount of pitting and the toxicity of the saliva injected cause foliar deformation, which in a major infestation dries the leaves out and leaves honeydew on them.

Nymphs

Adult

Damage by *B. tabaci* on potato leaves

Aphididae

Green peach aphid, ***Myzus persicae***

Wingless adult

Winged adult of *Myzus persicae*

Description

The adult is oval in shape and measures 1.2 to 2.5 mm. The body has a pair of abdominal appendages (cornicles) slightly swollen at the tips and prominent tubercles converging at the base of antennae.
The wingless adults are pale green and almost translucent. The winged adults have a black or dark brown head and thorax and a dark dorsal spot on the abdomen.

Damage

The green peach aphid settles mainly on the leaves at the bottom of young potato plants. It also attacks the flowers and shoots.

Glasshouse and potato aphid, ***Aulacorthum solani***

Description

The winged adult is an average-sized aphid measuring 1.8 to 3.0 mm. The antennae are long and pigmented except for the base of article III. The U-shaped forehead has high antennal tubercles with parallel edges. The abdomen is marked with loose, irregular cross striping with little pigmentation. The cornicles are long and straight, not swollen at the base, pale, with a short, pigmented apical section ending in a wide collar.
The wingless adult has a bright green to yellowish green abdomen, with just a large dark green spot at the base of the cornicles.

Damage

A. solani rarely causes significant direct damage to potato crops. It can, however, damage the stored tuber sprouts in warehouses with diffuse light.

Potato aphid, ***Macrosiphum euphorbiae***

Wingless adult of *Macrosiphum euphorbiae*

Distorted leaves

Description

The wingless adult is green to pink in colour with a dark green streak on its back. It is 2 to 4 mm long and has cylindrical cornicles that are twice as long as the tail and dark at the tip. The tail is triangular and very elongated and the fusiform antennae are longer than the body and brown at the tips.

Damage

The pitting slows down young plant growth, resulting in lower yield. Young plants infested with a large population of *M. euphorbiae* normally wilt and their leaves are covered with honeydew.

HEMIPTERA

Cicadellidae

Leafhoppers or jassids are very good jumpers.

Leafhopper ***Jacobiasca lybica***

The adult is long, white with transluscent wings longer than the body and with green nervation. The Female is 3 to 3.2 mm long and longer than the male, which measure is 2.2 to 2.5 mm. The adult is usually dark green.

The larvae move laterally. Adults and larvae suck the leaves. They induce a discoloration of the leaves and can transmit viruses.

Adult and symptom of burning due to jassids

Insects attacking vegetative organs and tubers in the field or when stored

LEPIDOPTERA

Gelechiidae

Three species of this family are reported on potatoes: *Phthorimaea operculella*, *Tecia solanivora* and *Symmetrischema tangolias*. Of these, *P. operculella* is probably the most harmful in a hot, tropical climate, above all during tuber storage. The other two have a fairly limited geographical distribution.

Phthorimaea operculella

Description

The adult is a small moth with a 10 to 12 mm wingspan. The abdomen is grey and the antennae are almost as long as the body. The wings are very narrow; the forewings are yellowish-grey sprinkled with small black spots whereas the hindwings are grey with long bristles.

The pink-white caterpillar measures 10 to 12 mm when fully developed. The head and prothorax are brown/black. Each thorax segment has a scattering of black dots with a few bristles.

Damage

Damage may occur in the field or in storage. When eggs are laid on leaves in the field, the caterpillar mines into the petiole of the leaf where laying occurred, or into other nearby leaves and stems within reach. It also takes advantage of cracks in the ground to penetrate the tuber and dig a twisting mine, which it covers with silken threads, moving its excrement to the outside. Eggs can also be laid directly in the tubers through cracks in ridges.

In the warehouse, the caterpillar nearing the end of its larval instar pupates in miscellaneous media - bags of potatoes, pallets, walls, etc. - before the adult moth emerges.

Caterpillar's mine (*P. operculella*)

Moth adults, dorsal and ventral view

MITES

Foliage mites

Tetranychus urticae, Aculops lycopersici and *Polyphagotarsonemus latus*

Yellow mite (= glasshouse spider mite), ***Tetranychus urticae***

Larvae and adults of *T. urticae*

Description

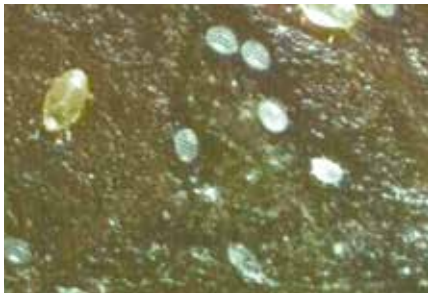
The greenish-yellow adult with two large dark spots on the sides is 0.5 mm long. It has four pairs of legs. The larva resembles the adult but has only three pairs of legs. The yellow, translucent egg measures 0.1 mm.

Damage

The females lay their eggs on weeds or other herbaceous plants in the fields or surrounding lands. The larvae and adults migrate onto the crop and spin silky webs on the underside of the potato leaves, protecting themselves from the wind and predators (and therefore from treatments). They pierce the leaves and suck out the cell sap to feed. Direct damage is caused by piercing the leaves to get food: the leaves start to look mottled then dry out. An outbreak can kill the plant. This is a highly polyphagous species, which attacks nearly 200 plant species -wild, vegetable, floral and fruit.

Polyphagotarsonemus latus

Symptoms on leaves



Mites seen with a lens

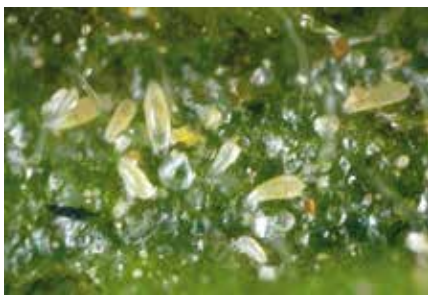
Description

The female measures 0.2 mm, and is oval, elongated and opalescent yellow. The male is more compact with long legs. The fourth pair of legs ends in a tubercle instead of a claw.

Damage

These mites are found mainly on the underside of leaves. They cause necrosis of lower leaf parts, which gradually fold over. The attacks are concentrated on the young shoots.

Aculops lycopersici



Mites seen with a lens

Description

These mites are virtually invisible to the naked eye.

Damage

The pitting makes the leaves and stems look bright, oily and a bronzish colour. Finally the leaves become hard and brown and the plant dries out.

Roots mite - *Rhizoglyphus echinopus*

Rhizoglyphus echinopus

Description

This is a small mite 0.5 to 0.8 mm long at the adult stage, with a brilliant white oval body and reddish legs. It develops through three nymphal stages, which takes about 3 weeks (depending on the ambient temperature).

Damage

This mite is a parasite of numerous cultivated plants, mainly miscellaneous bulb and tuber plants (garlic, amaryllis, dahlia, hyacinth, lily, onion, tulip, etc.) and sweet potato and potato. Attacks on potatoes can occur on both growing plants and stored tubers. The mite attacks the roots runners and tubers,, mining corridors filled with a granular flour. These symptoms can be confused with the potato worm disease caused nematodes.

FUNGAL DISEASES of leaves

Alternaria solani

The disease is first detected on the lower leaves then on the upper leaves through necrosis with concentric areas (left photo). The foliage dries out and falls as if the plant has reached maturity (right photo).
The tubers can also be infected.

Initial symptoms

Developed symptoms

Cladosporium fulvum

A whitish down can be seen on the underside of leaves, which then turn yellow and drop.

Phytophtora infestans

The disease manifests itself as aqueous necrosis on the lower leaves, which sometimes have a whitish mould on their edges. The fusion of necrosis makes the plant "collapse".
This soil fungus can attack the tubers near the surface of the soil with aqueous spots that become brown and serve as penetration paths for other organisms.
The disease is obvious in damp weather and heavy soils.

Aqueous necrosis on the edges of the leaflets

Collapsed plants

FUNGAL DISEASES causing wilting

Fusarium oxysporum, Verticillium albo-atrum, Rhizoctonia solani, Sclerotium rolfsii

These soil-borne fungi cause leaf wilts, which are similar and difficult to differentiate by laboratory examination. Pulling out the plant entirely and sectioning the stem can sometimes determine the cause, e.g.:

- gradual dieback of developed young plants, yellowing and necrosis of leaves, wilting and death of young plants, sometimes browning of conducting tissues, etc. (*Fusarium oxysporum* and *Verticillium albo-atrum*),
- death of young plants at all stages, black necrosis of the crown (stems), formation of small above-ground tubers and black sclerotia on stems and tubers (*Rhizoctonia solani*),
- sudden wilting of isolated plants with rotting crown and roots; the stem has a whitish mould speckled with small beige specks (sclerotia) at the soil surface (*Sclerotium rolfsii*).

Damage of *R. solani*

Damage of *F. oxysporum*

Sclerotia of *S. rolfsii*

BACTERIA

Ralstonia solanacearum

This disease causes one or more stems to wilt without prior yellowing at the onset of flowering. The wilting is accentuated during hot periods in the day. Sectioning the stem releases a bacterial exudate. The conducting tissues of the stem, runners and tubers are sometimes coloured brown.
This disease is the most significant potato bacterial disease in Sub-Saharan Africa.

Symptoms on plants

Symptoms on tubers

Pectobacterium (= Erwinia) carotovorum, P. atrosepticum, Dickeya spp.

The upper leaves are upright and curled, and the remainder of the foliage is yellow due to the lack of water supply to the young plant. The plant wilts and dies in hot, humid weather.
Black rot invades the crown and spreads to the roots, resulting in the most typical symptom, the appearance of blackleg (black rot, sometimes damp, at the base of stems). The disease frequently manifests on isolated young plants. The result is soft, rotting tubers with a characteristic smell. The symptoms are more apparent with lack of water.

Damage of *Pectobacterium carotovorum*:

Initial symptoms

Symptom of black leg

VIROSIS

Numerous virosis are reported on potatoes. The most frequent are mosaic, which is the economically most important in Africa, leaf roll, curly top and yellow dwarf.

Potato leaf roll (PLRV)

The foliage becomes pale and the leaflets are curled upwards like a horn. The leaves become thick, stiff and brittle.

Mosaic

These are characterized by mixed pale and dark green spots appearing between or on the leaf veins. Climatic conditions also play a part in the appearance of mosaic symptoms.

Curly top

This caused by a mix of viruses; the young plants are stunted and are much reduced in size - small, curly leaves due to vein shortening. The foliage typically looks curly and squat.

The leaf deformation can sometimes be less accentuated, with simple indentures and ripples on the edges.

VIROSIS - cont.

Yellow dwarf

Yellow dwarf symptoms are visible on the oldest leaves of adult plants : yellow spots arise and then evolve into necrotic spots between or on the leaf veins depending on the varieties affected; apical necrosis may also arise.

Symptoms alone cannot distinguish the virus responsible as symptoms vary with age, time of infection, temperature, and the genetics of both the virus and the plant host.
The Y virus produces various symptoms depending on the viral strain. The X virus associated with the Y virus could give rise to curly top or yellow dwarf.

PHYSIOLOGICAL DISEASES

Unfavourable environmental conditions, "unusual weather events" and food deficiencies are the major causes of physiological diseases, which are not always easy to diagnose, resulting in the wrong treatments being used.

Poor chemical fertilization

▪ Slowing down of young plant growth, leaflets with pale green border shrivelling upwards (**too much nitrogen**). ▪ Little plant development and late maturing of tubers, which show internal necrosis with a rusty appearance (**too much phosphorus**). ▪ Internodes are short, leaflets are dark brown and the parts between the veins turn yellow. Necrosis and dropping of lower leaves (**too much nitrogen**). ▪ Chlorotic plants with little development (**lack of nitrogen**). ▪ Stunted plants, with dark brown spots on the upper side of leaves; the blade then turns back to the underside, the leaves drop and the young plants die (**lack of potassium**). ▪ Plants with dull leaves, reddish at the edges (**lack of phosphorus**). ▪ Plants with a scrubby appearance and slender shoots (**lack of calcium**).	Low yield. Healthy-looking tubers blacken and become hard in cooking. Reduced yield.

Lack of water or far too much sun and heat

▪ The tubers develop localized brown spots, especially in the vascular ring (**lack of water**). ▪ Necrosis and greening of tubers (**too much heat**). ▪ Abiotic factors, such as lack of water, sun exposure and heat can also cause physiological disorders, which express themselves through more or less chronic wilt that varies according to weather conditions (temperature and humidity).	

NB: Excessive nutrients are rarely a problem in potato cultivation by small farmers in Africa (little use of chemical fertilizers); meteorological “problems” are far more widespread.

DISEASES DURING STORAGE

Infection complex of tubers

Dry rot

++	▪ Marbled, rust-coloured areas can be seen on the tuber skin (mildew). ▪ Tubers with depressed brown spots with whitish masses. The dried tuber is very hard (*Fusarium* sp.). ▪ Tubers with very shallow, depressed, dark brown spots, clearly distinguishable from the firm flesh of the tuber (*Alternaria solani*).	The infections produced during vegetation continue in storage where numerous saprophytes speed up the rotting of tubers.

Damp rot

++	▪ Rotting in tubers injured during harvesting in hot weather (*Pythium* sp.). ▪ Brown spot on tuber and formation of a viscous mass (*Pectobacterium* sp.). ▪ Presence of small protuberances or sometimes patches which release a brown powder (*Spongospora subterranea*).	The unattractive appearance of tubers stops them selling. Tuber rot can also have a negative effect on their taste.

DISEASES IN STORED TUBERS

These mainly stem from diseases caused by fungi and bacteria at planting, which then evolve due to poor storage conditions. They depreciate production and reduce marketable value.

Dry tuber rot

Brown to black rot, very dry and clearly depressed in the tubers (***Alternaria solani***).

Symptom of early blight on tubers

DISEASES IN STORED TUBERS - continued

Tubers with strongly tinted, rust-coloured flesh on the perimeter and with a fibrous or granular texture (***Phytophthora infestans***).

A tuber cross-section shows marbled areas, rust-coloured on the surface, which can extend to the middle of the tuber, with poorly defined contours.

Exterior view of tubers affected by *P. infestans*

Interior view of tubers affected by *P. infestans*

Tubers covered with small irregular sclerotia (***Rhizoctonia solani***).

The tubers from affected plants are small, misshapen, angular and sometimes have desquamations reminiscent of common scab. Lenticular necrosis or small corky plugs (dry core) are apparent in some cases.

Symptom of *R. solani* on tuber

Tubers with slightly-depressed, brown spots, ringed with concentric ripples on which a whitish mycelial cushion forms (***Fusarium* sp.**).

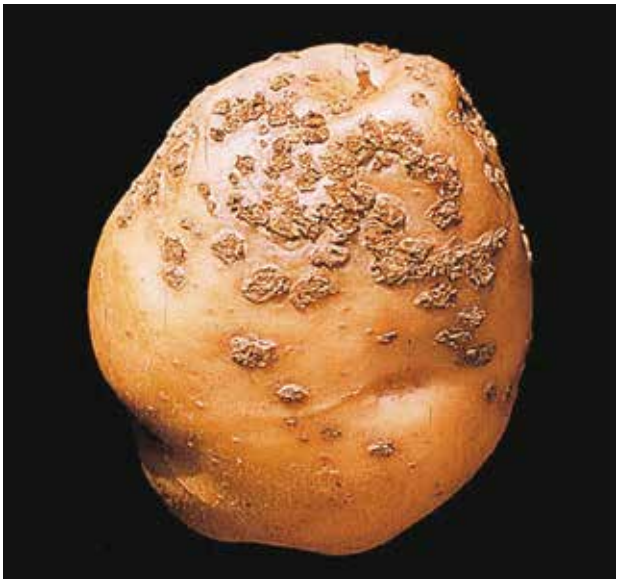
The tuber cross-section shows brown rot, which develops towards the inside where internal cavities covered with mycelium appear. The tuber can dry out gradually until it becomes a "mummified" tuber with a hard consistency.

External symptoms of fusarium wilt on tuber

DISEASES IN STORED TUBERS - continued

Presence of small prominent buds on the tubers, yellowish-brown in colour then dark. These buds merge to form patches (***Spongospora subterranea***).

The *S. subterranea* fungus establishes itself under the tuber epidermis where it causes pale pustules, which turn dark at maturity. The pustules then burst and release a powdery, brownish mass containing balloons of spores. The ultimate symptoms of **powdery scab** are numerous small corky depressions in the tubers surrounded by bits of torn epidermis.



Pustules formed by *Spongospora* sp.

Presence of small corky dots, sometimes joined in large patches or genuine galls, hollow or raised, separate or assembled (***Streptomyces scabies*** or **common scab**).

These symptoms have a variety of forms and are sometimes found only on the surface of tubers; pustule or raised scabs (with pustules sinking into craters in the tubers), cork scabs (presence of superficial corky spots) or star-shaped symptoms. These symptoms depend on miscellaneous factors, including the type of common scab strain, the variety and climatic conditions.

Symptoms of scabies pustules

Wet tuber rot

Brown spots on the tubers which rot and are converted into a viscous mass (***Pectobacterium* spp.**).

When the seed potatoes are affected by this type of rot, the first visible signs in the fields are missing plants, empty ridges and late emergence.

Bacterial soft rot (infection of tubers lenticels)

NEMATODES

Meloidogyne spp.

Several species of gall nematodes of the genus Meloidogyne can damage potatoes (lower yields, external deformations, internal necrosis). Certain species of nematodes are highly prevalent in hot countries, from the Mediterranean basin to the tropics: ***M. arenaria, M. javanica*** and ***M. incognita***. Others suit Mediterranean and temperate conditions better: *M. hapla, M. chitwoodi* and *M. fallax*.

These nematodes are transmitted by infected planting material: potato tubers (with or without visible symptoms) and any rooted plant (tomato, lettuce, etc.). They are very polyphagous and develop on numerous crops and weeds (nightshade, etc.).

Meloidogyne spp. produce nodes or considerable root and tuber deformation in potatoes and many other crops, especially market garden crops. Small whitish pearls, about the size of half a pinhead, can be glimpsed on the inside. These are the nematode's adult females.
A large part of the root system can become necrotic. The tubers of some varieties react by cracking lengthwise, whereas bulb-shaped protuberances will emerge through the epidermis in others.

Non-specific symptoms, mainly above ground, can be noted; irregular or halted growth, leaf colouration (chlorosis), excessive wilt when conditions are dry and hot.

Galls on roots

Galls on a tuber, Meloidogyne javanica

Helicotylenchus spp.

The symptoms are not specific and can be confused with those of other nematodes. These are spiral nematodes, which can be both endoparasites and ectoparasites. They attack the roots and cause the parts above ground to wilt.

Pratylenchus spp.

The affected plants wilt due to a reduction in the nourishing root system. The nematodes cause small brown necrotic injuries on the fibrous roots. The fleshy roots already affected have blackish-brown lesions, which are often invaded by fungi and saprophytic bacteria.

VERTEBRATES

Rats - *Rattus rattus, R. norvegicus*

Rats and mole rats sometimes feed on potato tubers by digging mines in the ridges or attacking exposed tubers. They frequently damage more tubers than they can consume.
The injuries to the tubers then become penetration paths for pathogenic micro-organisms that cause these tubers to rot.

DIPLOPODA

Millipedes

Description

Diplopoda are also known as millipedes. Their many legs (30 to 400) are attached to a round, segmented body with a hard carapace; they can measure up to 30 cm and are brown to blackish-brown in colour. They move slowly and curl up when disturbed. They lay their eggs in isolation or in clusters of 20 to 100 in the soil. They live in damp soils (as they dry out very quickly and die), and congregate around plants in soils with a high organic substance content, mainly compost heaps and other plant debris, where they take refuge during the day.

Damage

Millipedes tunnel into potato tubers.

Millipede

MOLLUSCA

Slugs and snails do not normally represent a serious threat to crops, but they can occasionally cause sufficient damage to warrant controlling them.

Achatina spp.

Several species belonging to this genus attack the young plants as soon as they emerge: they gnaw the stems and leaves and can quickly destroy sowings and plantings.
Achatina weynsi is one of the most significant snails found in the Democratic Republic of Congo. It has a greyish, stretched shell, with the spires sporting dark irregular cross-stripes, and can be up to 10 centimetres long. In Guinea, this species from the forest region climbs gradually higher to attack the potato crop.

Adult snail, *Achatina* sp.

1.3 Appearance of pests and diseases in terms of plant phenological stage

The following table shows the stages of cultivation during which crop enemies are potentially present and the stages during which their presence can do the most harm. It is especially during the latter stages that they must be monitored and controlled if necessary. The purpose is to show that the presence of a pest, disease or pathogenic agent is not always harmful to the crop.

The potato life cycle is variable depending on the variety, and may be influenced by cultural practices and climatic conditions. It is usually 2 to 4 months.

Stage	Approximate length of development stages	Defoliating caterpillars (Noctuidae & Sphingidae)		Beetles (Chrysomelidae)		Orthoptera (Grillidae & Pyrgomorphidae)		Tuber moth *Phthorimae operculella*		Biting-sucking insects (Homoptera : white flies, aphids ; Hemiptera : leafhoppers)		Isoptera (Termitidae)		Acari / mites	
Mother tuber	/														
From planting to 1st leaf	3 to 10 days														
Leaf development	Depending on the variety														
From tuberization to harvest	Depending on the variety														
Tuber storage	3 months and more														

Stage	Approximate length of development stages	Nematodes		Foliar fungal diseases		Fungal diseases of stems and tubers		Bacterial diseases of stems and tubers		Virus		Rats & mice		Millipedes	
Mother tuber	/														
From planting to 1st leave	3 to 10 days														
Leaf development	Depending on the variety														
From tuberization to harvest	Depending on the variety														
Tuber storage	3 months and more														

Periods during which pest or pathogenic agent is potentially present

Periods during which the appearance of a large numbers of pest or pathogenic agents can cause the greatest loss

1.4 Extent according to country / time of year and climate conditions favourable to pests and diseases

MALA = Malawi, RWA = Rwanda, BUR = Burundi, NIG = Nigeria, CAM = Cameroon, KEN = Kenya, UGA = Uganda, TAN = Tanzania, ANG = Angola, ETH = Ethiopia, SUD = Sudan, GUI = Republic of Guinea, MAD = Madagascar, MAL = Mali, BKF = Burkina Faso, SEN = Senegal, DOR = Dominican Republic.

0 = no damage
+ = limited damage
++ = average damage: control necessary
+++ = heavy damage: control essential

The addition of an index in brackets indicates an occasional increase of the importance of damage by location or time of the year. Example: +(++) = minor damage, but occasionally of moderate importance requiring the implementation of control measures.

X = generally limited damage (the pest or disease is reported in the country) but evolution of damage level over the year is not known
XX = damage can be significant, but evolution of damage level over the year is not known
XXX = damage can be heavy, but evolution of damage level over the year is not known
/ = no information available

Note: This inventory of pests and diseases has not been conducted exhaustively in all countries. The pest may be present, but has perhaps never been observed in the country on the crop, because it does not cause serious damage. Data on the distribution of these different species are mainly inspired by "Distribution Maps of Major Crop Pests and Diseases in Africa" published since 1985. It is therefore possible that the « parasitic status » of pests/diseases has changed, or that they have appeared in new countries. The data for Guinea have been updated through a mission carried out as part of the production of this guide.

Spodoptera exigua

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
MAL	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)	+ (+)
GUI	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +

Spodoptera littoralis

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	/	/	/	/	/	/	/	/	/	/	/	/
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)
GUI	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Helicoverpa armigera

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)	+(++)
BKF	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
SEN	++	++	++	++	++	++	++	++	++	++	++	++
GUI	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Agrotis ipsilon

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	/	/	/	/	/	/	/	/	/	/	/	/
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	/	/	/	/	/	/	/	/	/	/	/	/
ETH	/	/	/	/	/	/	/	/	/	/	/	/
SUD	X	X	X	X	X	X	X	X	X	X	X	X
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	/	/	/	/	/	/	/	/	/	/	/	/
SEN	++	++	++	++	++	++	++	++	++	++	++	++
GUI	++	++	++	++	++	++	++	++	++	++	++	++
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Agrotis segetum

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	/	/	/	/	/	/	/	/	/	/	/	/
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	/	/	/	/	/	/	/	/	/	/	/	/
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	/	/	/	/	/	/	/	/	/	/	/	/
SEN	X	X	X	X	X	X	X	X	X	X	X	X
GUI	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Acherontia atropos

Favourable conditions: no information. It is mainly found in tropical and subtropical Asia and the Pacific but it is also a secondary pest in West Africa.

Month	1	2	3	4	5	6	7	8	9	10	11	12
All countries	/	/	/	/	/	/	/	/	/	/	/	/

Microtermes spp., *Odontotermes* spp., *Macrotermes* spp., *Trinervitermes* spp., *Eutermes* spp.

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+++	+++	+++	+(+)	+(+)	+(+)	+	+	+	+(+)	+(+)	++

Gryllotalpa africana

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
SEN	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)
GUI	+	+	+	+	+	++(+)	+(+)	+(+)	+(+)	+(+)	+	+

Brachytrupes membranaceus

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	+	+	+	+	++(+)	+(+)	+(+)	+(+)	+(+)	+	+

Zonocerus variegatus

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	/	/	/	/	/	/	/	/	/	/	/	/
GUI	++	++	++	++	+(+)	+	0	0	0	0	+(+)	+(+)
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Bemisia tabaci

Favourable conditions: piercing-sucking insects feed on sap and react very positively under conditions of water stress in potato. Infestation is therefore substantially increased during periods of drought.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	/	/	/	/	/	/	/	/	/	/	/	/
MAL	+++	+++	+++	+++	++	++(+)	+(+)	+(+)	++	+++	+++	+++
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)
GUI	++	++	++	++	+(+)	0	0	0	0	+(+)	+(+)	+(+)
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Myzus persicae

Favourable conditions: piercing-sucking insects feed on sap and react very positively under conditions of water stress in potato. Infestation is therefore substantially increased during periods of drought.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	X	X	X	X	X	X	X	X	X	X	X	X
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	/	/	/	/	/	/	/	/	/	/	/	/
BKF	/	/	/	/	/	/	/	/	/	/	/	/
SEN	++	++	++	++	++	++	++	++	++	++	++	++
GUI	/	/	+	+ (+)	+ (+)	+	/	/	+ (+)	+ (+)	+	+
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Aphis gossypii

Favourable conditions: piercing-sucking insects feed on sap and react very positively under conditions of water stress in potato. Infestation is therefore substantially increased during periods of drought.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	/	/	/	/	/	/	/	/	/	/	/	/
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	/	/	/	/	/	/	/	/	/	/	/	/
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	/	/	/	/	/	/	/	/	/	/	/	/
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	+	+	+ (+)	+ (+)	+	/	/	+ (+)	+ (+)	+	+
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Macrosiphum euphorbiae

Favourable conditions: piercing-sucking insects feed on sap and react very positively under conditions of water stress in potato. Infestation is therefore substantially increased during periods of drought.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	+	+	+	+	0	0	0	+	++	++	+

Jacobiasca lybica

Favourable conditions: piercing-sucking insects feed on sap and react very positively under conditions of water stress in potato. Infestation is therefore substantially increased during periods of drought.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	X	X	X	X	X	X	X	X	X	X	X	X
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	/	/	/	/	/	/	/	/	/	/	/	/
MAL	/	/	/	/	/	/	/	/	/	/	/	/
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	X	X	X	X	X	X	X	X	X	X	X	X
GUI	+	+	+	0	0	0	0	+	+	+	+	+
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Phthorimaea operculella

Favourable conditions: : hot, dry weather is favourable to infestations because this is when the cracks in the soil are more important and the cycle of the pest is the fastest, therefore more important in dry agro-ecological zones.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
CAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
KEN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
UGA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
TAN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
ANG	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
ETH	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
SUD	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
MAD	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
MAL	/	/	/	/	/	/	/	/	/	/	/	/
BKF	/	/	/	/	/	/	/	/	/	/	/	/
SEN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GUI	+++	+++	+++	+++	++	++	++	++	++	++	+++	+++
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Andrector ruficornis

Favourable conditions: Unknown.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
CAM	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)

Tetranychus spp.

Favourable conditions: hot, dry weather.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
SEN	/	/	+	+	+	+	/	/	/	/	/	/
GUI	/	/	+	+	+	+	/	/	/	/	/	/

Polyphagotarsonemus latus

Favourable conditions: water stress.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	/	/	/	/	/	/	/	/	/	/	/	/
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	/	/	/	/	/	/	/	/	/	/	/	/
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	/	/	/	/	/	/	/	/	/	/	/	/
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	X	X	X	X	X	X	X	X	X	X	X	X
MAD	/	/	/	/	/	/	/	/	/	/	/	/
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	++	++	++	++	++	++	++	++	++	++	++	++
GUI	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Alternaria solani

Favourable conditions: alternating wet and dry periods (wet and cool nights below 15°C and/or with the presence of dew) promotes the growth and spore germination of the pathogen. The extent of infestation increases with altitude. The disease is severe in plantings in the rainy season with losses of over 15%.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
MAL	+(++)	+	/	/	/	/	/	/	+	+ (++)	+ (++)	+ (++)
BKF	+	+	/	/	/	/	/	/	+	+	+	++
SEN	++(+)	+	/	/	/	/	/	/	++(+)	++(+)	++(+)	++(+)
GUI	0	+	+	++	0	+	+	++	0	+	+	++

Cladosporium fulvum

Favourable conditions: the disease is aided to spread by the night dew.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	+	+	+	0	+	+	+	0	+	+	+

Phytophthora infestans

Favourable conditions: high relative humidity and limited temperature in regions of high altitude.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	X	X	X	X	X	X	X	X	X	X	X	X
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	X	X	X	X	X	X	X	X	X	X	X	X
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)	+ (++)
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)	++ (+)
GUI	+	+	+	+	+	+	+	+	+	+	+	+
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Fusarium oxysporum

Favourable conditions: very hot and dry weather causing a stress to the plants ; soil too heavy or too light, low humus and poor fertility.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
MAL	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	++	++	++	++	++	++	++	++	++	++	++	++
GUI	++	++	++	++	++(+)	++(+)	++(+)	++(+)	++	++	++	++
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Verticillium albo-atrum

Favourable conditions: hot and dry weather, well drained sandy soil.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	/	/	/	/	/	/	/	/	/	/	/	/
BUR	/	/	/	/	/	/	/	/	/	/	/	/
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	/	/	/	/	/	/	/	/	/	/	/	/
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	/	/	/	/	/	/	/	/	/	/	/	/
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	/	/	/	/	/	/	/	/	/	/	/	/
BKF	/	/	/	/	/	/	/	/	/	/	/	/
SEN	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	+	0	0	0	0	0	0	+	+	+	+
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Sclerotium rolfsii

Favourable conditions: warm soil with temperatures above 28°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	X	X	X	X	X	X	X	X	X	X	X	X
GUI	+	+	+	+	++	++	++	++	+	+	+	+

Rhizoctonia solani

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
MAL	X	X	X	X	X	X	X	X	X	X	X	X
GUI	+	+	+	+	++	++	++	++	+	+	+	+

Ralstonia solanacearum

Favourable conditions: high soil moisture, high temperatures, tuber injuries due to farming interventions and varietal sensibility.

Month	1	2	3	4	5	6	7	8	9	10	11	12
MALA	X	X	X	X	X	X	X	X	X	X	X	X
RWA	X	X	X	X	X	X	X	X	X	X	X	X
BUR	X	X	X	X	X	X	X	X	X	X	X	X
NIG	X	X	X	X	X	X	X	X	X	X	X	X
CAM	/	/	/	/	/	/	/	/	/	/	/	/
KEN	X	X	X	X	X	X	X	X	X	X	X	X
UGA	X	X	X	X	X	X	X	X	X	X	X	X
TAN	X	X	X	X	X	X	X	X	X	X	X	X
ANG	X	X	X	X	X	X	X	X	X	X	X	X
ETH	X	X	X	X	X	X	X	X	X	X	X	X
SUD	/	/	/	/	/	/	/	/	/	/	/	/
MAD	X	X	X	X	X	X	X	X	X	X	X	X
MAL	X	X	X	X	X	X	X	X	X	X	X	X
BKF	X	X	X	X	X	X	X	X	X	X	X	X
SEN	X	X	X	X	X	X	X	X	X	X	X	X
GUI	++	++	++	++	++	+++	+++	+++	+++	++	++	++
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Pectobacterium carotovorum, P. atrosepticum, Dickeya spp.

Favourable conditions: high temperatures (air) and high soil moisture (in fields). High relative humidity and poor ventilation of warehouses (damage to stocks).

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	0	+	++	0	0	+	++	0	0	+	++

Virosis

Favourable conditions: for the X virus, a cloudy weather with low temperatures (16 -20°C.) is favourable to the expression of the disease.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
UGA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GUI	0	0	+	+	+	+	/	/	+	+	+	+

Streptomyces scabies

Favourable conditions: sandy or stony light soil, pH between 5 and 8, soil temperatures between 20 and 22°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	++	++	+	+	++	++	+	+	+	++	+

Meloidogyne spp.

Favourable conditions: high temperatures and high soil moisture.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	+	++	++	0	+	++	++	0	+	++	++

Pratylenchus spp.

Favourable conditions: this nematode can survive and infect roots in dry soils. In ACP countries, it is mainly found in West and North Africa, the Caribbean and the Pacific Islands.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	+	+	+	0	+	+	+	0	+	+	+

Helicotylenchus spp.

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	0	0	0	0	+	+	+	0	0	0	0

Mus musculus

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	+	+	++	++	++	++	++	++	++	++	+	+

Rattus rattus

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	+	++	++	0	+	++	++	0	+	++	++

Millipedes

Favourable conditions: infestations are especially important at the beginning of the major rainy season, forcing farmers to plant late in rainfed farming. They become increasingly important pests in potatoes and other tubers plants (such as sweet potato) in some areas of East and West Africa.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	0	0	0	+	++	++	+	+	+	0	0

Achatina spp.

Favourable conditions: no information.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Other countries	/	/	/	/	/	/	/	/	/	/	/	/
GUI	0	0	0	+	+	++	++	++	+	+	0	0

2. Main control methods

2.1. Introduction

The potato is a perennial of the Solanaceae family, grown basically for its tubers, which are very high in starch; the tubers are used as human food but can also be fed to domestic animals and poultry.

The potato has few edaphic requirements. It has a clear preference for mild, misty climates. The plant thrives in all types of soil provided it has enough water. It does, however, prefer light, siliceous or silico-clayey soils. Potatoes require a great deal of water constantly throughout the growing period. It tolerates fairly low pH (5.5-6).

Globally, apart from the application of plant health products that are not always available to small potato farmers in ACP countries, a series of cultural and hygienic measures is available, designed to reduce losses from potato diseases and pests in these countries. This involves:

- using resistant varieties
- planting healthy seed potatoes
- ridging correctly and operating integrated pest management against diseases and pests in the field
- lifting tubers when mature
- lifting tubers in dry weather
- avoiding injury to tubers during lifting and transport
- encouraging injuries to heal by keeping tubers in a temperature of about 18°C for 10 days to 2 weeks before cool storage (if possible)
- avoiding leaving tubers out in the sun or rain
- sorting and eliminating infected tubers before storing them
- not washing tubers before storing them
- disinfecting the warehouse and the work tools before storing tubers
- ensuring good warehouse ventilation and a low temperature
- inspecting the warehouse regularly.

The appropriate measures for each case are specified in chapter 3.

In rotation, potato is the first in the cropping plan. It requires weeding and cleaning, and is demanding in terms of cultivation and maintenance.

Potatoes are planted in holes 5 to 6 cm deep, 30 to 35 cm apart, with 40 to 50 cm between the rows depending on the vigour of varieties grown.

The crop requires maintenance shortly after emergence; this includes hoeing at emergence, ridging twice, when the plants are 20 to 25 cm high and 1 month later, extra manure and preventive control of pests. Watering is necessary in hot, dry weather when growing potatoes in the off season.

Ridging increases the number and vigour of roots, protects tubers from the spores and eggs of certain pests to a certain extent, and shields them from the direct effect of the light (which causes them to turn green).

Potatoes react very well to manure, especially organic manure. The recommended mineral manure dose per ha is 80 to 150 kg of nitrogen and phosphoric acid and 150 to 300 kg of potassium. Nitrogen should be given twice: before planting in ammoniac form (urea, sulphate, ammonitrate) and after planting in nitric form.

The potato cycle varies from 3 to 8 months depending on the variety.

The yields per hectare can vary from 10 to 45 tonnes depending on the maturity group and the variety.

Potatoes are stored in dark, clean, ventilated premises, sheltered from the cold and damp. Where the pile of potatoes is up against a wall, this should be insulated with planks or straw. The pile should never be more than 50 cm high or wide. The length of the pile is of no importance.

Potato tubers are possible vectors of many pests of varying importance, depending on locations, varieties and crop systems. To maintain the crop in good health, choosing and preparing seed potatoes are therefore both very important, as are good growing practices.

Pressure from pests increases when the crop development conditions are unfavourable. Depending on circumstances, the following can occur:
- failure or late emergence
- necrosed stems at different levels or gnawed stems
- gnawed, pitted, curled or spoiled leaves
- no or little vegetation in places
- stunted plants
- poorly developed, destroyed or split roots
- mines in tubers
- gnawed, superficially affected, spoiled tubers often caused by rot.

2.2. Pest and disease cycles

Based on the stages of development of each pest or disease, the following describe the applicable control methods, as well as the effects of natural factors other than those related to climate (described in section1.4). of this guide. The control methods are then positioned in terms of the plant's development cycle.

Note: the illustrations of the cycles represent the different stages of development, but should not be used to identify pests diseases - for identification see section 1.2 of this guide.

The control methods for pests or diseases whose cycle is not illustrated are presented in a table. The second column of the table shows what actions should be taken to control the different stages of the pest/disease (first column). The actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in orange boxes.

Cultivation practices
Application of plant protection products

PHTHORIMAEA OPERCULELLA

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Eggs and caterpillars	Avoid planting in soil very light and not very compact in order to limit the laying of eggs			X			
	Plant only healthy tubers (or those previously treated with an insecticide)			X			
	Cover with soil the tubers exposed in the fields				X		
	Plan, if possible, an early harvest and never keep harvested tubers more than 24 hours in the fields					X	
	Burn dry leaves and weeds after harvest					X	
	Keep only healthy tubers						X
	Spray a systemic insecticide in the field or a contact insecticide in the warehouse				X		X
Adults	Clean around the warehouse to eliminate weeds that promote butterfly development						X
	Monitor the field continuously for early detection of the insect				X		
	Disinfect walls and floors of the store room with an insecticide before arrival of tubers						X
	Spray a systemic insecticide in the field or a contact insecticide in the warehouse				X		X

X = action to be taken at the cultivation stage shown in the corresponding column

SPODOPTERA SPP.

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Adults	Destroy weeds		X		X		
	Light traps can be placed over basins of water in the field to catch the adults at night				X		
Eggs	Remove egg masses manually				X		
Caterpillars	Spray a contact insecticide, as a priority on the early stages that are in groups				X		

X = action to be taken at the cultivation stage shown in the corresponding column

HELICOVERPA ARMIGERA

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Adults	Avoid, in the rotation, the succession of the potato by: cotton, various cultivated Malvaceae, maize and cultivated Solanaceae	X					
	Light traps can be placed over basins of water in the field to catch the adults at night				X		
Caterpillars	Spray a contact insecticide, as a priority on the early stages that are in groups				X		

X = action to be taken at the cultivation stage shown in the corresponding column

AGROTIS SPP.

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Adults	Set light traps or pheromone traps to detect the presence of adults in early season				X		
Caterpillars	Manual collection of larvae located during the day in shallow soil and around plants				X		
	Application of poisoned bait (cereal brans + contact insecticide) around the plants				X		
Chrysalis	Expose the chrysalises to the effect of the sun by a post-harvest tillage		X				

X = action to be taken at the cultivation stage shown in the corresponding column

ACHERONTIA ATROPOS

Key factors in the control strategy

The butterflies of this species can fly distances of several kilometres, so the invasion can originate from very distant sources of infestations.

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Caterpillars	Hand picking of the leaves with egg masses or groups of newly hatched young caterpillars				X		
	Use of neem extracts, effective against caterpillars				X		
	Spray a contact insecticide, as a priority on the early stages that are in groups				X		

X = action to be taken at the cultivation stage shown in the corresponding column

ANDRECTOR RUFICORNIS (CHRYSOMELIDAE)

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Larvae and adults	Spray a contact or systemic insecticide				X		
	The elimination of other host plants in the vicinity can also help reducing the population, as well as the remoteness of the crop from other host plants		X	X	X		

X = action to be taken at the cultivation stage shown in the corresponding column

GRYLLOTALPA AFRICANA AND *BRACHYTRUPES MEMBRANACEUS*

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Larvae and adults	Locate and dig holes to find and destroy adults or larvae manually				X		
	Application of poisoned bait (cereal brans + contact insecticide) around the plants				X		

X = action to be taken at the cultivation stage shown in the corresponding column

TERMITES

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Soldiers and workers	Destroy crop residues from the previous crop by good site preparation		X				
	Apply well decomposed organic matter as base fertilization		X				
	Maintain good soil moisture by regular irrigation				X		
	Preventive application of insecticides in the soil		X				
Queens	Locate and dig termite mounds in the fields and surrounding areas to remove and destroy the queens		X		X		
	Scrape clean the termite mounds and apply an insecticide with a smoke generator effect ; then fill the mounds		X		X		

X = action to be taken at the cultivation stage shown in the corresponding column

BEMISIA TABACI AND *JACOBIASCA LYBICA*

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Adults	Weed the edges of the field well		X		X		
	Do not plant near another sensitive crop reaching the end of its cycle	X	X	X			
	The presence of windbreaks slows down infestations brought by the wind		X				
Larvae and adults	Maintain the crop under a good water and mineral balance				X		
	Spray a systemic insecticide or repellent				X		

X = action to be taken at the cultivation stage shown in the corresponding column

NEMATODES
(*Meloidogyne* spp., *Pratylenchus* spp., *Helicotylenchus* spp.)

Key factors in the control strategy

Development stage of the pest	Action	Cultivation stages						
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage	Site selection
Multiplication on another crop or weed	Rotation and fallow ; 4-5 years between two potato crops and other Solanaceae	X	X					
Mobile phase in the soil	Proceed to flooding of the field before planting		X					
	Avoid sandy soils	X						
	Apply organic fertilizers such as well decomposed farmyard manure, which promotes the presence of natural enemies of nematodes in the soil, reducing their populations		X					
Penetration and development inside the plant	Application of nematicides		X					
Transport by water or removed soil	Avoid the provision of land or water from infested fields		X	X				
	Use of certified or treated seed			X				

X = action to be taken at the cultivation stage shown in the corresponding column

ALTERNARIA SOLANI AND *CLADOSPORIUM FULVUM*

Key factors in the control strategy

This disease is rarely a cause of considerable yield reduction requiring implementation of control measures.

Development stage of the fungus	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Germination and development on the plant	Good crop rotation practices (avoiding the succession of Solanaceae in the same field for 3 to 4 years)	X					
	Maintain good soil fertility		X		X		
	Harvest only fully mature tubers and be careful to not spoil them while rooting them up when the soil is moist					X	
	Conduct foliar treatments with fungicides				X		
Conservation in the tubers	Use clean seed, preferably those certified			X			
	Avoid wounding tubers during harvest and handling operations					X	X
	Sort and remove injured tubers during harvest					X	

X = action to be taken at the cultivation stage shown in the corresponding column

SCLEROTUM ROFSII, RIZOCTONIA SOLANI, FUSARIUM OXYSPORUM AND *VERTICILLIUM ALBO-ATRUM*

These diseases are propagated from the infested soil, infected tubers, contaminated work tools or spores transported by the wind, which penetrate through injuries.

Key factors in the control strategy

- Avoid planting in heavy, poorly drained soils and do not leave infected tubers or plant residues in the soil.
- Avoid fields with a history of withering.
- Lift the tubers when they are fully mature, in cool, dry weather. Newly lifted tubers must not be left in the sun for a long time.
- Avoid injuring the tubers during lifting, calibration and storage.
- Sort tubers before storing to eliminate tubers that are injured, cracked or starting to rot.
- Use dry, ventilated storage areas with a relative humidity of 95%.
- Use healthy seed potatoes in the soils and carry out appropriate crop rotation.
- Bury the infected haulms to facilitate their rapid decomposition.

Treating tubers with fungicides reduces the inoculum level and protects the seed tubers from infection coming from the soil.

PHYTOPHTORA INFESTANS

Key factors in the control strategy

Development stage of the fungus	Action	Cultivation stages					
		Site selection	Land preparation	Planting	Foliage development and tuberization	Tuber harvesting	Tuber storage
Persistence in soil	Good crop rotation practices (avoiding the succession of Solanaceae in the same field for 3 to 4 years)	X	X				
	Avoid fields with record of blights	X					
	Ensure good soil preparation and proper manure		X	X	X		
Conservation in the tubers	Use only certified seeds			X			
	Apply a seed treatment with an appropriate fungicide						X
Germination and development on the plant	Selection of tolerant varieties			X			
	Eliminate new growth of potatoes in nearby fields with herbicides or appropriate cultural practices		X		X		
	Ensure proper irrigation programme especially if it is performed by sprinkling				X		
	Destroy infected dead leaves 2 weeks before harvest to reduce tuber infection and disease problems in warehouses					X	
	Apply a fungicide on the leaves at the first sign of symptoms and during topkill or immediately after				X		
Germination and development on the tubers	Avoid damage (injuries) to the crop					X	
Water dispersal	Ensure proper irrigation program especially if it is performed by sprinkling				X		
Persistence in warehouse	Maintain good hygiene in the warehouse						X
	Regular sorting and elimination of infected tubers						X

X = action to be taken at the cultivation stage shown in the corresponding column

BACTERIAL DISEASES
(*Ralstonia solanacearum, Pectobacterium carotovorum, P. atrosepticum, Dickeya* spp.)

Key factors in the control strategy

- Use healthy seed potatoes certified exempt from disease.
- Use seed potato varieties known to be tolerant to these diseases.
- Add bleach to the rinsing water for soft rot before bagging the tubers for market.
- Operate crop rotation for at least 4 years without potatoes or other Solanaceae.
- Keeping the soil routinely damp reduces the incidence of *Ralstonia solanacearum*
- Eliminate wild weeds potentially acting as alternative hosts via manual or chemical weeding.
- Carefully wash crates, pallets and all tools used to handle tubers.
- Avoid fields with a history of withering.
- Dispose of all old potato sacks.
- Treating seed potatoes with an efficient bactericide reduces the severity of bacterial diseases.

VIRUSES
(potato leaf roll virus, mosaic virus, curly top virus, yellow dwarf virus and acropetal necrosis)

Key factors in the control strategy

- Avoid planting potatoes next to crops sensitive to viral attacks.
- Isolate new plantings from old ones.
- Use certified seed potatoes or those from healthy plots.
- Use resistant varieties.
- Ensure good crop rotation.
- Thin out potato regrowth in potato fields and surrounding areas.
- Treat chemically against vector insects, especially on the edge of the field to prevent them from migrating to the potatoes.

NON-PARASITE DISEASES

Key factors in the control strategy

- Ensure good soil management and adequate growing practices (good irrigation, fertilization and spacing between young plants).
- Avoid growing potatoes in soils liable to flooding or that are poorly drained.
- Handle the tubers gingerly from lifting to warehousing.
- Avoid storing potato tubers in poorly-ventilated warehouses.

RATS

Key factors in the control strategy

- Rats and mice reproduce in burrows; destroying these burrows can help to reduce their populations.
- The rodents hide in the vegetation and debris to avoid crossing open spaces where they can be spotted and where they are exposed to predators; keeping the field and adjoining spaces clean can help reduce the damage.
- Traps can be used, but it is important to place them where they will not disturb or injure livestock or children.

Control strategies applied by producers

- Certain farmers dig a deep ditch around the field to discourage the rodents from digging tunnels in the fields. This practice is also used to protect rice paddies in Guinea Forest from *Aulacodes*.
- In western Kenya, cow dung is mixed with pepper and put into burrows then burned to force the rodents out.
- Experience has shown that damage to cassava caused by the Middle East blind mole rat may be reduced by growing the young plants on mounds rather than ridges and by planting *Tephrosia vogelii*, a poisonous, deep-rooted shrub, in the field.

MILLIPEDES

- Millipedes can be a problem when the potato harvest is delayed, especially if it takes place only once the first rains have arrived.
- Millipedes can be a problem in fields near shaded sites (river edges with wooded banks).
- In regions with a millipede problem, do not rotate potato crops with other crops equally sensitive to millipedes, like sweet potatoes, ground nuts and to a lesser extent cassava and beans.

2.3. Resistant or tolerant varieties

The potato varieties used in ACP countries frequently come from developed countries in the Northern Hemisphere, where there are advanced programmes in creating disease- and pest-resistant varieties. Using resistant varieties is clearly a sensible practice in controlling certain bacterial diseases such as *Ralstonia solanacearum* (syn. : *Pseudomonas solanacearum*). Varieties such as Ackerson, Bintje, Wilpo, Gineke and Kerr's Picek are a better choice than the more sensitive Doré, Eesterling, Aquila and Furore to reduce the incidence of this disease (Richard and Boivin, 1994).
The varieties Apollo, Allians, Anoé, Blondy and Bintje are known to be fairly insensitive or resistant to fungal diseases, especially mildew, whereas Altesse (firm flesh, good yield, semi-early, good storage) is acknowledged as fairly sensitive to potato diseases.
The variety Bintje (flowery flesh, good yield, semi-early, good storage) is planted extensively in Guinea for its average resistance to diseases, among other reasons.
In Canada, the cultivar Russet Burbank resists blackleg caused by *Pectobacterium carotovorum* reasonably well, whereas all the other cultivars used are sensitive to this disease (Richard and Boivin, 1994).
The choice of a variety of cultivar must therefore take into account whether or not it is sensitive to diseases that are economically more significant in the producing countries.
The use of wilt-resistant varieties varies across Europe. In Western Europe, resistant varieties are not cultivated on a wide scale as all the commercially important characteristics, such as quality, yield and maturity, are not combined in a single wilt-resistant variety. However, in countries where fungicides are expensive or unavailable, planting resistant varieties is one of the most commonly used methods of reducing damage caused by wilt (www.endure-network.eu).
A difference in variety palatability has been noted in France in relation to slugs: for example, Monalisa is very palatable whereas Nicola is hardly at all (www.plantdepommedeterre.org).

2.4. Importance and use of natural ennemies

Aphids, potato virus vectors

Several species of aphids, mainly *Myzus persicae*, *Aulacorthum solani*, *Macrosiphum euphorbiae*, and *Aphis nasturtii* cause damage to potato. The damage caused by these piercing-sucking insects, such as taking the sap or developing sooty mould in the honeydew, has little direct impact on yield. On the other hand, the numerous viruses they transmit are a real problem, both for plots growing table potatoes (major yield losses) or those intended for seed propagation. These viruses can sometimes cause severe damage. The aim in treating against vector aphids is to delay contamination of plots and then limit the propagation of the virus. It is, however, very important to use pesticides that have little toxicity for the beneficial insect fauna. Various species of aphids, especially the potato aphid, are sensitive to the control methods using parasites, predators and indigenous fungus. In British Columbia (Canada), the beneficial insects are a major component in anti-aphid control strategies, especially in areas where the use of non-selective insecticides against other pests has been reduced or halted (Richard and Boivin, 1994). It is also important to encourage botanic species in the area surrounding the plot that are potential hosts for beneficial insects (micro-hymenopteran parasites, hoverflies), such as *Phacelia*.

Micro-hymenoptera such as *Trichogramma* have been used successfully in various biological control programmes against aphids in Europe.

In Colombia, the use of biological control as an alternative to chemical control has been assessed for two major potato pests the Guatemalan potato moth *Tecia solanivora* (Gelechiidae: Lepidoptera) and the Andean potato weevil *Premnotrypes vorax* (Curculionidae: Coleoptera). The study showed high potential in using egg parasitoids, *Trichogramma lopezandinensis* and *Trichogramma* sp., and also egg predator bugs including: *Buchananiella contigua* and *Lyctocoris campestris* (Anthocoridae: Heteroptera) to control the Guatemalan potato moth (Espitia, 2002).

Whiteflies

Parasitic Hymenoptera and predators such as mites, ladybirds and chrysops are important for the natural control of whiteflies, which are polyphagous pests in miscellaneous horticultural crops such as potatoes.

3. Monitoring the phytosanitary state of the crop and intervention thresholds

The key to including pesticides in an integrated pest management programme in conjunction with other preventive means is plant health warnings based on defining intervention levels against the pests.

In ACP countries, apart from a few cases of potato mildew control in Cuba, plant health warnings are still in an embryonic state. On the other hand, in Northern Hemisphere countries such as Canada, producers and supervisory agents have organized themselves into a Plant Health Warning Network to establish intervention thresholds against miscellaneous potato pests, rationalizing plant health treatments as far as possible. These thresholds are determined from variable indices for the relevant pests, as shown in the examples below.

Leafhopper

A theoretical threshold of 10 larvae per 100 leaves, taken from the middle of the plant, has been determined in Canada. Insecticides should be applied when this threshold is reached. Leafhopper populations exceeding this threshold for two consecutive potato development stages or more can cause significant yield losses.

Green peach aphid, *Myzus persicae* and other aphids

The green peach aphid normally settles on leaves at the base of young plants. The screening technique to assess the abundance of this or other aphids attacking the potato is to count the number of aphids (winged and wingless) on 100 plants chosen at random in the field using a pre-established scheme: in the diagonals, mid-sections or haphazardly. Counting takes place on three compound leaves per plant, taken at the tip, middle and base of the plant, as the different aphid species are found at different heights on the plant. The need for treatment stems from a sudden, major increase in the number of aphids per plant (Richard and Boivin, 1994).

In ACP countries, leaf-green or golden-yellow water traps (bowls) can be used to detect the first flights of winged aphids in order to decide whether or not to apply insecticides. This is especially important for fields set aside for seed production, where action is essential before the aphids can transmit viral diseases.

Cutworms (*Spodoptera exigua, S. littoralis* and *Helicoverpa armigera*)

Light traps are used in many countries, mainly in Cuba, to monitor moth populations of these species and to decide on the right time to act.

4. Plant Protection Products and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of plant protection products (PPP) are indicated, followed by a list of active substances or biocontrol agents and, when available, the recommended critical good agricultural practice (GAP).

Pre-harvest intervals (PHI) () are indicated to either:

- comply with EU maximum residue levels (MRLs) (for potato tubers exported to EU),
- comply with the Codex MRL (for products consumed in countries referring to Codex MRLs),
- produce without quantifiable residues and so comply with private standards requiring « 0 » residues.

Any change in one or more elements of these GAPs (increase in the doses, frequency of application and number of applications, last application before harvest not respecting the recommended pre-harvest interval) can result in residues in excess of the MRL in force. These GAPs do not represent a treatment calendar to be applied. In practice, the frequency of treatments must take account locally of the severity of attacks and the real risks of damage. GAPs indicated are mostly European GAPs that are indicative. No GAPs have been tested by PIP so far in ACP countries.

When there is intrinsically no residue issue for an active substance or a biological agent (highlighted in blue in the tables), the PHI is fixed by default at 7 days.

The list of active substances proposed has been drawn up taking into account the products used by ACP producers and the products registered in ACP countries or elsewhere. The active substances are classified by resistance risk group (Fungicide Resistance Action Committee[1] ; and Insecticide Resistance Action Committee[2]). In practice, it is important to alternate active substances belonging to different groups in order to prevent the emergence of resistance.

The most appropriate development stages of the crop (green boxes in tables) for the application of each active substance are also suggested, taking into account the PHI to be respected so as to comply with MRLs, as well as the active substances' modes of action and effects on natural enemies.

Other substances act as physical traps for some small insects, nematodes and fungi and are not considered to be like conventional PPP. For instance, propylene glycol alginate can trap aphids, mites and leafhoppers as well as powdery mildews when applied correctly. This substance has no pesticide resistance and no residues of concern, but users should check local authorization for use on crops.

PIP updates the compilation of GAPs quarterly on its website, taking into account changes in EU or Codex MRLs.

[1] FRAC: www.frac.info/

[2] IRAC: www.irac-online.org

Leaf-eating caterpillars - Noctuidae (*Spodoptera exigua, S. littoralis, Helicoverpa armigera, Agrotis* spp.) & sphyngides (*Acherontia atropos*)

Strategy: In case of heavy attacks not controllable by natural enemies or manual collection, insecticides may be sprayed on potato aerial parts.

Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – Pyrethroids (sodium channel modulators)												
Cypermethrin	40	3	15	7	/	/		■	■	■		
Deltamethrin	12.5	2	15	7	/	/		■	■	■		
Lambda-cyhalothrin	15	3	15	21	/	/		■	■	■		
Bifenthrin	20	2	21	7	/	/		■	■	■		
Group 5 – Spynosines												
Spinetoram	48	3	/	/	/	/		■	■	■		
Group 18 – Ecdysone agonists / moulting disruptors												
Azadirachtin	150	/	/	7				■	■	■		
Group 11 – Microbial disruptors of insect midgut membranes												
Bacillus thuringiensis	/	/	/	7				■	■	■		

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the limit of quantification (LOQ) (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Andrector ruficornis (chrysomelidae)												
Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – Pyrethroids (sodium channel modulators)												
Cypermethrin	40	3	15	7	/	/						
Lambda-cyhalothrin	7,5	3	/	14	/	/						
Cyfluthrin	15	3	15	7	/	/						
Group 5 – Spynosines (nicotinic acetylcholine receptor allosteric activators)												
Spinosad	120	2	15	7	/	/						
Group 4 – Nicotinic acetylcholine receptor agonists												
Thiamethoxam	200	3	/	7	/	/						
Group 11 – Microbial disruptors of insect midgut membranes												
Bacillus thuringiensis	/	/	/	7								

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Cutworms, terrestrial orthoptera and termites - *Agrotis* spp., *Gryllotalpa africana, Brachytrupes membranaceus, Zonocerus variegatus & Microtermes* spp.												
Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – Pyrethroids (sodium channel modulators)												
Cypermethrin	40	3	15	7	/	/						
Cyfluthrin	15	3	15	7	/	/						
Bifenthrin	20	2	21	7	/	/						
Group 1 – Organophosphates and carbamates (acetylcholine esterase inhibitors)												
Dimethoate	30	2	21	21	/	/						

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Biting-sucking insects - white flies (*Bemisia tabaci)*, jassids (*Jacobiasca lybica*), aphids (*Myzus persicae, Aulacorthum solani, Macrosiphum euphorbiae*)													
Active substance	Recommended GAP*						Proposed application period						
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – Pyrethroids (sodium channel modulators)													
Cypermethrin	40	3	15	7	/	/		■	■	■		
Deltamethrin	12,5	2	15	7	/	/		■	■	■		
Lambda-cyhalothrin	12,5	3	15	14	/	/		■	■	■		
Bifenthrin	20	2	21	7	/	/		■	■	■		
Group 1 – Organophosphates and carbamates (acetylcholine esterase inhibitors)													
Dimethoate	30	2	21	21	/	/		■	■	■		

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Potato tuber moth - *Phthorimaea operculella, Tecia solanivora*													
Active substance	Recommended GAP*						Proposed application period						
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – Pyrethroids (sodium channel modulators)													
Bifenthrin	20	2	21	7	/	/				■	■	
Lambda-cyhalothrin	12,5	3	15	14	/	/				■		
Group 5 – Spynosines (nicotinic acetylcholine receptor allosteric activators)													
Spinetoram	48	3	/	/	/	/				■		
Group 1 – Organophosphates and carbamates (acetylcholine esterase inhibitors)													
Dimethoate	30	2	21	21	/	/				■		
Chlorpyriphos-methyl	/	2	/	15	/	/				■	■	

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Mites - foliage mites *(Tetranychus urticae, Aculops lycopersis, Polyphagotarsonemus latus)* and root mites *(Rhizoglyphus echinopus)*												
Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 6 – Avermectins (chloride channel activators)												
Abamectin	20	2	7	14	/	/						
Group 3 – Pyrethroids (sodium channel modulators)												
Bifenthrin**	20	2	21	7	/	/						

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

** : only to control Tetranychus

/ : elements of the recommended GAP not available

Nematodes - *Meloidogyne* spp., *Helicotylenchus* spp., *Pratylenchus* spp.												
Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 1 – Organophosphates and carbamates (acetylcholine esterase inhibitors)												
Fosthiazate	3000	1	/	120	/	/						

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Foliar diseases - *Alternaria solani, Cladosporium fulvum*													
Active substance	Recommended GAP*						Proposed application period						
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group M – Multi-site action fungicides (dithiocarbamates)													
Mancozeb	1250 - 1750	2	14	7	/	/						
Maneb	1600-2000	2	14	/	/	/							
Group 2 – Dicarboximides (disruptors of osmotic signal transduction)													
Iprodione	750	2	/	30	/	/							

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Potato blight - *Phytophthora infestans*													
Strategy: For this pathogen, in addition to good soil preparation, it is recommended to use healthy or treated seeds to control the sources of primary inoculum and the starting point of early attacks.													
Active substance	Recommended GAP*						Proposed application period						
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group M – Multi site action fungicides (chloronitriles and dithiocarbamates)													
Chlorothalonil	1500	2		7	/	/							
Mancozeb	1575	2	14	7	/	/							
Maneb	1600-2000	2	14	/	/	/							
Group 29 – Respiration disruptors													
Fluazinam	200	2	/	7	/	/							
Group 4 – Phenyl amide fungicides (disruptors of nucleic acid synthesis)													
Metalaxyl-M to 3,88% (+ Mancozeb 64%)	97 (+ 1600)	/	/	7									
Group 27 – Cyanoacetamide-oxime (unknown mode of action)													
Cymoxanil to 4% (+ Mancozeb 46,5%)	100 (+ 1162,5)	/	/	7									
Group 40 – CAA fungicides (Carboxylic Acid Amides, disruptors of cellulose synthase)													
Mandipropamid	/	/	/	7									

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

Fungal wilt - *Fusarium oxysporum, Verticillium albo-atrum, Rhizoctonia solani, Sclerotium rolfsii*

Strategy: For this pathogen, in addition to good soil preparation and long rotation, it is recommended to implement preventive or curative treatments of seeds or plant organs with appropriate fungicides.

Active substance	Recommended GAP*						Proposed application period					
	Dose g/ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval recommended (days)			Soil preparation	Germination	Active growth	Stabilized vegetation	Senescence	Harvest and storage
				EU MRL	Codex MRL	LOQ						
Group 3 – DMI fungicides (demethylation inhibitors, sterol biosynthesis inhibitors)												
Imazalil	100	/	/	/	/	/		■				■
Group 2 – Dicarboximides (disruptors of osmotic signal transduction)												
Iprodione	750	2		30	/	/			■	■	■	
Group 1 – MBC fungicides (methyl benzimidazole carbamates; mitosis and cell division disruptors)												
Carbendazime	400-500	2	14	7	/	/			■	■	■	
Group M – Multi-site action fungicides (dithiocarbamates)												
Mancozeb	1575	2	14	7	/	/		■	■	■	■	
Thiram	1500 g/hl of water	1	n.a.	n.a.	/	/		■				

* : the elements of the recommended GAP allow to meet the European MRL, the Codex MRL or the LOQ (cf. section 6 of this guide and the introduction to section 4)

/ : elements of the recommended GAP not available

n.a. : non applicable

5. Existing registrations

Note: the information below may have been modified; growers should check the legislation in force in their own country. The process of harmonization of registrations procedures in African countries belonging to the same economic community could make significant changes to the list of Plant Protection Products (PPP) authorized for the protection of potato in these regions.

▪ Countries of Central and Southern Africa
No information available.

▪ CILSS countries (Burkina Faso, Cape Verde, Gambia, Guineae-Bissau, Mali, Mauritania, Niger, Senegal, Chad) – CSP registration
All these Sahelian countries have a standardized registration coordinated by the Sahelian Pesticides Committee. The following active substances listed in section 4 of this guide are included in PPP registered on vegetables and so could be used on potato: abamectin, chlorpyrifos-methyl, cypermethrin, lambda-cyhalothrin and mancozeb.

▪ Guinea
Guinea has its own phytosanitary regulation. The following active substances included in section 4 of this guide have a registration for use on potato: chlorothalonil, cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin, mancozeb and maneb.

▪ Nigeria
No information available.

▪ Jamaica and Dominican Republic
No information available.

▪ Kenya
Kenya has its own phytosanitary regulation. The following active substances included in section 4 of this guide have a registration for use on potato: abamectin, *Bacillus thringiensis*, chlorpyrifos-methyl, cymoxanil, cypermethrin, deltamethrin, dimethoate, iprodione, lambda-cyhalothrin, mancozeb, metalaxyl-M, spinosad and thiamethoxam.

6. Regulations and pesticide residues

Status of the active substances in regulation 1107/2009, European MRLs and Codex MRLs - Updated in April 2013

Caution: The information contained in this table is subject to change by future decisions of the EU Commission and Codex.

Active substance	European regulations		Codex MRL Potato or tuber vegetables
	Status REG 1107/2009	EU MRL	
Abamectin	Approved	0.01*	0.01*
Azadirachtin	Approved	1	/
Bacillus thuringiensis	Approved	n.a.	/
Bifenthrin	Approved	0.05*	/
Carbendazime	Approved	0.1*	/
Chlorothalonil	Approved	0.02	0.3
Chlorpyrifos-methyl	Approved	0.05*	0.01*
Cyfluthrin	Approved	0.04	0.01*
Cymoxanil	Approved	0.05*	/
Cypermethrin	Approved	0.05*	0.01*
Deltamethrin	Approved	0.2	0.01*
Dimethoate	Approved	0.02*	0.05
Fluazinam	Approved	0.05*	/
Fosthiazate	Approved	0.02*	/
Imazalil	Approved	3	5
Iprodione	Approved	0.02*	/
Lambda-cyhalothrin	Approved	0.02*	0.01*
Mancozeb	Approved	0.3	0.2
Mandipropamid	Approved	0.01*	0.01*
Maneb	Approved	0.3	0.2
Metalaxyl-M	Approved	0.05*	0.05*
Spinosad	Approved	0.02*	0.01*
Spinetoram	Pending	0.05*	/
Thiamethoxam	Approved	0.3	0.3
Thiram	Approved	0.1*	/

Approved: active substance allowed for selling in the PPP market in EU

Not approved: active substance not allowed for selling in the PPP EU market, but can be used by growers outside the EU as long as residues comply with current EU MRL if the commodity is exported to EU.

* = LOQ
n.a. not applicable
/ = doesn't exist or not available

Note on the status of active substances in the EU

Before a Plant Protection Product can be marketed in the EU, its active substance must be approved by the European Commission. Regulation (EC) 1107/2009 (replacing former Directive 91/414/EEC) came into force on 14 June 2011. By 25 May 2011 the Commission adopted Implementing Regulation (EU) N° 540/2011 as regards the list of approved active substances. These Regulations and all other related Regulations can be accessed using the search facility on the following: http://ec.europa.eu/food/plant/protection/evaluation/index_en.htm

It should be noted that if an active substance is not registered in the EU it can still be used in the ACP countries in food items exported to Europe, provided the residue complies with the EU MRL.

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.
The maximum residue level (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

Pursuant to Regulation (EC) No 396/2005 harmonized Community MRLs have been established.

The European Commission (EC) sets MRLs applying to foodstuffs marketed in the territories of the EU countries, either produced in the EU or in third countries.

Annex I to the Regulation contains the list of crops (Regulation (EC) 178/2006) on which MRLs are assigned, Annexes II and III contain the MRLs: temporary MRLs can be found in Annex III, final MRLs in Annex II. Substances for which an MRL is not required are listed in Annex IV (Regulation (EC) 149/2008). When there is no specific MRL for a substance / crop, a default MRL, usually set at 0.01 mg/kg, is applied.

When establishing an MRL, the EU takes into account the Codex MRL if it is set for the same agricultural practices and it passes the dietary risk assessment. Where appropriate Codex MRLs exist, the import tolerance will be set at this level.

EU harmonized MRLs came into force on 1 September 2008 and are published in the MRL database on the website of the Commission http://ec.europa.eu/food/plant/plant_protection_products/pesticides_database/index_en.htm

See also the leaflet "New rules on pesticide residues in food": http://ec.europa.eu/food/plant/protection/pesticides/explanation_pesticide_residues.pdf

How are MRLs applied and monitored in the EU?

- Operators, traders and importers are responsible for food safety, and therefore for compliance with MRLs.
- The Member State authorities are responsible for monitoring and enforcement of MRLs.
- To ensure the effective and uniform application of these limits, the Commission has established a multiannual community monitoring program, defining for each Member State the main combinations of crops and pesticides to be monitored and the minimum number of samples to be taken. Member States must report results to the Commission, which publishes an annual report. At present the reports are published by the European Food Safety Authority (EFSA): www.efsa.europa.eu/en/scdocs.htm
- In case of detection of pesticide residue levels posing a risk to consumers, information is transmitted through the Rapid Alert System for Food and Feed (RASFF) and appropriate measures are taken to protect the consumer. The database is accessible on http://ec.europa.eu/food/food/rapidalert/rasff_portal_database_en.htm and RASFF publishes an annual report http://ec.europa.eu/food/food/rapidalert/index_en.htm.
- PIP provides monthly updates on its website.

MRLs in ACP countries – Codex

The Codex Alimentarius Commission was established in 1961 by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) with the objective to develop an international food code and food standards. Membership of the Codex Alimentarius Commission is open to all Member Nations and Associate Members of FAO and WHO. More than 180 countries and the European Community are members of the Codex Alimentarius Commission.

The Joint FAO/WHO Meetings on Pesticide Residues (JMPR) are not officially part of the Codex Alimentarius Commission structure, but provide independent scientific expert advice to the Commission and its specialist Committee on Pesticide Residues for the establishment of Codex Maximum Residue Limits, Codex MRLs for pesticides which are recognized by most of the member countries and widely used, especially by countries that have no own system for evaluating and setting MRLs.

The Codex MRL database can be found on the web site: www.codexalimentarius.net/pestres/data/index.html?lang=en.

Annexes

References and useful documents

- Collectif, *Principales maladies, insectes et nématodes de la pomme de terre*, Centre international de la pomme de terre, Lima, 1990 : 96 p.
- Wolfgang Radtke et Walter Rieckmann, *Maladies et ravageurs de la pomme de terre*, éd. Th. Mann-Gelsenkircher-Buer, 1991.
- *Maladies, ravageurs et désordres de la pomme de terre. Guide d'identification et fiches descriptives*, ITCF, 2008 : 192 p.
- C. Richard et G. Boivin (1994) : Maladies et ravageurs des cultures légumières au Canada. Société Canadienne de Phytopathologie et la Société d'Entomologie du Canada : 589 p.
- E. J. E. Buyckx (1962) : Précis des maladies et des insectes nuisibles rencontrés sur les plantes cultivées au Congo, au Rwanda et au Burundi. Institut National pour l'étude agronomique du Congo (I.N.E.A.C.) : 708 p.
- J.-C. Garnaud et G. Rouanet (1966) : Guide pratique de défense des cultures. Editions LE CAROUSSEL et ACTA : 224p.
- E. Espitia, 2002, Biological control of the two major potato pests in Colombia. Michigan State University, Department of Entomology, East Lansing, MI and Aristobulo Lopez-Avila, Colombian Corporation of Agricultural Research, Corpoica, Manejo Integrado de Plagas (IPM) Las Palmas, Bogota, DC, Colombia.
- B. Vanderhofstadt et al. (2009) : Guide de la culture de la pomme de terre en Afrique de l'Ouest. Edit. CDE et CTA : 82 p.
- R. Besin (2010). Potato pests. UK Cooperative Extension Service. 3.
- Z. Ambang, N. D. Omokolo, I. S. Ouzounov (2002). Evaluation de l'efficacité de la *Bacillus thuringiensis* contre les larves et imagos de *Andrector ruficormis* sur des plants de *Solanum tuberosum* au Cameroun. Tropicultura 20 (3) : 113-117.
- Guide pratique de la culture de la pomme de terre en Afrique de l'Ouest - CDE

Online resources

INRA: www.inra.fr/internet/Produits/HYPPZ/RAVAGEUR/, www.inra.fr/agritox/php/fiches.php
Le Plant Français de Pomme de terre: www.plantdepommedeterre.org/
Observatoire des Résidus de Pesticides: www.observatoire-pesticides.gouv.fr/index.php
US Environmental Protection Agency: www.epa.gov/pesticides/
Inter-réseaux Développement rural: www.inter-reseaux.org/IMG/pdf_rapport_M-_MOENNE_ASF.pdf
http://morgane-en-afrique.over-blog.com/
Centre pour le Développement de l'Entreprise: www.cde.int/documents/Production_Pomme_de_terre.pdf
Infonet Biovision: www.infonet-biovision.org/default/ct/139/crops

CROP PRODUCTION PROTOCOLS

Avocado (*Persea americana*)
French bean (*Phaseolus vulgaris*)
Okra (*Abelmoschus esculentus*)
Passion fruit (*Passiflora edulis*)
Pineapple Cayenne (*Ananas comosus*)
Pineapple MD2 (*Ananas comosus*)
Mango (*Mangifera indica*)
Papaya (*Carica papaya*)
Pea (*Pisum sativum*)
Cherry tomato (*Lycopersicon esculentum*)

GUIDES TO GOOD PLANT PROTECTION PRACTICES

Amaranth (*Amaranthus* spp.)
Baby carrot (*Daucus carota*)
Baby and sweet corn (*Zea mays*)
Baby Leek (*Allium porrum*)
Baby pak choy (*Brassica campestris* var. *chinensis*), baby cauliflower (*Brassica oleracea* var. *botrytis*), baby broccoli and sprouting broccoli (*Brassica oleracea* var. *italica*) *and head cabbages* (*Brassica oleracea var. capitata* and *var. sabauda*)
Banana (*Musa* spp. – plantain (*matoke*), apple banana, red banana, baby banana and other ethnics bananas)
Cassava (*Manihot esculenta*)
Chillies (*Capsicum frutescens, Capsicum annuum, Capsicum chinense*) and sweet peppers (*Capsicum annuum*)
Citrus (*Citrus* sp.)
Coconut (*Cocus nucifera*)
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica, Benincasa, Luffa, Lagenaria, Trichosanthes, Sechium* and *Coccinia*
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon)*
Garlic, onions, shallots (*Allium sativum, Allium cepa, Allium ascalonicum*)
Ginger (*Zingiber officinale*)
Guava (*Psidium catteyanum*)
Lettuce *(Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)
Lychee (*Litchi chinensis*)
Melon (*Cucumis melo*)
Organic Avocado (*Persea americana*)
Organic Mango (*Mangifera indica*)
Organic Papaya (*Carica papaya*)
Organic Pineapple (*Ananas comosus*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomoea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)

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