POWDERY MILDEW

INTRODUCTION :

Powdery mildews, caused by various species of fungi (Family Erysiphaceae), can affect trees, shrubs, roses, perennials, annuals, bulbous plants, vegetables, fruits and many indoor plants. Each species of powdery mildew affects only specific types of plant. However a few plants are susceptible to more than one type of powdery mildew. Powdery mildews are particularly prevalent under dry soil conditions and when days are warm and dry followed by cold nights. For many plants, most severe attacks can occur in early autumn at the end of the growing season.

Plants commonly affected

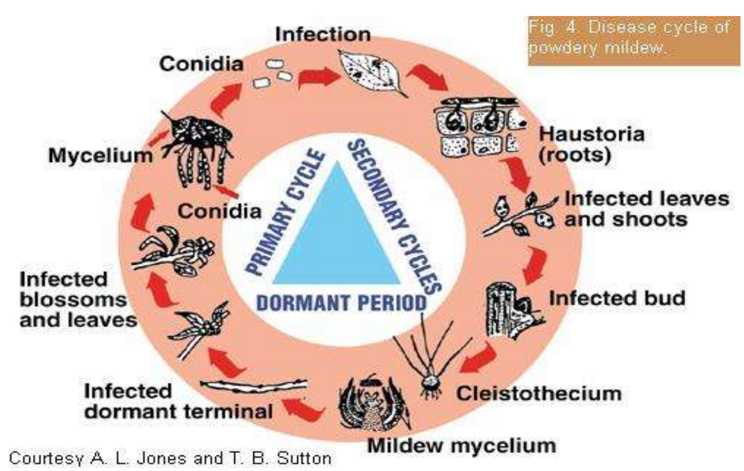
Apple: Apple Powdery Mildew (*Podosphaera leucotricha*)
Apricot, Cherry & Plum: Plum Powdery Mildew (*Podosphaera tridactyla*)
Begonia: Begonia Powdery Mildew (*Oidium begoniae* var. *macrosporum*)
Crucifers & Poppy: Crucifer Powdery Mildew (*Erysiphe cruciferarum*)
Cucumber & Marrow: {Cucumber Mildew (*Sphaerotheca fuliginea*)
{Cucurbit Powdery Mildew (*Erysiphe cichoracearum*)
Gooseberry & Blackcurrant: American Gooseberry Mildew (*Sphaerotheca mors-uvae*)
Grapes: Vine Powdery Mildew (*Uncinula necator*)
Pea & Lupin: Pea Powdery Mildew (*Erysiphe pisi*)
Peach: Peach Powdery Mildew (*Sphaerotheca pannosa*)*
Rose: Rose Powdery Mildew (*Sphaerotheca pannosa*)*
Strawberry, Raspberry,
Blackberry & Filipendula: Strawberry Powdery Mildew (*Sphaerotheca macularis*) * Cross infection does not seem to occur naturally.

Typical symptoms

Discrete off-white patches appear on the leaves, and often the stems and buds. These patches join up and a powdery white coating develops. Leaves can curl at the margins, becoming distorted, or turn yellow or purple and fall early. Infected parts may wither and die back. On woody plants blossoms may wither and fall. On some plants such as vines, peaches and gooseberries, the flowers and fruits may be affected. Fruits of grapes and strawberries will be covered with a powdery-white coating. On gooseberries a brown felt may cover the fruit and stems, on which black dots develop.

Life cycle

Powdery mildew-causing fungi overwinter in a dormant state on plant debris and, in the case of woody plants, on buds. The fungi produce spores, which the wind spreads to new hosts. Further spores are produced throughout the spring and summer, infecting new plants. These spores give the characteristic powdery appearance to infected plants.



Pea powdery mildew (*Erysiphe pisi*) can be carried in the seed.

Prevention and control

Timing: Grow early peas to mature before the high summer drought period, when plants arevery prone to powdery mildew. Early sowings of turnips and swedes are more susceptible, so delay sowing as long as possible.

Correct feeding: Healthy plants are better able to resist, or to withstand, infection. Ensure that plants are well-fed and healthy, but do not overdo the nitrogen, as this can encourage weak sappy growth, which is more easily infected.

Moisture: Drying at the roots weakens plants and encourages powdery mildew. A soil that is rich in organic matter will retain more moisture; mulching well will help reduce water loss. Water, when necessary, *before* the soil dries out. Plants growing at the base of a wall may be particularly susceptible to mildew problems as they are sheltered from rainfall and may need watering even during wet weather.

Bio-Stimulants: Research on seaweed extracts has shown them to help plants fight off fungal attack, on fruit in particular. Seaweed does not have a fungicidal action, rather it strengthens and stimulates the plant. Seaweed is now used commercially in vineyards around the world.

Doing nothing: Mildew on outdoor courgettes, cucumbers and pumpkins often occurs near the end of the season, so on these plants it may not affect production. On perennial plants, however, infected foliage must be removed as soon as it is detected, to ensure that the disease does not get a hold.

Resistant varieties: For Asters try hybrids of *Aster novae-angliae* and *A. lateriflorus*. Resistant varieties of rose include 'Queen Elisabeth' and 'National Trust'. Two apple varieties which have shown resistance to powdery mildew at Ryton are 'Redsleeves' and 'Worcester Pearmain'. Resistant varieties of peas, and other vegetables, can be found in The Organic Gardening Catalogue.

Cultural control: Plant out vegetables and ornamentals at the correct spacing. Avoid overcrowding by winter-pruning woody plants for an open framework. Summer pruning may increase infection by causing buds to swell, opening them to over-wintering spores. Prune out the first shoots to show signs of mildew in spring – taking great care not to spread the infection by showering spores onto healthy foliage, by pruning straight into a plastic bag. Clear away all dead foliage from infected herbaceous plants at the end of the season. Remove all leaves and runners from strawberries after fruiting. Infected foliage can be safely composted as it is an air-borne disease and will not be spread via the compost.

In the greenhouse: Ensure adequate ventilation in the summer; avoid overcrowding, and do not allow plants to dry out. Do not over water in winter. Hygiene is very important. At the end of the year remove all plant debris, to clear the house of spores, and clean the glasshouse with warm soapy water.

Chemical control – a last resort: Although sulphur is acceptable under organic regulations for the control of powdery mildew, it is a powerful chemical which is not harmless in the environment. Some varieties of plant may be damaged by sulphur, such as the apple 'Cox's Orange Pippin'. If you are unsure, spray an isolated leaf or shoot, and watch for scorching or leaf-fall within 24 hours.

Potassium bicarbonate is a recently approved fungicide under the 'Commodity Substance Approval Scheme' (26 July 2005). Soil Association, certificate holders must seek approval before using this substance but there is nothing to stop organic gardeners, who are not selling produce with an organic logo, giving it a try – alongside the other cultural practices recommended too.A maximum dilution of 20g/litre (approx 3oz per gallon) is allowed. However, a regular spray of a weaker solution (2.5-5g/litre) at 7-10 day intervals seems to work better. Always do a spray test on a few singular leaves, as bicarbonate may scorch leaves.

POWDERY MILDEW OF PEA

ETIOLOGY :

- Erysiphe polygoni (Erysiphe pisi)
- Class : Ascomycetes
- Order : Eryphales
- Family : erysiphaceae
- Biotroph / obligate parasite
- Ectophytic mycelium
- Septate mycelium
- Hyaline, elliptical, barrel shaped conidia

Figure : powdery mildew in pea leaf

Symptoms :

Symptoms include white, powderyspots on lower leaves and stems which can eventually spread to the entire plant. Severely affected crops are covered in a white mat of powdery spores and may appear to have a bluish or silvery sheen. The underside of infected leaves turn yellow below the powdery infection. The disease is favoured by warm, sunny and dry conditions during the day, along with cool nights favouring heavy dew in the morning. Heavy rain can actually wash some of the powdery spores and growth off the leaves, resulting reduce the useable leaf area, cause stunted plants and affect the development of the pods and seeds. The disease can reduce yield, delay maturity, make it difficult to do a proper job of desiccating the crop, and sometimes lead to an increased occurrence of combine fires. Late seeding in past years compounded the harmful effect of the disease, since the pods and seeds of many pea crops were not developed before the infestation occurred.

Figure : powdery mildew in leaf and stem of pea

DISEASE CYCLE :

- ✓ Primary inoculums : Clestothecia living in the soil.
- ✓ Cleistothecia are formed on crop debris after conditioning by soil temperature and moisture.
- ✓ Clestiothecia are formed on latesr stage of plant.
- ✓ After disintegrating of cleistothecia, the ascospores are released and infest lower leaves.
- ✓ Fungus produces conidia and starts secondary cycle.
- ✓ More severe during dry season than wet season.
- ✓ Conidia germinate at 20-24^{0}c and RH 100 %.
- ✓ Under favourable environmental condition, conidia germinate within 1hr an entire leaf may be colonized in 150 hrs.

CONTROL MEASURES :

- ✓ Burn all plant debris and destroy the collateral/alternate host.
- ✓ Early sowing sustains less damage; or early variety e.g L-116.
- ✓ Apply sprinkle irrigation (why ?).
- ✓ Crop rotation = 3-4 yrs with cereals, sugarcane, gram.
- ✓ Use of resistant variety ; Rachana, PM-2.
- ✓ Chemical spray of sulphex or wettable sulphur@ 3gm/ltr at interval of 10-15 days.
- ✓ Sulphur dust – 25kg/ha.
- ✓ Karathione- 0.2%.

LATE BLIGHT OF POTATO

INTRODUCTION :

Late blight is an extremely destructive fungal disease of potatoes. The fungus attacks both tubers and Oliage at any stage of development and is capable of rapid development and spread. Soft rot of tubers often occurs in storage following tuber infections. Consequently, the tolerance for late blight is usually very low.

ETIOLOGY:

- Kingdom : Stramenopila
- Phylum : Oomycota
- Order : Peronosporales
- Family : Pythiaceae
- Genus : *Phytophthora*
- Species : *infestans*
- Synonyms : *Botrytis infestans* , *Botrytis devastatrix* , *Botrytis solani* , *Peronospora infestans*
- Common names : Potato Late Blight, late blight, blight, potato murrain

The mycelium is hyaline, branched, coenocytic and produces indeterminate, sympodially branched sporangiophores distinguishable from the somatic hyphae. The thin-walled, lemonshaped,hyaline sporangium (21-38x 12-23µm), having an apical papilla, is borne at the tip ofthe branch and, as it matures, the tip of the branch swells and continues to elongate, resulting in the sporangium being turned laterally. A sporulating hypha is characterized by periodic swelling that marks the points at which sporangia had been attached. Depending on prevailing conditions, a sporangium may germinate directly to form a germ tube or indirectly to form 8-10 swimming zoospores. The latter have two different types of flagella, which are of taxonomic significance. Most strains are heterothallic and production of the sexual spore (oospore) requires two compatibility groups (mating types). Reproductive structures are antheridia and oogonia from opposite mating types. During the development of these structures, the antheridium is punctured by the oogonium, which grows through it and matures into a round body above the antheridium – an arrangement termed amphigynous. The oospore (25-35 µm) has a thickened wall that renders it resistant to unfavourable conditions. It germinates to form a zoosporangium.

SYMPTOMS :

The first symptoms of late blight in the field are small, dark, circular to irregularly shaped lesions, which appear 3-5 days after infection (fig.1). These usually appear first on the lower leaves, where the microclimate is more humid. However, they may occur on upper leaves if weather conditions are favourable and the pathogen has been carried into the field by air currents. Lesions often begin to develop on the compound leaf near the point of attachment to the petiole (which is often cupped) or at the leaf edges, where dew is retained longst. During cool, moist weather , lesions expand rapidly into large, dark, brown or black spots, often surrounded by a pale green to yellow border (fig 2) . Lesions are not limited by leaf veins, and if formed at leaf tips or edges, they can cause young expanding leaves to be misshapen. As new infections occur and existing lesions coalese, entire leaves may become blighted and killed within a few days (fig3). On stems, lesions are often initiated at the point of attachment to the stem, and leaves become detached shortly after infection (fig4). The lesions continue to develop along the length of the stem and can remain active even in hot, dry weather. In the early morning or during cool, damp weather, a white, velvety growth may be seem on infected leaves and stems (fig5). This white, velvety growth distinguishes late blight from several other foliar disesases of potato. Plants severly affected by late blight also have a distinctive odor resulting from the rapid breakdown of potato by chemical vine-kill or occurring after severe frost.

Late blight infection of tubers is characterized by irregularly shaped, slightly depressed brown to purplish areas on the skin. These symptoms may be less obvious on russet and red-skinned cultivar. A tan to reddish brown, dry, granular rot is found under the skin in the discolored area, extending into the tuber usually less than ½ inch (fig 6). The extent of rotting in a tuber depends on the susceptibility of the cultivar, temperature and length of time after the cultivar, temperature and length of time after the initial infection. The margin of diseased tissue is not distinct and is marked by brown finger-like extensions into the healthy tissue of the tuber. In time, the entire tuber becomes blighted and discolored. Late blight rot of tubers is often accompanied by soft rot.

Positive identification of the blight can be made by microscopic examination of lesions from infected leaves or tubers collected when the fungus is producing spores (fig 7). The water mold can be quickly identified by the distinctive size and shape of the spores and spore-bearing stalks.

Figure 1 small dark circular to irregular lesions appear on leaves 3-5 days after infection.

Figure 2: lesions expand rapidly in cool, moist weather into brown to black spots that are often surrounded by green border.

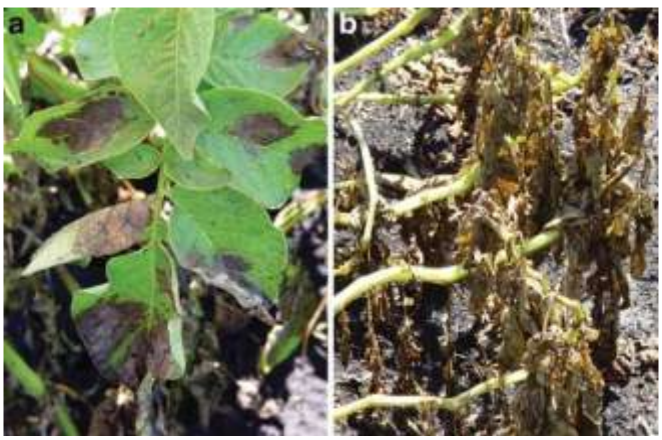


Figure3 a.lesions are not limited by veins and expand rapidly. b.entire leaves become blightened within days of the initial infection.

Figure 4 a. stem lesions b. leaves may detached shorlty after infection.

Figure 5. a.small white, velvety growth (arrows) may be seen on the undersides of leaves in the early morning.b,c. it may also occur on the surface of leaves and stems during cool, damp weather.

Figure 6 : Tuber late blight symptoms, characterized by discoloration of the potato skin and a tan to reddish brown, dry, granular rot underneath the discolored skin.

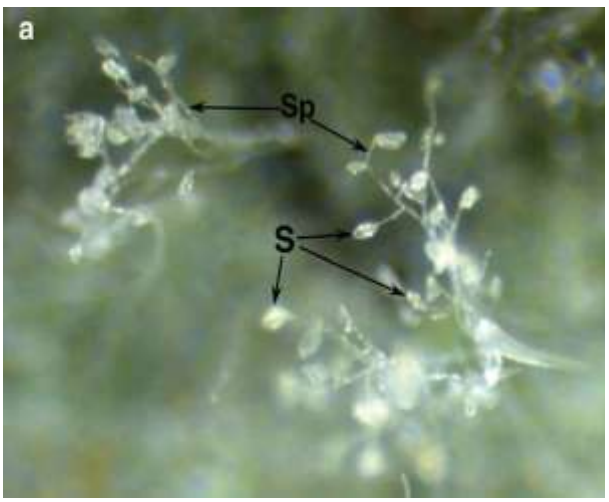


Figure 7a. sporangia

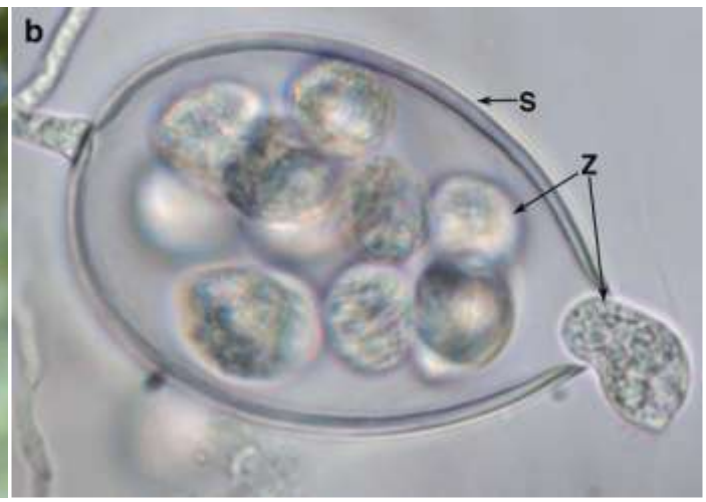


Figure 7.b. sporangia germinate

DISEASE CYCLE :

Phytopthera infestans, the casual agent of late blight, is not a true fungus but a water mold belonging to the phylum oomycetes. Oomycetes such as p. infestans form large, clear, lemon-shaped spores called sporangia on stalks called sporangiophores. Though they are relatively large in comparision to those of true fungi, they cannot be seen without the aid of a microscope that can magnify at least 100 times. The sporangiophores have distinct periodic sweelings at points where sporangia were produced.

Sporangia may germinate at temperatures between 44 and 55^{o}f when free water is present on leaves from 8 to 12 motile zoospores per sporangium. These swim freely in water films, attach to the leaf surface with a germ tube, either through stomata or by means of direct penetration. At temperatures of 55 to 70^{o}f, sporangia germinate by means of a single germ tube. Night temperatures of 50 to 60^{o}f accompanied by light rain, fog or heavy dew and followed by days of 60 to 75^{0}f with high relative humidity are ideal for late blight infection and development.

Tubers may become infected if sporangia produced on the foliage are washed down into the soil by rain or irrigation water. Water-borne spores to follow stems and stolons in a water film into the soil, reach tubers and cause infection. Tubers near the soil surface are thus more likely to be infected. Phytopthora infestans can survive only in living potato tissue. It usually survives from year in infected tubers in storage, in piles of cull potatoes or in infected tubers missed during harvest that remain unfrozen over the winter (volunteers to potato foliage by airborne spores. Infected sexual spore known as oospore. Oospores are resistant to freezing and other environmental extremes and can survive in diseased leaves and stems or free in soil. When only one of the mating types is present, the fungus can survive over winter, or if they are buried deeply enough in soil to sprout, the disease cycle is broken, and very often the disease doesnot appear even when the weather conditions are favourable.

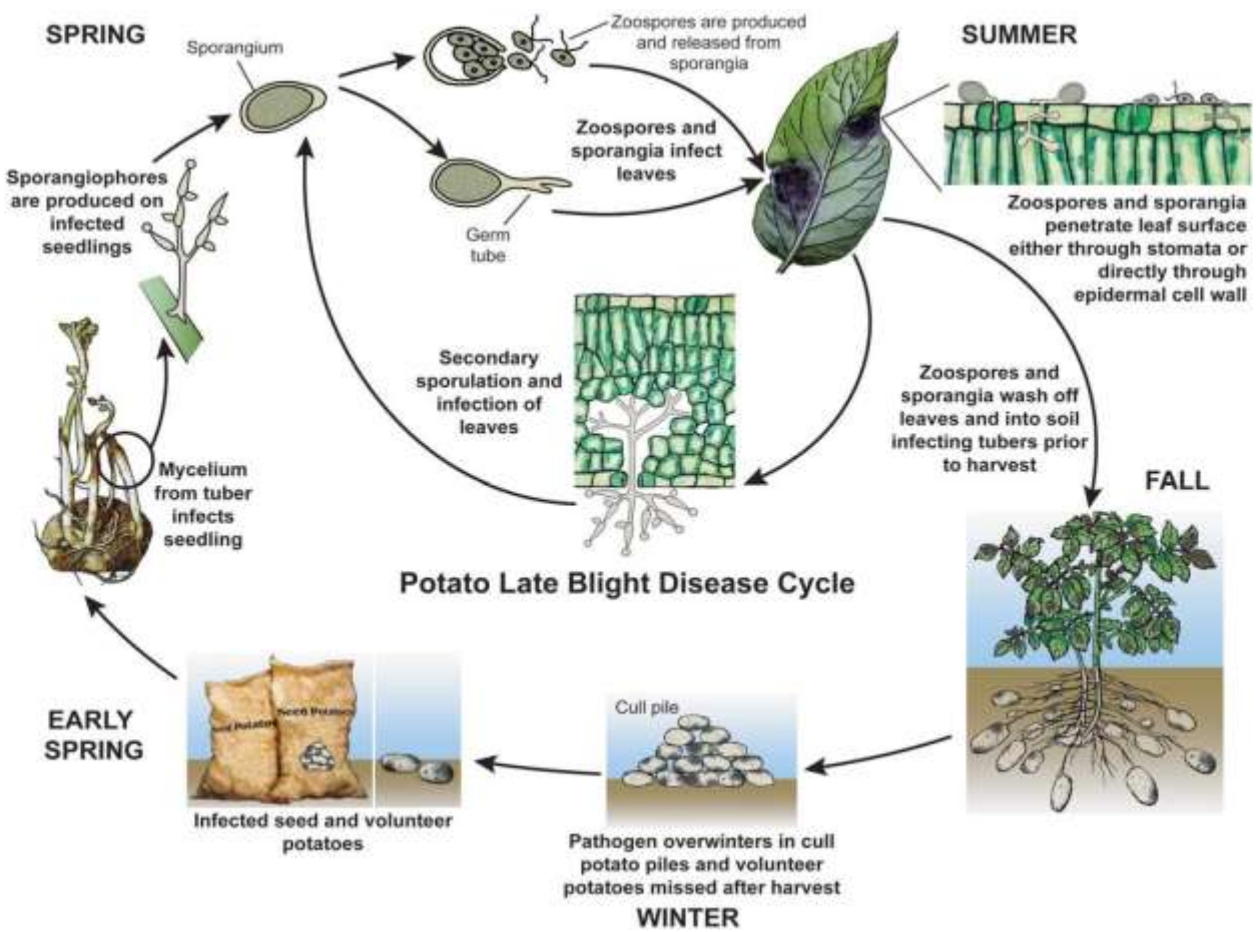


Figure : disease cycle of potato late blight

BIOLOGY AND EPIDEMIOLOGY :

P. infestans perennates as mycelium in infected tubers a) left in the field after harvest, b) in cullpiles close to production areas, c) in seed pieces, d) in tomato fruits produced in close proximity to potato farms, e) in wild *Solanum* spp. or f) in soil. In the tropics potato is grown continuously, so that disease can be initiated in newly planted fields by air-borne sporangia. Mycelium in tubers invades the sprouts, emerging above ground in them and sporulates to form the primary inoculum (Fig.3.). The conditions favouring sporangium production, dissemination 9 and infection determine the extent of the epiphytotic. Optimum temperature and RH for sporangium formation are 18-22°C and 100% , minimum RH is 91 % and the temperature range is 3-26°C. The optimum temperature range for zoospore formation is 12-15 $^{\circ}$C and for the formation of germ tubes from zoospores it is 21-24C. Sporangia producegerm tubes most rapidly at 25°C. Thus, cool, moist nights favour the most rapid production and germination of inoculum. Optimal development after infection requires somewhat warmer temperatures. In such conditions sporangial production can occur within 14 days of infection, which indicates why late blight is used so frequently to exemplify the polcyclic type of pathogen. The sporangium falling on susceptible host tissue germinates to produce about 8 biflagellate zoospores at cooler temperatures (12-15°C) or directly produces germ tubes in slightly warmer conditions (20-27°C). Zoospores require a film of water in which they migrate over the plant surface. Entry into host tissue is either through stomata or directly into the epidermis. The ramifying mycelium in the host is both inter- and intracellular, displaying necrotrophic properties of rapid cell destruction that cause the devastating blight.Tuber infection arises from sporangia being washed down from aerial plant parts. Zoospores germinate and enter through lenticels and wounds, the mycelium being intercellular and feeding on tuber cells via variously- shaped haustoria.

MANAGEMENT AND CONTROL :

Plant Quarantine

As with any crop that is vegetatively propagated, there is great risk in using any but the highest quality, disease-free planting material. This requires controlling the entry of seed potato through appropriate quarantine regulations. An indigenous certification programme is the most desirable approach, but requires virus indexing capabilities that may be difficult to institute. Only certified seed of the most resistant varieties, known to perform well in the area, should be planted.Planting is normally scheduled to permit maximum crop growth before the expected date of the first blight- favourable weather.

Sanitation

Sources of perennating (overwintering) mycelium- dumps, cull heaps, volunteer potato plants and nearby tomato plants need to be destroyed.

Avoid conditions favouring late blight

a) Select fields that are well drained and, at planting, avoid areas that would be difficult to spray by air -areas next to windbreaks, houses, power lines or around irrigation towers.

b) If irrigation is used, ensure that the above areas are not excessively wet, since they tend to remain wet for longer periods than the open field. Overly wet areas are more favourable for blight development. Timing irrigation cycles to allow plants to dry before nightfall reduces the chances of active fungal sporulation.

c) Control the application of nitrogen to avoid unnecessarily heavy top growth that would extend the period in which the RH within the canopy exceeds 90 %.

d) Store seed pieces at < 7°C and cut just before the tuber sprout in order to reduce the possibility of contamination between different seed lots. Seed stores should be carefully cleaned and all equipment disinfected.

e) Become familiar with the weed hosts in the area and eliminate them before planting. General weed control within the crop will improve airflow through the canopy and assist in reducing humidity.

f) Carefully monitor the crop for early symptoms of late blight, concentrating on areas known to remain damp for longer periods. Obtain diagnosis from extension personnel, if there is uncertainty over symptom recognition. Check for sections that were not properly covered by fungicide application, e.g., areas below power lines and upwind from windbreaks.

g) Make use of any forecasting service that is provided and keep records of daily weather reports and weekly projections.
h) Prevent tuber infection, by maintaining soil on plant hills (done in a period of sunny weather) and, at least two weeks before harvest, by killing the vines with an appropriate herbicide. Scheduling harvest operations to avoid damp conditions reduces the possibility of tuber infection.

Fungicide Application

The use of fungicides is recommended-even though resistant/ tolerant varieties are available and planting tolerant varieties is advisable, since they retard the development of blight and, consequently, reduce the need for chemical management. There is also the risk of infection by a race(s) of the pathogen to which the varieties in use are not resistant. In light of the more universal distribution of A1 and A2 mating types, the rate of emergence of new pathogenic strains is likely to increase.

Resistant varieties

The earliest attempts at breeding resistant varieties used *Solanum tuberosum* in which a number of minor resistance genes were discovered. In the 1940s and 1950s four major resistance genes (R1 to R4) found in *S. demissum* were incorporated into a number of commercial varieties. However, the fungus developed physiologic races that overcame the resistance of the four R genes. Most present day varieties are susceptible to *P. infestans*, though in differing degrees. Varieties resulting from crosses of *S. tuberosum* with wild species have shown broad resistance to all known races of the pathogen for a period of time, only to succumb to some hitherto unknown race. Until such time that varieties expressing more durable horizontal resistance are developed, the use of existing varieties in fully integrated management programmes may lead to reduced costs of and dependence on fungicide application. Due to the wide range of potato varieties that are developed in various locations worldwide and the notorious variability of the pathogen, varietal selection for any particular area needs to be based on thorough evaluation.