

# A review of early blight on potatoes

J E van der Waals, Department of Microbiology and Plant Pathology, University of Pretoria

Early blight is one of the major foliar diseases of potatoes and causes premature defoliation of potato plants almost everywhere they are grown. The causal agent is *Alternaria solani*. Disease symptoms are characteristic dark brown to black lesions with concentric rings, which produce a 'target spot' effect. Symptoms are initially observed on older, senescing leaves. The first recorded observation of early blight in South Africa was in Natal in 1900.

## Geographic distribution

Early blight is widespread in most areas where potatoes or tomatoes are grown, but is especially prevalent in the tropics and temperate zones. The disease is a potential threat where potatoes are grown under irrigation or during times of heavy dew. Early blight is prevalent in all provinces in South Africa and is a limiting factor in production in late summer. Early blight is one of three diseases taken into account when selecting new potato varieties in South Africa, the other two being late blight and common scab. Early blight tuber rot may occur if tubers wounded during harvest are inoculated by *A. solani* spores found on or near the soil surface. Tuber rot is, however, not common and has limited distribution.

## Economic importance

The primary damage of early blight is due to premature defoliation of the plant. Photosynthesis rates increase and respiration rates decrease in apparently healthy tissues. Physiological changes are difficult to measure and evaluation of crop loss is based on the level of disease. Early literature (1945) cites yield losses of 5 - 50%. There is often a discrepancy between damage to foliage and yield loss, which is due to the increase in disease spread at the end of the season, when most of the yield has been produced. When tomato fruit or potato tubers become infected, the quantity and quality of marketable produce is decreased and the number of secondary pathogens increases. Control of early blight has

been shown to increase yield.

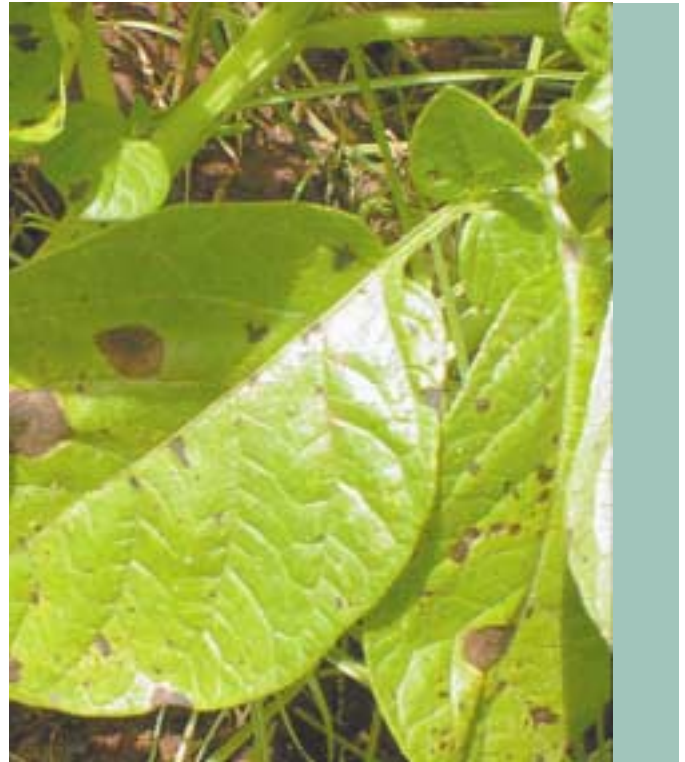
## Symptoms

Symptoms are initially observed on older, senescing leaves. Likewise, the most susceptible plants are those that are physiologically old, weak, malnourished and wounded by wind, sand, hail or insects. Characteristic symptoms are dark brown or black lesions with concentric rings on leaves, which produce a 'target spot' effect. This zonation is induced by day-night fluctuations in temperature, moisture and radiation and is often absent in greenhouse-inoculated plants. Lesions are similar on all hosts. Enlarging lesions are often surrounded by a narrow chlorotic halo due to toxins produced by the pathogen, which move

ahead into uninfected epidermal cells. Lesions are usually oval in shape, but under unfavourable conditions may remain small and angular, conforming to the interveinal spaces. Lesions enlarge, coalesce and eventually cause death of the leaf. Spores may be seen on older lesions when viewed under a microscope. Lesions can also develop on stems and petioles. Infected tubers develop a dry rot, characterised by isolated, dark, irregular, sunken lesions on the surface. Diseased tissue under lesions is dark brown, firm and 10-12 mm deep.

## Host susceptibility

Numerous studies have shown that young, immature potato tissues and plants have a transient resistance to early blight



(susceptibility is age-conditioned). In tomato, *A. solani* causes a collar rot in seedlings and early blight in mature plants; whereas in potatoes, it causes early blight of mature plants, which intensifies at flowering. Host susceptibility of potatoes is thus strongly correlated with cultivar maturity and early blight susceptibility decreases as cultivar maturity levels increase. This type of resistance is known as temporary resistance and should be distinguished from permanent resistance which is unaffected by plant age, rate of cultivar maturity and yield.

The effect of age on susceptibility is modified by prevailing temperature, which suggests that susceptibility is governed by physiological, rather than chronological, age. Other growth or stress factors that also affect susceptibility include vigour of plant growth, soil moisture and nutrition. However, the physiological causes are not well described. Increased sensitivity of older leaves to toxins and

enzymes due to changes in the membrane composition does not explain the susceptibility of tomato seedlings to the disease. Reduction in ratio of tuber yield to foliage is associated with a reduction in lesion size and early blight incidence. It has been suggested that susceptibility increases in plants deficient in sugars, but that this is due to increased sporulation, rather than increased infection. Reports exist for varietal susceptibility levels in South Africa, America, India, Israel and Peru. In South Africa, some potato cultivars are less susceptible than others, but none has total resistance. The four main cultivars, BP1, Buffelspoort, Up-to-date and Vanderplank, are all susceptible. Indeed, Vanderplank appears to be the most susceptible of all the commercial cultivars. Relatively high levels of resistance exist in the cultivars Mnandi and Ropedi.

#### Host nutrition

High nitrogen levels, together with low phos-

phorus and medium to high potassium levels, decrease host susceptibility. This may be explained as follows: High N levels may prolong vegetative growth and delay ripening, low levels of P lead to reduced fruiting and low K levels cause reduced tuber formation. Calcium deficiencies may also reduce tuber formation. The apparent infection rate and final amount of early blight decrease with increasing rates of nitrogen fertilisation, but unfortunately this also causes a drop in specific gravity of tubers and reduces chip quality.

#### Host range

The most important hosts of *A. solani* are tomato, potato and eggplant. Other hosts include horse nettle, chili, black nightshade and non-solanaceous hosts such as wild cabbage, cucumber and zinnia.

#### DISEASE CYCLE

##### Overwintering and survival

*Alternaria solani* is a poly-

cyclic pathogen, as many cycles of infection are possible during a season. Primary infections on new plantings of potatoes or tomatoes are caused by overwintering inoculum. The pathogen overwinters as mycelium or conidia in plant debris, soil and infected tubers or on other host plants of the same family. Chlamydospores have also been reported as a source of overwintering inoculum for early blight, allowing the pathogen to survive cold temperatures in or on the soil. The inoculum remains infective in debris in uncultivated soil for 5 to 8 months. The dark pigmentation of the hyphae increases their resistance to lysis. Spores survive most frequently in infected debris and seed and best in dry, fallow fields.

##### Dispersal

Wind, rain and insects are the principle methods of dissemination of *A. solani*. The primary inoculum produces conidia in the

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spring, which are then dispersed to the lower leaves of the plant where they germinate and penetrate the epidermis directly, through stomata or wounds.

With the use of spore traps, it has been found that peak spore dispersal precedes the hottest and driest hour of the day by two hours, and the time of maximum wind velocity by four hours. A rapid rate of dispersal does not set in until infection has reached the stage at which whole leaves dry up and plants begin to die. The curve of wind velocity resembles that of spore dispersal, however, there appears to be no significant correlation between spore dispersal and other climatological factors.

## Infection

Spore germination is facilitated by free moisture, but can be induced by relative humidities close to saturation. With a favourable

inoculum dose and wetting period, the minimum temperature for infection can be as low as 10°C, the maximum >35°C, and the optimum between 20°C and 30°C.

Incubation periods (time from infection to symptom development) vary greatly, depending on age and susceptibility of plants. Epidemics increase in severity after sandstorms, due to increased wounding of the epidermis. The primary infections become necrotic with chlorotic halos. Mycelium from necrotic lesions produces conidia that infect healthy leaves and begin secondary infections. Tubers are infected through wounds, as the conidia are unable to infect directly through intact periderm. Wound healing, by suberisation and the development of wound periderm, reduces infection markedly.

## Sporulation

On potato plants, sporulation occurs between 5 and 3 °C, with the optimum around 20°C. The heaviest sporulation occurs after heavy rain or dew. Large numbers of spores are produced during alternating wet and dry periods. Sporulation of the pathogen is affected by the state of the host and tends to accelerate with an increase in necrotic tissue formation and a decrease in photosynthesis. Sporulation is inhibited by sugars, which promote vegetative growth and even the production of conidiophores. Sporulation in the field requires at least two days. Conidiophores are produced during a night with wet conditions. Light and dryness the next day induces the production of conidia, which are then formed during the second wet night.

## Epidemics

Moisture plays a major role in the development of

early blight. Studies have shown that free water is critical for disease development and that duration of leaf wetness can account for up to almost 90 % of variability in disease development and severity. Increased leaf maturity, heavy fruit load, crowded plants, above-average rainfall or dew and shading also enhance early blight development. Epidemics do not generally occur until late in the season, when the plants are most susceptible.

*Alternaria solani* reacts differently to weather conditions, depending on the circumstances. In certain cases, weather factors may act indirectly by influencing the susceptibility of the host. Cooler temperatures may, for instance, retard the growth of the plant, while short photoperiods are associated with a decrease in sugar content in leaves.



### Control

Despite the paucity of experimental work on the control of early blight in South Africa, guidelines have been proposed for the control of the disease. These include the following:

- Kill off the foliage at least 2–3 weeks before harvesting to prevent tuber infection.
- Overhead irrigation promotes development of early blight by increasing the leaf wetness period. If only overhead irrigation is available, it should not be applied at night, as this practice will increase spread of, and infection by, the pathogen.
- Promote plant health and growth through balanced fertilisation.
- Use tolerant cultivars if possible.
- Restrict volunteer plants and cull piles to reduce the number of fungal spores in the area.
- Rotate with non-host

crops, such as forage crops and grains, including maize.

- Use certified seed.



- Avoid harvesting too early or under wet conditions and do not wound the tubers during harvesting and sorting. These various cultural practices can reduce the severity of early blight, but under situations of sufficient inoculum and environmental conditions favourable for disease,

complete control will not be provided. The most effective control method is a fungicide spray programme used from early in the growing season to vine kill. Almost as many fungicide formulations are registered for the control of early blight as for all other potato diseases together. It is recommended that contact fungicides be applied regularly in the early stages of the disease to prevent infection. From flowering onwards, 3–4 sprays of a systemic or contact fungicide should be applied. If symptoms appear before flowering, a systemic fungicide must be applied immediately. Proper timing of initial and subsequent fungicide applications can reduce the overall number of sprays with no significant loss of yield.

### Conclusion

Although the *A. solani* pathosystem on potato

and tomato has been researched extensively, various aspects remain that need to be investigated. Major gaps in our knowledge of the epidemiology and economic impact of the disease still exist in South Africa. One of these is forecasting of early blight in South Africa. Many early blight forecasters have been developed and evaluated in the past; however, none are applicable to South African conditions and cultivars. A study is currently underway to modify the PLANT-Plus early blight forecaster for South Africa and to evaluate the cost-effectiveness and accuracy thereof. The long-term goal of this project is to combine the early and late blight PLANT-Plus forecasters, as to provide growers with one comprehensive forecasting model for the two most important foliar diseases on potatoes in South Africa.