Paper 9

TUBER-BORNE DISEASES OF POTATOES

J. Hedley
Advisory Services Division,
Ministry of Agriculture and Fisheries,
Wellington.

R.C. Close
Microbiology Department,
Lincoln College

INTRODUCTION

The control of tuber-borne diseases of potatoes involves, as with other plant diseases, a continuous programme of care and attention. Tubers spend much of their life cycle out of sight, either underground or in storage, but this must not mean they are out of mind. Plant care during growth to maintain freedom from pathogens, equipment hygiene to avoid pathogen spread, and attention to in-store environment to maintain tuber health are all part of the cycle of plant health care.

Because of their differing life cycles, each pathogen needs different avoidance techniques or chemical treatments to prevent it causing disease. Some of the major diseases of potatoes are briefly described. A short resource reference list is appended.

FUNGAL DISEASES

Gangrene or phoma rot

Symptoms

The disease takes the form of rots in the tuber, usually firm rather than soft rots. The exterior appearance is usually of irregular brown/black depressions in the tuber surface. Rots are normally sharp edged, may be shallow, and spreading over much of tuber surface or may be deep with tuber hollowing. Tuber symptom can vary with cultivar and the phoma variety involved.

Causal organism

The fungus Phoma exigua. Two varieties are concerned — mainly *P. exigua* var. *foveata* but also *P. exigua* var. *exigua.*

Spread

The main source of inoculum is from infected tubers. If infected seed is planted this gives rise to contaminated progeny tubers which, when wounded become diseased. The pathogen can be transmitted to uncontaminated tubers from infected tubers or from contaminated machinery or sacks. Once contaminated, any rough handling which injures the tuber precipitates disease development.

The fungus can also be spread in rain showers — sporing lesions can develop on senescent haulms and not only lead to heavy contamination of the tubers of that plant, but also provide spores which can be spread to other plants by rain splash and wind. Despite this, spread by the seed tuber is the major source of the disease. Years where gangrene is severe are usually those when the weather is wet and cold prior to harvesting.

Control

The best method of control is the use of clean seed. If such seed cannot be obtained, and contamination is suspected, then a fungicide can be applied. In some countries, fumigants, fogs, dips and sprays of compounds such as 2-aminobutane (fumigant), thiabendazole, thiophanate-methyl, and imazalil are used with success. (Hedley and Genet, 1979). For treatment to be effective, it is important that the fungicide is applied as soon after tuber lifting as possible, so that the pathogen is inactivated on the tuber surface before it penetrates the tuber and becomes inaccessible. Careful spray calibration and complete tuber coverage are important (Hedley, 1980a).

Avoidance measures, such as minimising injuries and using good cultural techniques, e.g. using a warm (15°C) post-harvest curing period should be added into the programme.

Phoma rot is one of the more important potato diseases, particularly in Europe, where much research on disease control is in progress. In some countries, e.g. Holland, regulations governing the suitability of a property for seed production involve testing for the present or absence of the gangrene pathogen.

Dry rot

Symptoms

This disease can be seen as brown, frequently circular, rots. The tuber skin wrinkles as the rot enlarges, and the rotted tissue becomes dry and mealy. White or blue-green fungal material can develop on tubers which rot during storage.

Causal organism

The fungus *Fusarium solani* var. *coeruleum* is the principal pathogen, but other *Fusarium* species can be involved.

Spread

The pathogen is spread by infected seed or contaminated equipment. The planting of infected tubers produces contaminated progeny tubers and this contamination, as with that from other tubers, soil, machinery or sacks, will lead to infection when tubers are wounded.

Control

The use of non-contaminated or non-infected seed and clean equipment is the best way to avoid disease. Otherwise, the use of a post-harvest fungicide such as thiabendazole, prochloraz, or carbendazm as a dip or spray, has been found effective.

Treatment as soon as possible after harvest is preferable. Many cultivars become more susceptible to dry rot as the storage period progresses, so some growers apply spray treatments when grading out in late season, depending on cultivar susceptibility and disease incidence. Care should be taken to avoid tuber injury and to disinfect machinery (Hedley 1980a, 1980b).

Rhizoctonia

Symptoms

This disease has various phases. In the young plant there can be stem cankers — clear edged, ginger-brown stem lesions. As the plant develops, stolon infection can be seen — in the form of brown lesions, and the black sclerotia cause a cosmetic blemish on the tubers, known as black scurf.

Causal organism

The fungus generally known as *Rhizoctonia solani* is the pathogen responsible. The pathogen has had several nomenclatural changes — the most recent of which was to *Thanatephorus cucumeris.*

Spread

As the fungus is found on tubers and in soils, it can be transmitted from both sources. However, unless a soil has been in continuous potato production, it is generally accepted that seed is the more important source of inoculum. The fungus is transmitted from the mother tuber to the stolons and progeny tubers.

Control

The use of clean seed and land with a long potato rotation cycle greatly reduces the likelihood of infection. In addition, delays of more than 2-3 weeks between haulm desiccation and lifting of the crop should be avoided, as this is the period of greatest sclerotia development. As the most severe cases of canker develop in cold and, in particular, wet soil conditions, such conditions should be avoided where possible.

Fungicide control is possible. Pre-storage chemical treatment effects tend to be small so pre-planting treatment is favoured. In New Zealand, work with benomyl, benodanil and thiabendazole have shown some control of the disease, and it is also reported that, in some areas, a 2% formaldehyde dip has achieved disease control and given yield increases. Two products among those used overseas — iprodione as a mist and thiabendazole as a mist or dust — have also given control of stem canker (black scurf control is not claimed).

Overseas and New Zealand research results are not always consistent. Some cultivars show a greater response to treatment than others — some are less affected by the disease and some do not react well to treatment. Benefits from treatment need to be carefully evaluated. Situations where treatment is likely to be worthwhile include cold wet conditions where stolon pruning is a regular occurrence and where a heavy set is required (e.g. for seed). As greater importance is attached to cosmetic appearance, so treatment for this disease will become more common practice.

Powdery scab

Symptoms

Infections causes small blisters or pimples, which become white outgrowths early in the season and later darken and change into shallow depressions containing a brown/green dust of spore balls.

Casual organism

The fungus *Spongospora subterranea* causes this disease.

Spread

The pathogen is spread by infected tubers and contaminated soil; it can persist in the soil for many years.

Control

The disease is best avoided by using clean seed and uncontaminated land. The ideal control is the use of resistant cultivars; Sebago and Katahdin are reported to show reasonable resistance. Contaminated tubers can be disinfected using a 2% commercial formalin dip for 5 minutes, but this treatment cannot be used on damaged or sprouting tubers. Likewise, machinery can be disinfected to avoid spreading contamination.

Crop rotation is advised where powdery scab is found — but this has to be a long rotation as spore balls can survive for 6 years in soil. The use of well drained land can help avoid disease. Victorian workers have shown that withholding irrigation for two weeks around tuber setting (when half the stolons have pea sized tubers) can control the disease but yield is reduced. The disease is worst when a crop is over-watered during tuber initiation.

Chemical treatments have been used, but most have not proved effective. In Australia, captafol at 40 kg/ha (80% a.i.) applied prior to planting and watered in, has been shown to give satisfactory control (this compound has sensitivity problems with many users and is not registered for this use in New Zealand). Mancozeb at 20 kg/ha (80% wettable powder) has also been found to control powdery scab.

Verticillium wilt

Symptoms

In good growing conditions, infected plants tend to produce yellow leaves earlier in the senescent period than

healthy plants. In dry conditions, plants may be stunted earlier in growth and show lower leaf yellowing much earlier. Vascular discolouration is evident within infected stems. As infected plants die, haulms turn black or grey and become dry and brittle.

Causal organism

In the south of New Zealand the pathogen is *Verticillium albo-atrum* and in the north *V. dahliae.*

Spread

This disease is a particular problem with the cultivar Red King. Spread is associated with infected or contaminated seed, i.e. the pathogen can be inside or on the surface of the seed. Normally, *V. albo-atrum* does not persist in the soil for many years, so seed transmission is thought to be more important than soil transmission (where good rotation is practised).

Control

With adequate rotation, the use of uninfected, uncontaminated seed should ensure adequate control of this disease. Trials have shown that surface application of fungicides such as thiabendazole, benomyl or formaldehyde reduces tuber surface contamination (Hedley, 1978, 1980c). Hence, regular tuber treatment should ensure a line remains relatively healthy.

Other fungal diseases

There are many other tuber diseases, some of which such as silver scurf, can be very common, but which will not become of concern until greater importance is attached to the overall appearance of table potatoes. Other diseases occur sporadically and are usually of regional importance only, e.g. skin spot, leak and pink rot.

Physiological disorders of tubers such as black spot, internal rust spot and hollow heart can occur without fungal infection.

BACTERIAL DISEASES

Blackleg and bacterial soft rot

Symptoms

Seed tubers rot underground and plant stems show a soft black decay. Plants may initially become more erect, with curled leaves, but as the disease progresses may collapse completely. Infected tubers can rot in store — this may range from a vascular discolouration to a whole tuber rot.

Causal organism

The bacterium *Erwinia carotovora* is the pathogen. Two varieties are involved *E.c. pv. atroseptica* and *E.c. pv. carotovora.*

Spread

This is mainly by infected or contaminated tubers, but can also be by soil, plant material, water and contaminated machinery. In some countries, the pathogens have been found in irrigation and rain water, and associated with the roots of other plants (e.g. weeds in the potato fields). (Perombolan, 1981). When dealing with high health material, these low level background contaminations may be significant. It is generally thought that the progeny tubers become contaminated by the mother tuber, the degree of contamination being greater the longer the mother tuber takes to decay. Infection is also worse in wet conditions — in warm dry soils the bacteria do not survive well and the tuber lenticels are less available to penetration. All cultivars are susceptible, although the disease seems to be more prevalent in Sebago.

Control

The most effective means of control is to use only uncontaminated material. The control achieved by using pathogen-tested (PT) lines has been far superior to other methods. Care should be taken, however, to ensure that recontamination, while it may be inevitable, takes place as slowly as possible. Infected plants and tubers in store should be removed, machinery disinfected, anaerobic soil conditions (i.e. waterlogged ground) avoided, and tubers harvested when mature. Harvesting should not be carried out in wet conditions. Likewise, damp, poorly ventilated conditions in the potato store should be avoided.

There have been a number of antibacterial products tested as tuber dips and some have been found to be effective. However, none of these are as yet commercially developed. Some products which are claimed to control blackleg are available overseas, but none have reputable support.

Common Scab

Symptoms

Light to dark brown corky scabs on the tuber surface. They are usually small, 5-10 mm in diameter, and frequently coalesce, and may be either raised and cushion-like or sunken, giving a pitted appearance.

Causal organism

The bacterium, *Streptomyces scabies,* is the pathogen. There are many strains of this bacterium, which have different reactions and respond to differing conditions.

Spread

The pathogen is spread by tubers — but most potato growing soils are now contaminated.

Control

Control is difficult on those soils which are most disposed to disease production — light gravelly soils with alkaline to neutral reaction, low humus content and low moisture. Several practices can lower disease incidence. The use of clean potatoes is a first requirement. The reduction of pH helps, but in practice this can be difficult as only at relatively low pH levels (below pH 6) is there a marked reduction of scab intensity and incidence. This reaction can vary with the strain of pathogen. Generally, it is good policy to lime, if necessary, after potatoes rather than in the 1-2 years preceding the crop. Control by irrigation has been found to be successful. During the first four weeks of tuber development, when the tissue is young and the lenticels most susceptible to attack by streptomyces, a high moisture level should be maintained. Care should, however, be taken not to over-irrigate poorly drained land.

Some sources recommend the use of green manures which, if readily decomposable, can increase acidity and lead to reduced scab infection.

VIRUS DISEASES

Virus diseases are important in potato crops, because they reduce yields and are the main reason for the degeneration of seed potatoes. After infecting plants, viruses live and multiply in cells, spread from cell to cell, cause symptoms to develop in the plant, and affect growth and yields. Athough viruses do not invade the true seed, they are present in most parts of the infected plants, including seed potato tubers, and so virus-infected plants appear in subsequent crops. If control of viruses is not attempted then spread from plant to plant will occur each season, until the crop may become completely infected. Spread takes place in two ways:

- when sap containing virus particles is transferred from plant to plant, either when plants touch in the field, or by machinery moving through crops;
- by aphids, both winged and wingless. These insects may spread viruses either rapidly (in minutes), in which case the aphid soon loses this ability, or spread may require several hours or days to occur and the aphid remains capable of infecting plants for the duration of its life.

From research it is known that there are twenty-one viruses capable of infecting potatoes. Some are of major importance, while others are of less significance. The number of potato viruses recorded in New Zealand is eight, though others may occur but have not yet been detected. The three main viruses in the country are potato leaf roll virus, severe mosaic (potato virus Y), and mild mosaic (potato virus X). The pathogen tested scheme (Paper 6), together with seed potato certification, provides adequate control of most virus problems.

Potato leaf roll virus

Symptoms

The initial or primary symptoms of potato leaf roll virus appear in the upper leaves of the plant which are rolled inwards, tend to be more erect and are often tinged purple (e.g. in Ilam Hardy). The virus then moves down through the plant and infects the tubers where it sometimes causes 'net necrosis', which is a browning of the vascular bundles in the tuber. The virus persists in the tuber, and if the tuber is replanted, the virus multiplies as the plant grows and affects the development. Secondary symptoms (those in the plant growing from an infected tuber) generally appear as stunting of plants, together with an upward and inward rolling of the lower leaves which are yellow, thick and harsh. Yield of tubers is reduced mainly through a reduction in tuber size rather than tuber number.

Spread

Spread from plant to plant is **only** by aphids, mainly by the green peach aphid *Myzus persicae.* Once the aphid becomes infected with virus, it remains infected. In spring, the winged aphids enter potato crops from host plants away from the crop. At this stage the aphid is generally not carrying the virus. It needs to acquire the virus from infected plants in the crop, which takes one to two days. Winged aphids, and subsequently wingless aphids, must then move to healthy plants in the crop and feed for one to two days for the virus to be transmitted to healthy plants and for them to become infected. Thus several days are needed for successful spread of leaf roll, allowing time for insecticides to be used to destroy aphids and so prevent virus spread.

Control

Control methods include:

- Use of resistant cultivars. A resistant cultivar at present available is Katahdin, in which there is a much slower rate of infection as compared with a very susceptible cultivar such as Ilam Hardy. All of the main cultivars grown in New Zealand are susceptible.
- Seed potato certification. This ensures that seed tubers contain a very low level of infection with leaf roll. During storage of certified seed, it is important that the developing shoots do not become infested with aphids. Spread can take place at this stage as the aphids can move from the sprouts of one seed tuber to another.
- Use of insecticides to control aphids and so prevent virus spread. This is best achieved by using granular organophosphate insecticides in the furrow at planting. The chemicals available are disulfoton (marketed as Disyston, and Solvirex) and phorate (marked as Thimet). They are available as granules, and should be applied into the furrow through suitable applicators mounted on the potato planter. These chemicals will control aphids at shoot emergence and then for at least six weeks after emergence. There are no chemical residues in tubers from treated crops. Table 1 gives results from several trials to test effectiveness of aphid control in preventing spread of leaf roll virus.

Table 1. Control of potato leaf roll virus spread in the cultivar Ilam Hardy, by the use of granular organo-phosphate insecticide applied in the furrow at planting for aphid control.

Trial	% leaf roll in seed potatoes from	
	untreated areas	areas treated with granules
1	11.0	2.0
2	16.0	2.5
3	23.0	6.0
4	53.0	4.0
5	80.0	6.0

(from Close, 1965 and unpublished data)

Aphid surveys of untreated potato crops in the South and North Islands have shown that large numbers of aphids are generally present, even at emergence. Although there are lower numbers in seed potato areas, it is still essential

for seed potato growers to use insecticides to prevent spread. Growers in many table potato areas could use insecticides to allow them to use their seed for a further season. In addition, trials with Katahdin have proved conclusively that where there are high aphid numbers, increased yields will result from control of aphids. In other words, aphids can damage crops far more than is realized.

In the South Auckland area, insecticides in the furrow at planting have been less successful in preventing spread of leaf roll virus. This is because:

- the shoots emerge quickly and so are initially unprotected;
- the source of aphids and virus is very often infected potatoes in adjacent fields, thus winged aphids can bring the virus into emerging potato crops;
- the presence of many leaf roll infected volunteers (self-sets) in potato and other crops provide a ready source of virus for spread to healthy plants.

Severe mosaic (potato virus Y)

Symptoms

Because of the introduction of a number of cultivars resistant to this virus, it is now only a problem in a few cultivars. It is important to note that the virus can cause different symptoms in different cultivars, and that there can be differences between the primary symptoms, i.e. those immediately following infection, and the secondary symptoms which appear in the subsequent crop and arise from infections in the seed tubers.

The cultivars in which severe mosaic is of concern are Red King Edward, Epicure, Jersey Bennes, and Glen Ilam. In the first three, severe mosaic causes a slight stunting of growth and a slight distortion of leaves which are yellow-green in colour often with a mottle (light and dark-green areas) present. In Glen Ilam, symptoms are more severe with stunting of plants, prostrate stems, and leaves drooping and curling.

Spread

This virus is spread by transfer of virus in the sap from plant to plant during cultivation and other operations. It is also spread by aphids, mainly the green peach aphid. The aphid acquires the virus and spreads it to healthy plants within minutes. However, the aphid rapidly loses its ability to transmit the virus.

Control

This is achieved by:

- Pathogen tested seed schemes (see Paper 6)
- Seed potato certification. Crops grown for seed are rogued of infected plants and are then inspected to ensure that certification standards are maintained.
- Late planting. In Canterbury, crops planted in late November will avoid aphid flights and consequent virus spread. Insecticides applied to early planted crops will not prevent aphids from spreading this virus.
- Use of resistant cultivars. Ilam Hardy, Rua, Sebago, Katahdin and all new cultivars released by Crop Research Division, DSIR are resistant to this virus.

Mild mosaic (potato virus X)

Symptoms and spread

Mild mosaic virus is not spread by aphids, but only by movement of sap from plant to plant. In many older cultivars all the plants are infected but there are few symptoms. Although the plants appear 'healthy' there can be reductions in yield of 10 to 20%, when yields from infected plants are compared with those from virus X-free plants.

Control

Mild mosaic is controlled by the use of resistant cultivars. All new cultivars released by Crop Research Division are resistant, as are Ilam Hardy, Red King Edward, Epicure, Jersey Bennes. Resistance to mild mosaic has been found, over many years, to be stable in that the resistance factors have not deteriorated.

Other viruses

The five other viruses that occur in New Zealand are potato virus S, potato virus M, potato virus A, potato aucuba mosaic virus and alfalfa mosaic virus. The effects of these on potato production in New Zealand have not been fully measured. Only one, potato virus S, occurs in a high proportion of plants of most cultivars. In future, it may be possible to develop cultivars resistant to this virus. At present, the pathogen tested scheme is attempting to ensure that lines of seed tubers are produced which are free of potato virus S.

GENERAL CONCLUSIONS

From the information presented, it is clear that many diseases of potatoes are spread from one season to the next by means of inoculum that survives **only** on or in the seed tubers. Some pathogens, however, can survive in the soil so planned crop rotations are essential.

Since seed potatoes are the main source of many diseases, every effort should be made to ensure that the seed tubers are free of pathogens. This is the aim of the pathogen-tested (PT) scheme (Martin, 1985), which has been developed as a co-operative project between a merchant, a potato grower and Crop Research Division of DSIR. Comprehensive testing for fungi, bacteria and viruses ensures that the initial plant material in tissue culture is free of these pathogens. The tissue is multiplied and retested, grown on in the glasshouse, and ultimately provides tubers for growing in the field. Although PT stocks are certified free of **known** pathogens, they are **not** resistant, but still susceptible and can become re-infected. Every care must be taken during each year of the multiplication process, in the glasshouse and in the field, to ensure that the plants or harvested tubers do not become re-infected. Testing at all stages of the multiplication process is required to ensure that freedom from known pathogens is being maintained. Ensuring that the seed tubers remain disease free becomes increasingly difficult as the volume of seed tubers increases up to commercial levels. As a consequence, the PT scheme has been developed as a

continuous process, with new material being produced in the glasshouse annually, and being introduced into a well-developed and planned system of pathogen-tested seed potato certification and production.

Other control strategies should still be retained, such as crop rotation, treatment of tubers before planting and immediately after harvest, use of insecticides during the season to control aphids and viruses as well as other insects, and use of fungicide sprays as and when required.

With respect to tuber-borne diseases, an alternative method of avoiding many problems is to consider the use of true potato seed (TPS). (Bedi, 1978 and Anderson, 1985). The viruses which infect potatoes are not transmitted through true seed, nor in general are fungi and bacteria, though some degree of care in the extraction of true seed is necessary. The main difficulty arising from the use of TPS is, because the seed is not genetically uniform (as are seed tubers), the resulting plants are variable in size, leaf shape, tuber shape and yield. However, considerable progress has been made and continues to be made in developing seed that produces a more uniform potato crop.

SUMMARY

There are four major areas for the control of tuber-borne diseases of potatoes:

- Only healthy, high quality seed tubers should be planted. If pathogen-tested stocks are not used, growers should purchase high grade seed from reputed growers or develop their own nucleus stock. This should be graded with care, and the stock should be dipped in a suitable fungicide prior to planting. Careful rogueing of infected plants at an early stage of crop development is essential. Regular fungicidal treatment either every year or every other year to disinfect tubers is a recommended practice to maintain seed health.
- Care of the tubers and plants in the field. This involves crop rotation, chemical application to avoid aphids and virus infection, and the rogueing of plants showing disease. Careful harvesting to minimize damage to tubers is necessary, and spraying of the tubers with a fungicide soon after harvest is advisable.
- Good storage conditions. Storage conditions need to ensure curing of the tubers for a period after harvest, and then to provide for appropriate storage temperatures and humidities in relation to final use of the tubers. Good ventilation is essential.
- Equipment hygiene. Attention should be paid to hygiene to ensure that tuber-borne pathogens are not spread on machinery and other equipment.

REFERENCES

Anderson, J.A.D. 1985. Potato production from true seed; is there a future? In: *Potatoes a Changing Scene. N.Z. Agronomy Society Special Publication 3:* 43-45.

Bedi, A.S. 1978. The potential of true potato seed. *Crop Research News 20:* 28-30.

Brenchley, G.H. and Wilcox, H.J. 1979. *Potato diseases.* ADAS, MAFF, Her Majesty's Stationery Office, U.K. 105 pp.

Close, R.C. 1965. Control of leaf roll virus in potatoes. *The Dominion Potato Bulletin 29:* 1-6.

de Bokx, J.A. 1972. *Viruses of Potatoes and Seed Potato Production.* PUDOC, The Netherlands: 233 pp.

Hawthorne, B. 1980. Stem canker and black scurf of potatoes. *Aglink FPP 465:* 2 pp.

Hedley, J. 1978. Verticillium wilt, preliminary results and investigation of wilt of Red King Edwards in Southland. *N.Z. Potato Bulletin 71:* 14-15.

Hedley, J. 1980a. Pre-storage tuber treatment can insure against disease. *N.Z. Potato Bulletin 76:* 12.

Hedley, J. 1980b. Gangrene and dry rot in potatoes. *Aglink FPP 216:* 2 pp.

Hedley, J. 1980c. Verticillium wilt. Further results of investigation of wilt in Red King Edwards in Southland. *N.Z. Potato Bulletin 78:* 6-8.

Hedley, J. and Genet, R. 1979. Control of potato storage diseases. *N.Z. Potato Bulletin 73:* 648.

Hodgson, W.A., Pond, D.D. and Munro, J. 1974. Diseases and pests of potatoes. *Canada Department of Agriculture, Publication 1492:* 69 pp.

Hooker, W.J. 1981. *Compendium of Potato Diseases.* American Phytopathological Society: 125 pp.

Martin, S. 1985. Pathogen tested potatoes in New Zealand. I. Production of pathogen tested seed. In: *Potatoes: a changing scene. N.Z. Agronomy Society Special Publication 3:* 35-37.

Perombelon, M.C.N. 1981. Survival of *Erwinia carotovora* in soil and water in Scotland. *Conference Papers of the 8th Triennial Conference of the European Association for Potato Research:* 90.

Rich, A.E. 1983. *Potato Diseases. Academic Press:* 238 pp.

Rough, B.F.A. and Close, R.C. 1965. Use of disulfoton on potatoes. *Proceedings 18th N.Z. Weed and Pest Control Conference:* 188-196.