

Phytophthora root rot of raspberry and other cane fruits

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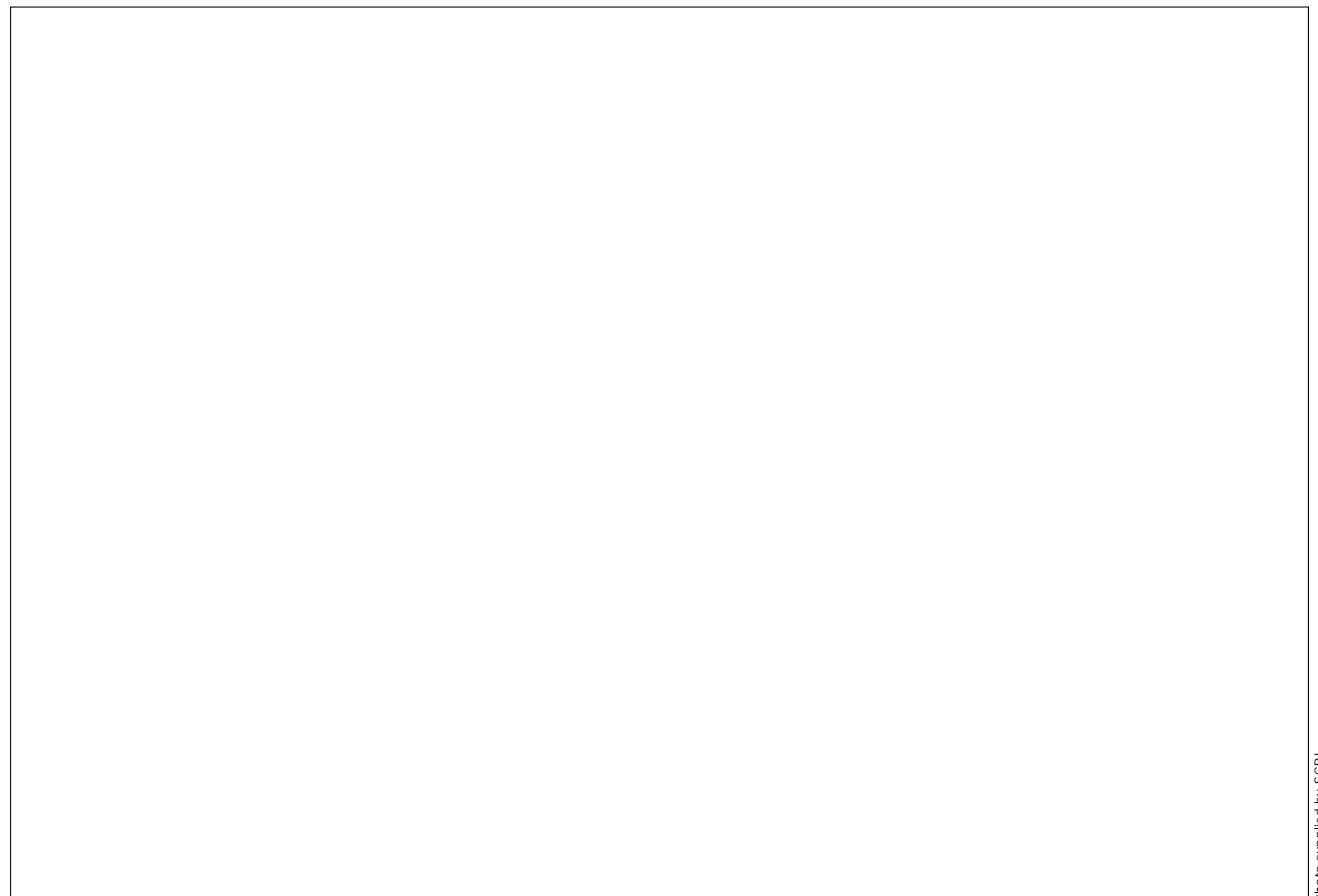
This factsheet provides information on the biology of *Phytophthora fragariae* var. *rubi* and the effect it has on raspberry and other cane fruit crops. It summarises techniques that should be employed both to avoid and contain infection and offers the currently approved control measures.

Background

Phytophthora root rot of raspberry and other cane fruit crops brings about root death, leading to die back of both the floricanes (fruiting canes) and primocanes. The root rot can be caused by a number of species of the soil-borne fungi *Phytophthora*. The most important is now recognised as

being *Phytophthora fragariae* var. *rubi* (*P. fragariae* var. *rubi*). The disease was first reported in raspberry plantations in Scotland in 1937. Further reports were made in North America in the 1950's and 1960's, but it wasn't until the mid 1970's that serious outbreaks began to occur in the United Kingdom, leading to significant loss of plantations in both Scotland and England. It is not

uncommon for plantations to die out completely within three years of initial infection occurring. The disease led to significant reductions in total yields being produced by raspberry plantations in Scotland in the 1980's and 1990's, and made a significant contribution to the rapid decline of raspberry production in Scotland during that period (Figure 1).



1 Phytophthora root rot has led to rapid die-back of raspberry plantations and a corresponding decline in raspberry production in Scotland

Symptoms

Symptoms generally first appear on single plants or isolated groups of canes within a plantation (Figure 2). As the disease develops, it spreads to the roots of other canes, very often along the length of the crop row.

Symptoms can develop on both primocanes and floricanes. Where plants are affected, fewer numbers of primocanes may emerge in the spring months compared to healthy plants and those that do may be weak. Infected primocanes may exhibit signs of wilting and die back shortly after emergence. The tips of the primocanes often wilt first, producing a characteristic 'shepherd's crook' effect (Figure 3). Affected primocanes may initially develop water-soaked lesions on one side, which run upwards from their base. These later turn dark purple or brown in colour as the canes wilt and die (Figure 4). Where the die back of primocanes is slower, the leaves gradually turn chlorotic, wilt and then die during the summer months. In some instances, primocanes may be infected but survive and remain symptomless until the following season, when they become floricanes.

Affected floricanes produce weak fruiting laterals that tend to wilt or turn yellow and necrotic either around the leaf margin or between the leaf veins. Severely affected floricanes wilt and usually die before harvest begins.

Affected plants or stools often have weak and poorly developed root systems when compared to healthy plants (Figures 5 & 6). When the roots of infected plants are examined, they will

be found to possess very few, if any root hairs. If the epidermis is scraped away from surviving main roots using a pen knife, the underlying cortical tissue is usually found to be necrotic and

red/brown in colour, with a distinct margin at the interface between diseased and healthy tissue. Dead root tissue can sometimes be found as far back as the crown region of plants.



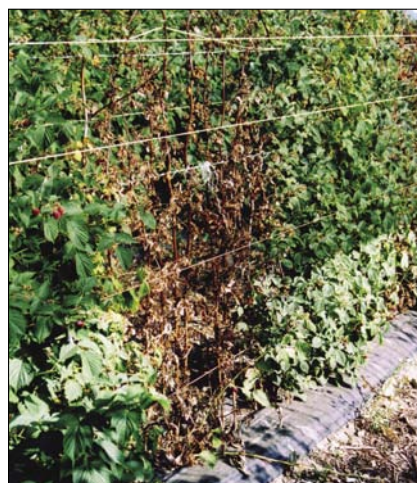
3 Affected spawn exhibiting the classic 'shepherd's crook' effect



4 Water soaked lesions develop at the base of spawn, which may later turn dark purple or brown in colour



5 Illustration of poorly developed and dying root systems (three roots on left) compared to healthy roots (on far right)



2 Symptoms first appear on single plants or isolated groups of canes



6 Declining root volume in module raised plants caused by increasing levels of Phytophthora infection

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Infection and spread

Initial infection and spread can be brought about by several means:

- By planting infected plant material on clean land or into soil less substrate
- The movement of contaminated soil or run-off water from infested to clean sites
- Use of contaminated irrigation water

The movement of contaminated soil on plants, farm machinery, footwear or clothing can rapidly lead to the spread of this disease around an individual or several farms.

Conditions that favour spread

The spread of the fungus *P. fragariae* var. *rubi* is dependent upon the presence of high levels of soil moisture. The most common form of inoculum is the zoospore stage. These zoospores are contained within sporangia. The

production of sporangia and discharge of zoospores are favoured by moist and wet soils (Figure 7). Optimum discharge of zoospores occurs when soils are saturated with water and at soil temperatures of between 4–25°C. The most common period of infection therefore occurs during periods of prolonged wet weather. In the United Kingdom, such conditions most commonly occur between autumn and spring. The discharge of the zoospores is impeded

when soils begin to drain and dry out, normally in the summer months.

Early infections are often (but not always) located in areas of a plantation where the drainage is impeded. They can also be found in areas where the soil has a clay texture or in low lying areas of the field to which soil water drains. Extended periods of wet weather can spread the infection along the length of a row or to other low lying areas of the plantation.



7 Waterlogging and poor drainage can lead to root death and *Phytophthora* infection

Life cycle

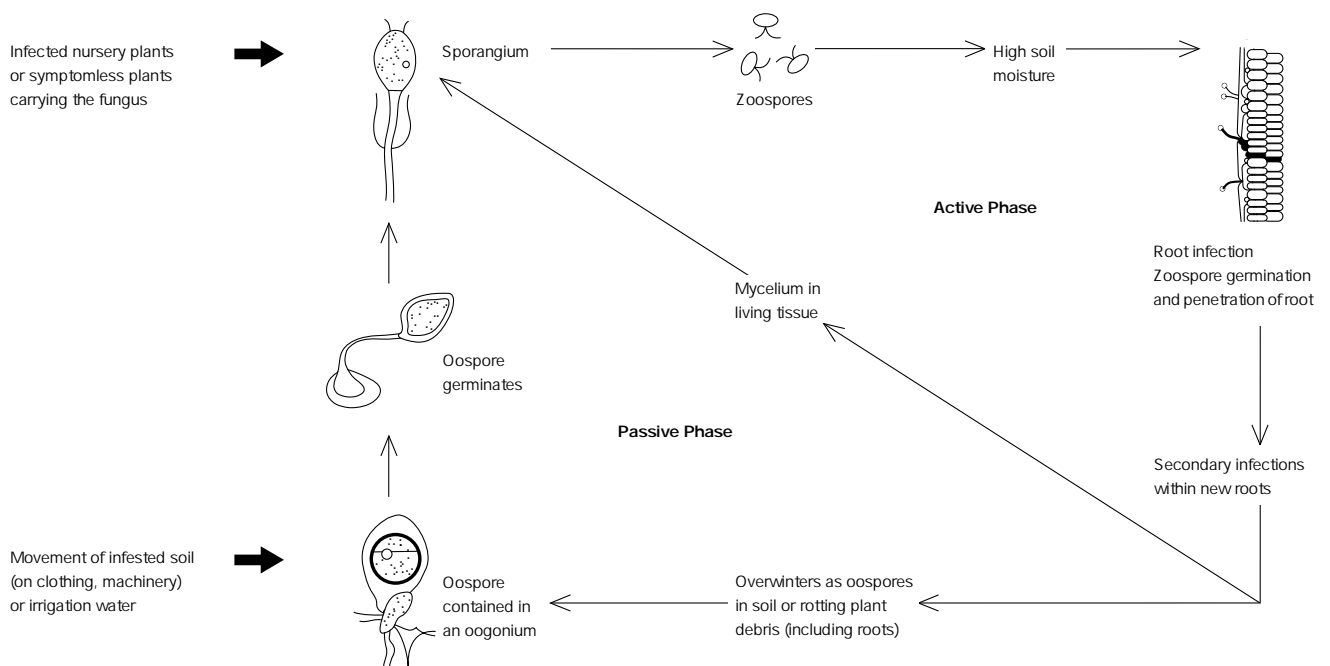
The life cycle of *P. fragariae* var. *rubi* consists of two phases—an active phase when infection of raspberries occurs

and a passive phase when the fungus remains inactive in the soil (Diagram 1).

The fungus survives during this passive phase in the form of dormant oospores, which are released into the

soil from dead or dying root tissue. These oospores can remain viable for many years in the absence of a host and are relatively insensitive to environmental extremes and fungicides

Diagram 1 Life cycle of the fungus *Phytophthora fragariae* var. *rubi*



applied to the soil. They can be moved to new sites either on rotting roots or plant debris, in soil, on clothing, machinery or in irrigation water. In the presence of new host plants, the oospores can germinate, giving rise to the active phase.

In the active phase, sporangia are produced which release zoospores during periods of wet soil conditions. These move through soil water and attack raspberry root tissue, setting up new infection. Prolonged periods of soil water logging can also lead to

sections of roots being asphyxiated or root cracking. This in turn leads to an increased release of root exudates, to which zoospores are chemically attracted. The fungus can persist for some time as mycelium, within the living plant tissue.

Cultural control measures

Propagation

Raspberry propagators must be particularly vigilant to the risk that visitors pose to their units, who may have come from infected premises. To reduce the risk of cross contamination, when visitors arrive on their premises, propagators should:

- always insist that clean protective footwear is worn that is fit for the purpose
- always insist clean coveralls are worn
- only allow the propagation site vehicles to be used for transport around the property

Healthy planting material

Healthy planting material is an essential starting point for a healthy crop. Plants should be purchased from a recognised certification scheme. Both SEERAD and Defra, through its Plant Health Propagation Scheme (PHPS), offer such a service to the industry. Such schemes aim to provide a reliable source of healthy plant material, which is propagated according to strict protocols.

Plants grown within the PHPS have a known history regarding the health status of parent material. They are grown on sites which are isolated from fruiting plantations. Sites are chosen that have either practiced long crop rotations between cane fruit crops or that have never previously grown cane fruit. Defra Plant Health Inspectors routinely examine and test the plants during their propagation, checking for the presence of pests and diseases including Phytophthora.

Growers intending to purchase plants are advised to visit plant propagators to inspect both their facilities and plants

during the growing season. It must be emphasised that no health scheme can guarantee freedom from disease, but they can help to reduce the risk.

Site, soil and substrate selection

Selecting virgin land, which has never produced raspberries or cane fruit crops before is the best way of avoiding infection, although the availability of such land is often scarce in the main fruit growing areas. Phytophthora infection has become so common in raspberries in the UK, that sites that have grown raspberries before should be considered to have a high risk of containing the fungus. To completely avoid any risk of infection, it is better to plant raspberries and cane fruit crops on virgin sites or in soil-less substrates than to use previously cropped soils. Where the only option is to plant in soil that has previously been used for raspberries, consideration should be given to the health status of the previous crop and where necessary, thought can be given to the various control measures that may need to be employed to control this disease.

Field sites with heavy soil (clay) and poor drainage should be avoided wherever possible. If site availability is limited, then the installation of tile drains will help to reduce the risk of water logging. Ensuring that ditches are free flowing will further help to reduce the build up of soil water in wet conditions. The action of sub-soiling during periods when soils are dry will provide new channels in the soil profile to further improve drainage. However, even if such remedial action is followed, the risk of spread on infected sites will still be high on such soils during wet conditions.

Cane fruit crops grown in soil-less substrates should carry no fungal disease, unless they have been contaminated on site by diseased planting

material, infected soils or irrigation water. Although peat and most other soil-less substrates cannot be considered to be sterile, if manufactured, handled, stored and decanted into pots, bags or troughs correctly, at the point of planting they should not contain *P. fragariae* var. *rubi* spores. To produce conditions that are not conducive to the development or spread of this fungus, substrates should be chosen that have a high level of air filled porosity (preferably 15% or more), to allow free drainage and promote healthy root development.

Organic matter and soil additives

Before planting, some growers incorporate organic matter such as well rotted farm yard manure or composted green waste. When used in heavy or clay based soils, this helps to improve soil texture, structure and drainage. In very free draining sandy soils, it not only improves soil texture and structure, but also reduces the risk of water runoff and the possibility of soil erosion during periods of heavy rainfall. In theory, the use of organic matter will help to reduce the frequency and degree of water logging or the movement of water down crop rows, thus reducing the risk of infection and rapid spread of this disease.

Some growers also lay mulches of straw, composted green waste (Figure 8) or other well rotted organic material onto the soil surface in the crop row. This maintains or improves the organic matter content of the soil and thereby promotes the growth of new fibrous roots close to the surface, thereby counteracting the loss of roots to the disease, deeper in the soil.

In the case of the straw, it is allowed to rot down into the soil during the winter months. However, there is evidence that the straw can also produce anaerobic conditions in the surface of

the soil as it decays, which can actually exacerbate the spread of Phytophthora rather than reduce it. Research and commercial experience in Switzerland and Germany has demonstrated that to create conditions less conducive to the development and spread of Phytophthora, it is safer and more effective to use composted green waste. However, this treatment cannot be guaranteed to work.

Site preparation

Well in advance of planting cane fruit crops in a field soil, a careful assessment of the site should be carried out, by digging several pits at various points across the field and examining the soil profile. The soil should be checked for signs of compaction, poor drainage and regular water logging of the soil in or immediately below the expected rooting zone (Figure 9). Where necessary, subsoiling should be carried out before planting when conditions are dry, to break through any layers of compaction, thereby improving both the drainage of the soil and plant root growth.

When planning to establish a crop through polythene mulched raised beds, it is important to create a deep, well structured soil tilth to a depth of 250 mm within and 250 mm below the actual base of each bed. This will allow planting of either bare rooted canes or module raised plants to the optimum depth, ensuring rapid establishment and healthy root and cane growth. The fact that the soil in and below the beds is well drained will help to reduce the chance of infection occurring later, during periods of wet weather.

Planting and establishment

Rapid root growth immediately after planting is vital to ensure that a healthy and balanced plant develops. Such plants may be better able to tolerate any fungal spores, which may already be present in the soil. Plant roots must not be allowed to dry out before planting takes place. To avoid this, the plants should not be laid out in the field ahead of planting, but instead kept moist by covering them with damp sacking or polythene sheeting.

Growing systems

P. fragariae var. *rubi* zoospores are very dependent on soil moisture to spread and infect new roots. It is therefore important to employ systems that will reduce the risk of infection by avoiding waterlogged conditions in the root zone. Planting into raised beds or ridges can help to prevent a proportion of the root system from being waterlogged (Figure 10 – overleaf). This is particularly important on heavy soils or those which are inherently slow to drain.

Although soil-less substrates are generally devoid of any existing *P. fragariae* var. *rubi* spores, should infection occur, the risk of rapid disease development and spread is high due to the constant levels of moisture at certain times of the year. Care should always be taken to avoid the contamination of substrates with *P. fragariae* var. *rubi* spores. This can sometimes occur when substrates are stored prior to use on soil or areas of

yard where infection has been known to exist in the past.

Where containerised plants are protected throughout the year, it should be possible to maintain more control over the moisture content of the substrate. However in this situation, the nutrient status of the substrate and volume of nutrients being applied should be carefully monitored. The build up of high salt levels and subsequent high EC should be avoided to obviate the need to flush out the substrate with high volumes of water. This practice can create ideal conditions for Phytophthora. In autumn and winter, when the crop is outside the main growing period, low levels of moisture can be maintained and this will reduce the spread of Phytophthora. This is in contrast to field soil grown crops, where there is very little opportunity to control soil moisture levels at this time of year, so crops are at higher risk of infection because of the likelihood of waterlogging.



8 Composted green waste can be used as a mulch on the soil surface to improve the organic matter content of the soil and to promote the growth of new fibrous roots close to the surface



9 Examination of the soil profile can sometimes reveal signs of compaction and poor drainage

Container grown crops that are situated in the field but not protected during the dormant season must be able to drain freely at all times. This is particularly important where pots or containers are laid on the tops of raised beds or ridges, which are covered with polythene sheeting. To prevent them from becoming waterlogged, adequate drainage holes should exist in the bases of the pots or troughs and also in the polythene mulch covering the surface of the bed or ridge. Beds and ridges should be formed with a profile which will allow excess water to run away from the containers, thus avoiding the base of the containers and basal roots from sitting down in water. Sitting the containers on wooden batons (Figure 11) or commercially available products such as 'Draineasi' (Figure 12) will further help to remove both rainfall and drainage water from the base of these containers. Their use will also help to maintain a physical barrier between the roots and the surface of the soil, which may contain *P. fragariae* var. *rubi* spores.

Some trough systems employ polythene sheets, which are laid along the length of the rows so that the surplus drainage water is channelled to the end of the row via a drainage pipe. Such systems can increase the risk of Phytophthora spread along the rows as the zoospores move in the water as it passes to the end of the row.

Although to date, nutrient film techniques or hydroponics have not been used for commercial raspberry production, they have been experimented with in other soft fruit crops such as strawberry. Although they have produced satisfactory crops, the risk of Phytophthora spread by the recirculation of water is very high. In the case of strawberry, in some instances infection by red core (caused by the related fungus *Phytophthora fragariae*) has been rampant, resulting in the loss of the whole crop.

Irrigation management

Careful irrigation of field or container grown raspberries is important throughout the life of the crop. Irrigation is important in the crop establishment phase to ensure rapid growth. However, excessive application of irrigation at any stage of the plant life should be

avoided, especially on heavier soils. This will increase the risk of waterlogging and subsequent risk of Phytophthora infection and spread.

Nutrition and soil pH

Years of observation by pathologists and consultants suggest that plants which are grown in soils with a neutral pH value appear to be less susceptible to Phytophthora infection. Although raspberries and other cane fruit crops can tolerate a low pH, their vigour and uptake of some nutrients at this level may be impaired and this may partly explain why they are less susceptible to Phytophthora at a neutral pH value. However, care should be taken not to raise the pH to such an extent that the raspberry crop becomes subject to deficiencies of certain micronutrients at high pH values, including iron and manganese.

Varietal resistance

Although varieties can vary greatly as regards their level of susceptibility or tolerance to infection by Phytophthora root rot, all varieties that are currently of commercial value in the UK can succumb to this disease. Although it was previously believed that blackberries were not affected by Phytophthora, it should be noted that some cultivars of blackberry have recently been found to be susceptible to Phytophthora, as are some raspberry x blackberry hybrids, such as loganberry.

A Horticulture LINK project that is part funded by HDC (SF 63) and conducted at the Scottish Crop Research Institute has been undertaken to identify genes in resistant raspberry varieties that confer a resistance trait to Phytophthora root rot. Having identified these genes, it should be possible in future raspberry



10 Planting into raised beds or ridges can help to prevent a proportion of the root system from being waterlogged



11 Use of batons beneath containers helps to improve removal of drainage water



12 Use of commercial products such as Draineasi helps to improve removal of drainage water

breeding programmes to screen new seedling selections for their presence or absence. This will reduce the time currently taken in the selection process when screening new material, thus speeding up the process of releasing new resistant varieties to the industry.

Hygiene

The scrupulous removal of soil from machinery, hand tools, footwear and clothing after working on infected sites and before moving to healthy plantations will help to reduce the spread of Phytophthora

from site to site. Where crops are protected by permanent structures all year round, the routine dipping of footwear in a bath containing a suitable disinfectant at the entrance to individual houses, can help to maintain freedom from Phytophthora.

Chemical control measures

The use of chemical control options is an important component in the control of Phytophthora. However, due its limited effectiveness and the persistent nature of *P. fragariae* var. *rubi* spores, it is essential that chemical control measures be used as part of an integrated disease management strategy. Such action will then enable chemical treatments to be more effective.

Soil fumigation

Of all the soil fumigants currently available to commercial raspberry growers, steam is the only one that is likely to provide good control of Phytophthora. However at present, this is only a feasible option for glasshouse growers and is only as good as the depth of soil to which it penetrates. Although chemical fumigants such as metham sodium and dazomet can all help to

reduce the numbers of spores in the soil, their effectiveness is limited both by the depth of treatment and the soil conditions at the time of treatment.

Fungicide drench treatments

For crops that are planted in field soils or soil-less substrates, there are currently specific off-label approvals available that permit the use of fungicide drenches to penetrate the root zone. These must be applied as directed sprays onto the soil or compost surface, around the bases of the canes. If applied in the recommended volumes of water, these fungicides should come into contact with a high proportion of the plant roots in the top soil, particularly those just below the soil surface, and protect them against attack by the fungal zoospores.

There are currently two active ingredients (fluazinam and metalaxyl-M) that have specific off-label approvals for use on cane fruit crops. Their numbers,

rates of use and other details are listed in Table 1.

Significant numbers of growers currently grow cane fruit crops in field soils on raised beds or ridges through a polythene mulch. Irrigation is applied through a trickle irrigation line that is laid beneath the polythene mulch. The presence of the mulch restricts access to fungicide drenches, should Phytophthora infection occur. Some growers have attempted to apply the fungicide by passing it through the irrigation line during irrigation cycles, but this has consistently failed to provide adequate control. Should infection occur, it is best to remove the polythene mulch to allow the fungicide drench to adequately penetrate the root zone.

Table 1 Summary of the fungicides with specific off-label approvals currently available for use in controlling Phytophthora root rot in cane fruit crops

Active Ingredient	Product names	Approval	Application/Use	Rate of Use	Volume of water
fluazinam	Shirlan Shirlan programme	SOLAs 2168/03 2080/03	Applied as a drenching spray to the soil/compost around base of canes to penetrate root zone. 2 applications permitted/year. Latest application made before end of March in year of harvest. Permitted on outdoor and protected crops. Permitted for use on raspberry, black and hybridberry.	Field – 1.5 litres/ha Pot – 1.5 ml per litre	Field – 1250 litres/ha Pot – 500ml per 5 litres of compost
metalaxyl-M	SL 567A	SOLA 1515/05	Applied as a drenching spray to the soil/compost around base of canes to penetrate root zone. Can be applied as a split dose of two applications of 1.3 litres of product per hectare each, in October and March. Permitted only on outdoor raspberry crops.	1.3 litres/ha	1000 litres/ha

Action points for growers

- Before planting a raspberry crop in a field soil, consider the previous history of the site and avoid those known to be infected with *Phytophthora*.
- Choose field soils which are free-draining and devoid of low lying areas.
- Consider planting on a raised bed or ridge system to reduce the risk of waterlogging and improve plant rooting depth.
- Install field drainage to further reduce the risk of waterlogging.
- Purchase certified healthy plant material and satisfy yourself that all reasonable procedures have been followed to avoid infection occurring before you take delivery of the plants.
- Where raspberries are grown in containers, be sure to sit these on batons or alternative materials to improve drainage and avoid direct contact with soils.
- Where infection occurs on polythene mulched ridges, remove the polythene to improve access for fungicidal drenches.

Further information

Names and addresses of plant diagnostic laboratories:

ADAS Pest Evaluation Services

ADAS High Mowthorpe
Duggleby
Malton
North Yorkshire YO17 8BP
Tel. (01944) 738434
www.adas.co.uk

Central Science Laboratory

Sand Hutton
York YO41 1LZ
Tel. (01904) 462000
www.csl.gov.uk

The Plant Clinic

East Malling Research
East Malling
Kent ME19 6BJ
Tel. (01732) 843833
www.emr.ac.uk

Scottish Crop Research Institute

Invergowrie
Dundee DD2 5DA
Tel. (01382) 562731
www.fruithealth.co.uk

Stockbridge Technology Centre Ltd

Cawood
Selby
North Yorkshire YO8 3TZ
Tel. (01757) 268275
www.stc-nyorks.co.uk

Names and addresses of UK raspberry and cane fruit suppliers offering plants with a SEERAD or Defra plant health certificate:

Darby Plants Ltd

Broad Fen Farm, Severalls Road
Methwold Hythe, Thetford IP26 4QU
Tel. (01366) 727229

Hargreaves Plants Ltd

Cowpers Gate, Long Sutton
Spalding, Lincs PE12 9BS
Tel. (01406) 366300

Haygrove Plants

Redbank Farm, Little Marcle
Ledbury, Herefordshire HR8 2JL
Tel. (01531) 633659

Highland Fruit Stocks

Mains of Murthly, Aberfeldy PH15 2EA
Tel. (01887) 829899

Messrs David McIntyre

Cruachan, Wester Essendy
Blairgowrie PH10 6RA
Tel. (01250) 884212

Messrs J McIntyre & Sons

Moyness Nurseries, Coupar Angus
Road, Blairgowrie PH10 6UT
Tel. (01250) 873135

T J Moore

20 Bilney Road, Gressenhall
Dereham, Norfolk NR20 4EG
Tel. (01362) 861091

Scottish Nuclear Stock Association Ltd

Buchal Farmhouse
Alyth, Blairgowrie PH11 8JS
Tel. (01575) 560349

Thomas Thomson (Blairgowrie) Ltd

Bramblebank Works
Blairgowrie PH10 7HY
Tel. (01250) 872266

Edward Vinson Plants Ltd

4 Ewell Barn, Graveney Road
Faversham, Kent ME13 8UP
Tel. (01795) 537500

R W Walpole (Strawberry Plants) Ltd

Ivy Farm, Tuxhill Road
Terrington St. Clement, Kings Lynn,
Norfolk PE34 4PX
Tel. (01553) 828829

J M Watson Fruit Growers Ltd

Mill of Montague
Balbeggie, Perth PH2 7PR
Tel. (01821) 640271

Welsh Fruit Stocks

Bryngwyn, Powys
Via Kington, Hereford HR5 3QZ
Tel. (01497) 851209

Woods Nurseries Plants Ltd

Tarry Hill, Swineshead
Boston, Lincs PE20 3LL
Tel. (01205) 821155

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