

Tim O'Neill and Sarah Mayne, ADAS

# Control of narcissus leaf scorch, smoulder and white mould

Smoulder and white mould are the most common and damaging foliar diseases affecting commercial narcissus production in England and Scotland. Leaf scorch is the main foliar disease of Tazetta narcissus, especially on the Scilly Isles. This factsheet provides information on biology of the three diseases and guidelines for their effective management.



Figure 1. Narcissus production in north east Scotland

## Action points

- If you are uncertain of the cause of premature leaf dieback, have a sample examined for *Peyronellaea curtisii* (leaf scorch), *Botrytis narcissicola* (smoulder) and *Ramularia vallisumbrosae* (white mould) (see Figures 2–13).
- Assess the risk of foliar diseases, for example, from cultivar stock history, production location, field topography, disease occurrence in the crop the previous season, whether flowers were cropped the previous season and recent weather.
- Apply preventative foliar sprays where there is a high disease risk, especially of leaf scorch or white mould.
- Use fungicides from at least two different fungicide groups to minimise the risk of selecting fungicide resistant strains.
- Monitor occurrence of foliar diseases to inform fungicide product choice and spray interval.
- Monitor carefully for white mould after periods of cool (5–10°C), wet (12–24 hours' leaf wetness) weather; these conditions being particularly favourable to infection by *R. vallisumbrosae*.
- For crops where flowers will be harvested the following year, consider applying one or more sprays of products that control foliar diseases, delay senescence, and increase flower yield, such as Signum, Tracker or Vivid. Note that some fungicides delay senescence even in the absence of foliar disease.
- Where early lifting or an autumn herbicide treatment is required, do not apply a late spray of a fungicide that delays leaf dieback.





Figure 2. Leaf scorch, smoulder and white mould can all cause premature leaf dieback and reduced bulb yield

## Economic importance of the disease

The farm gate value of the UK narcissus industry is estimated to be in excess of £30million, with exports of bulbs and flowers worth over £20million annually to the economy. Over the last 30 years, smoulder has become more significant and is estimated by the industry to cause a consistent loss of bulb yield of about 10%. The disease occurs in all the major narcissus growing areas, although it tends to be most troublesome in eastern counties. White mould is now present in all major narcissus growing areas and epidemic attacks occur in some years. Leaf scorch is a significant problem attacking Tazetta cultivars on the Scilly Isles where the early narcissus flower industry is a major contributor to the local economy; it occurs occasionally elsewhere.

## Leaf scorch

Leaf scorch, caused by the fungus *Peyronellaea curtisii* (previously *Stagonospora curtisii*), is mainly a disease of south west England where it is favoured by the mild, wet weather conditions. It is most common on Tazetta types such as Grand Soleil d'Or and Innsidgen.

## Symptoms

The name leaf scorch derives from the scorched or reddish-brown appearance of emerging leaf tips. This initial symptom may easily be mistaken for frost or herbicide damage. Later, minute water-soaked spots with yellow centres develop. The centres become red-brown and necrotic as the lesions expand. These lesions remain small, rarely exceeding 2x5mm. Although these brown elliptical spots remain relatively small, the leaf tissue above turns yellow and dies. Even in dried, withered leaves, the small brown elliptical spots can still be seen. The transitional area between healthy and diseased leaf tissue is typically yellow. Fruiting bodies (pycnidia) develop in large numbers in the lesions, just visible to the naked eye as small brown swellings. The fungus also causes spots and blotches on flower stalks and flowers. In susceptible varieties, leaf scorch can result in leaf dieback four to eight weeks before they should normally die; growers estimate that the resultant loss in bulb weight can be 30% or more. It does not usually cause bulb decay. The numerous spherical brown pycnidia (c.0.2mm diameter) within lesions serve to distinguish leaf scorch from smoulder and white mould: smoulder occasionally produces relatively large irregularly shaped black sclerotia within leaf lesions; white mould produces numerous small (c.0.1mm diameter) black sclerotia.



Figure 3. Tip browning due to leaf scorch infection





Figure 4. Widespread infection by leaf scorch in a susceptible variety

### Sources and spread

*Peyronellaea curtisii* persists in or on dormant bulbs and this is considered the principal source of inoculum. The fungus may be found between papery scales or between papery and fleshy scales. Both the leaf tip scorch symptom and initial leaf spot infections (primary symptoms) take place as emerging leaves extend through the neck of the bulb. Primary symptoms usually occur only on the outer leaves.

Pycnidia developing within primary symptoms contain a large number of spores, which are extruded when leaves are wet. These spores are splashed or blown in wind-driven rain onto other leaves and flowers and onto neighbouring plants to cause fresh infections (secondary symptoms).

*Peyronellaea curtisii* can survive in old leaf debris for more than a year and this is likely to be an alternative source of initial inoculum. Infested leaf debris could potentially initiate infection in following crops or increase disease spread in current crops.



Figure 5. Leaf scorch lesion with small, spherical pycnidia visible

### Infection conditions and disease development

Fungal mycelium of *P. curtisii* present in the bulb neck at planting infects emerging leaves. Conditions that cause the pathogen to recommence growth are uncertain. There is some evidence that the number of primaries in new plantings is associated with bulb storage conditions; storage at low temperature sometimes increases the problem, especially if combined with late planting. The number of primaries does not appear to be related to the previous season's foliar spread. Wounding of emerging leaves is not necessary for infection to occur, although it is likely to increase disease development. In experimental work on inoculated wounded leaves, water-soaked areas occurred within 24 hours, necrotic lesions within 48 hours and pycnidia within three days; on unwounded leaves the timescale was longer.

Wet conditions are required for rapid disease spread by spores. Water on leaves causes mature pycnidia to swell and extrude spores; water splash results in spore spread from infected to healthy tissue; free water is necessary for the spores to germinate. With moist conditions for 48 hours, spores result in small, pale spots after around four days and typical red brown elliptical spots after around 10 days. Germinated spores produce infection hyphae, which penetrate the waxy cuticle; after this stage, the fungus is largely independent of external moisture. Mycelial growth occurs between the cuticle and the epidermal cell wall. Severe disease symptoms are most likely in wet weather and mild temperatures (15–20°C).

While leaf spots arising from bulb infection are located near the leaf tip, secondary leaf spots are formed over all parts of the leaf and can be especially numerous towards the base. The mycelium in leaves grows down into the bulb neck as the leaves gradually die and very probably remains alive in the remnants of dead leaves during the bulb dormant period.



## Smoulder

Smoulder is a fungal disease caused by *Botryotinia narcissicola* (usually present as, and known by, its asexual stage, *Botrytis narcissicola*). The fungus is common wherever narcissus are grown. Generally, the disease is present at relatively low levels and develops quite slowly but occasionally, especially in cool wet seasons, it can spread through a crop resulting in rapid premature leaf dieback and greatly reduced bulb yields. *Botrytis cinerea* is also sometimes recovered from narcissus, though experimental work shows it is considerably less pathogenic to the crop than *B. narcissicola*, and probably occurs mainly as a saprophyte.

## Symptoms

The initial symptoms of smoulder are dark brown-black leaf tips on emerging shoots in the spring. These primaries often have their leaf tips withered, distorted, adhering and blackened. In humid weather, affected tissues are covered in a grey, furry sporing mass of the causal fungus. Later, other leaves develop dark brown lesions surrounded by yellowing areas. These lesions may occur at the leaf tip or on one side of a leaf, the latter resulting in characteristic sickle-shaped lesions. Flower buds may develop brown lesions and open flowers may develop spotting.

Further lesions may develop after flowering especially where the leaf flexes and cracks. These lesions, which arise from air blown or water splashed spores, are pale brown, oval and large

(20–30 by 10–15mm). In wet weather, they may spread and merge leading to early leaf dieback, which can easily be mistaken for natural leaf senescence. Also at this time, a stalk end rot may develop after flower picking, from the cut end downwards. As with leaf lesions, in humid weather flower stalk end rots are likely to develop the grey sporulation typical of *Botrytis*.

As the leaves die back, the fungus grows down into the bulb neck. Sclerotia may form at soil level in the base of rotting shoots, in the bulb neck and in leaf debris on the ground.

In experimental work, reduction of dieback from smoulder by the use of fungicides has resulted in prolonged retention of green leaves and flower stalks and large increases in bulb yield.



Figure 6. A sickle-shaped smoulder lesion with a black sclerotium visible



Figure 7. *Botrytis narcissicola* can result in large pale-brown oval lesions in wet weather

## Sources and spread

The main source of smoulder is infected bulbs, where *Botrytis narcissicola* occurs as fungal mycelium in the bulb neck and as black resting bodies (sclerotia, around 1–3mm by 1–2mm in size) in the neck and outer papery scales. Leaves become infected as they emerge through the bulb neck, resulting in 'primary' infector plants seen early in a season. Experimental work has demonstrated that sclerotia of *B. narcissicola* in leaf debris and in the soil can result in primary symptoms as shoots push through infested soil. When conditions are favourable (cool and wet), *B. narcissicola* sporulates profusely on leaf, flower bud and flower stalk lesions and the spores (conidia) are dispersed by wind and water-splash to neighbouring plants. As the leaves die back, sclerotia form in the leaf tissue and in leaf debris on the ground. In addition to producing fungal hyphae and conidia, sclerotia may occasionally germinate in winter and spring to produce a second spore type, the ascospore; the importance of ascospores in the spread of smoulder is uncertain.

The fungus is sometimes recovered from apparently healthy green tissue, suggesting there may be an endophytic stage, and/or a latent phase between infection and the development of visible lesions.

## Infection conditions and disease development

Experimental work has demonstrated that leaf wounding is required for *B. narcissicola* dispersal spores (conidia) to cause lesions soon after they land on leaves. Hail may be one factor sufficient to cause wounding and allow rapid disease development; leaf damage (eg cracking) during flower picking is probably another.

In experimental work, heavy rain was insufficient to allow penetration by *B. narcissicola* of the leaf surface and cause lesion formation. However, the survival of the fungus was enhanced on leaf material that had been subjected to heavy rainfall.

The optimum climatic conditions for infection of leaves by conidia are a temperature of 12°C and a period of leaf wetness of at least six hours, although with longer periods of wetness duration (about 24 hours) the fungus can infect at a wider range of temperatures (from 4–16°C).

Observations indicate that temperature and rainfall at the time of shoot emergence can influence the severity of smoulder, the disease being worse in cool, wet seasons. Smoulder is a disease that tends to be present in most crops to some extent. It is rarely damaging in the first year down and increases in incidence the greater the number of seasons that bulbs are left in the ground. This reflects spread from primaries to other plants by dispersal spores during the growing season, subsequent growth of the fungus from dying foliage down into the bulb neck and consequently an increase in the number of primaries emerging the following season.



Figure 8. Flower bud decay due to smoulder



Figure 9. *B. narcissicola* sclerotia visible in old leaf bases in the bulb neck



## White mould

White mould, caused by the fungus *Ramularia vallisumbrosae*, was primarily a disease of south west England, south Wales and south west Scotland until 2000. In 2001, the disease was confirmed in eastern England for the first time, and in June 2011, in north east Scotland. White mould now occurs regularly in the main narcissus growing regions (Cornwall, eastern England and north east Scotland) causing significant crop damage if not adequately managed. It is also reported as an increasing problem in the Republic of Ireland.

### Symptoms

White mould appears initially as small, slightly sunken, grey-green or yellowish spots or streaks near the leaf tip. These increase in size to form yellowish-brown oval lesions. In early crops in the south west these may appear as early as January, soon after leaf emergence. In wet or humid weather, a powdery white mass of spores develops within the central area of the lesion. Further lesions develop on both leaves and flower stems, often coalescing to cause rapid leaf dieback. Roughly circular patches of dead foliage, several metres in diameter, frequently occur in affected crops. Later in the season, small dark resting bodies (sclerotia), around 0.1mm in diameter, develop within affected areas of leaves and stems. In warm, wet springs the disease becomes epidemic and causes the leaves to die down early. The loss of green leaf area and early senescence cause a considerable reduction of bulb size and potential flowers for the next season.



Figure 10. White mould leaf lesions showing a powdery, white spore mass in the central areas



Figure 11. White mould flower stem infection





Figure 12. A patch of narcissus badly affected by white mould

### Sources and spread

There is no evidence that *R. vallisumbrosae* is carried on bulbs and initial outbreaks each year are believed to originate from the minute black sclerotia that survive the summer in leaf debris. These germinate in the winter, usually from December to March, to produce dispersal spores (mainly scolecospores) which can infect the new leaves as they emerge. The fungus may attack leaves and flower stalks a few centimetres below ground level but bulbs are not attacked. Spores are spread from the white powdery fungal mass on leaf lesions by wind and water-splash to cause further leaf and flower stalk infections.

### Infection conditions and disease development

Experimental work showed the optimum temperature for germination of sclerotia in winter/spring was 5–10°C; water was also required. The optimum climatic conditions for infection by spores arising from sclerotia and white mould affected leaves were a temperature of 5–10°C and leaf wetness of 12–14 hours' duration. As with *B. narcissicola*, damage is required for rapid development of leaf lesions to occur. Preliminary investigations have shown evidence that different spore types produced by white mould have different climatic criteria for their formation.

In warm, wet springs the disease can become epidemic, causing leaves to die down early, but in cool, dry weather the spores cannot survive for long, the disease is checked and spore formation prevented. Observations suggest wind-blown rain is important for epidemic development, with field boundaries sometime acting as a barrier to disease spread.



Figure 13. White mould sclerotia in leaf debris; small black sclerotia are just visible on the upper mid-section of the lower leaf



## Some other foliar disorders and fungal diseases

### Hot-water damage

Hot-water treatment (HWT) of bulbs outside the safe treatment period or without warm storage can damage the flowers and leaves. Leaves damaged by HWT show speckling of tips, surface roughening and occasionally distortion.

### Cold damage

Exposure of young leaves in very cold weather can prevent exposed parts becoming green, resulting in a chlorotic band across the leaf later in the season. Alternating periods of slow and rapid growth in winter can also result in horizontal bands across the leaf.

### Daffodil 'rust'

'Rust' occurs sporadically on daffodils, causing significant loss of flower crops in some years. It has been regarded as a physiological disorder, and lesions were recently shown to be associated with a high soil water content – but also with the presence of a *Stemphylium* species (Project BOF 76a). Daffodil 'rust' is not due to a rust fungus and does not warrant specific fungicide applications.



Figure 14. Severe damage occurring after hot-water treatment



Figure 15. An example of frost damage in narcissus



Figure 16. Commercial daffodil stems showing mild to moderate symptoms of physiological rust.





Figure 17. *Botrytis polyblastis* causing flower spot

## Fire

This disease, caused by the fungus *Botryotinia* (*Botrytis*) *polyblastis* is primarily found on the flowers and was common in south west England before the practice of picking flowers in tight bud was adopted. Symptoms are pale brown spots on open flowers. As the flowers wither, the fungus produces masses of conidia, which are dispersed onto the leaves to cause spotting. Sclerotia are produced in the leaf spots as infected leaves die down. The life cycle recommences when sclerotia in leaf trash germinate in late winter to produce ascospores that infect narcissus flowering at that time. Cultivars of the Tazetta group are very susceptible.

## Integrated disease management

Foliar sprays of fungicides are the cornerstone for management of all three diseases. Some fungicides also delay foliar dieback and hence may increase bulb yields even in the absence of significant levels of foliar disease.

## Resistant cultivars

Choice of cultivar greatly affects the risk of damaging attacks from leaf scorch and white mould; smoulder is less affected by cultivar. Utilising knowledge of cultivar susceptibility is helpful when the number of spray days is restricted because of rain or wind.

Leaf scorch is most often worst on Poeticus, Polyanthus, Poetaz and Tazetta types, although most varieties can be attacked when conditions favour the disease. Recent observations indicate Israeli Paperwhites are more prone to infection than some others. The Tazetta variety Innisidgen is reported as most susceptible to leaf scorch, followed by Sols varieties (also the most likely to show early dieback in spring). Some other flower crops in the family Amaryllidaceae have also been recorded as hosts of leaf scorch, including Amaryllis, Galanthus and Nerine.

White mould is especially damaging on late-flowering cultivars such as Cheerfulness, although some early and maincrop cultivars including California, Dutch Master, Planet and Hollywood can be severely affected.

With smoulder, experimental work showed that Golden Harvest was more susceptible than Dutch Master, with Cheerfulness and King Alfred intermediate. Grower observations have noted damaging attacks in cultivars Golden Harvest, Tamara, Planet and Tamsyn in recent years.

## Hot-water treatment

Historically, HWT, including the use of formalin, has been shown to greatly decrease infection by *P. curtisii* (leaf scorch) and *B. narcissicola* (smoulder) in bulbs. Smoulder was rarely a problem where bulbs were lifted and treated annually. Although formalin is no longer permitted as a hot-water dip additive, it is considered likely that HWT alone (three hours at 44.4°C) will reduce bulb infection by *P. curtisii* and *B. narcissicola* to some degree. The effect of current fungicides and biocides, added to the hot water tank for control of stem and bulb eelworm (*Ditylenchus dipsaci*) and basal rot (*Fusarium oxysporum* f. sp. *narcissi*), on the viability of *B. narcissicola* and *P. curtisii* in bulbs is unknown.

## Sanitation

Roguing infected plants and removal of crop debris are logical approaches for reducing disease pressure. However, where examined for reduction of smoulder they have not proved reliably effective in reducing disease levels. Furthermore, they involve considerable labour inputs, which are increasingly expensive or unavailable. Rotation of narcissus with non-susceptible crops for five to six years is strongly recommended for management of basal rot. Such rotations will likely greatly reduce the persistence of *R. vallisumbrosae* and *P. curtisii* in the soil. Because of the risk of debris and soil blowing from one field to the next, it is recommended that, where possible, new plantings should not be adjacent to current crops or fields where narcissus crops were grown the previous year. Tractors, spray machinery and boots should also be washed between crops, especially after work in a crop obviously affected by one or more of the foliar diseases.

Roguing of infected plants and removal of crop debris may be practical and contribute to disease management where a cultivar is grown on a very limited scale, such as a display area.

## Fungicide products and programmes

### Fungicide products

Field trials on the use of fungicides for management of smoulder and white mould were conducted in 1998–2002 (BOF 041) and 2012–2013 (BOF 072 and 072a). The results of these trials provide useful guidance on product selection and treatment timing. However, some of the products found effective then are no longer permitted for use on narcissus. With leaf scorch, no fungicide efficacy trials have been conducted for over 30 years. From the set of fungicides currently permitted on narcissus, it is therefore necessary to consider products with activity against fungi closely related to the target pathogens, and products from the same fungicide groups as those previously found effective on smoulder or white mould but no longer permitted, in order to provide options to construct a sustainable spray programme (Tables 1 and 2). Fungicides shown to have activity against a particular disease by field trials or other experiments are distinguished from those considered likely to have activity. Growers report that applications against white mould and smoulder typically offer additional control of leaf scorch.



For all three diseases, there are several fungicide products available, from different fungicide groups, which are active or likely active against the target pathogens. Note that many products are restricted to a maximum of two spray applications per crop, and some to just one (eg Bravo 500). Where narcissus is grown for galantamine production, some additional fungicides are permitted (eg tebuconazole, as in Follicur).

In BOF 041, 072 and 072a, fungicides were used at their label recommended rate in order to provide a fair evaluation and to check for possible phytotoxicity to narcissus. It may not be necessary to use products at their maximum label rate for the same beneficial effects. The efficacy of mixtures of two or more fungicides each applied at a reduced rate on management of narcissus foliar diseases has not been examined in trials work.

### Fungicide timing

Studies in BOF 41 on control of smoulder and white mould found that:

- Bulb yield increase was greater with sprays applied both during emergence and around flowering (four sprays in total)
- Programmes consisting of just two sprays, focused either during emergence or around flowering or after flowering, gave little control of smoulder and a relatively small increase in bulb yield
- For white mould, spray programmes commencing before first symptoms appeared were usually more effective than those commencing at or after, the appearance of first symptoms
- For white mould, the number of sprays required to achieve effective control ranged from three to six depending on products used and the season.

### Studies in BOF 72 and 72a found that:

- When three fungicide sprays were applied from immediately after the end of flowering, there was little benefit in applying sprays before flower harvest. This strategy would not be appropriate where disease becomes obvious before flower harvest or for areas where there is a history of early foliar disease
- In a crop of cv. Early Flame, fungicide treatments that gave good control of foliar disease and delayed leaf dieback also increased flower yield the following year. Compared with untreated crop, flower yield was increased by Signum (44%), Tracker (27%) and Vivid (22%).

### Example spray programmes

Some example guideline spray programmes devised to comply with label or EAMU conditions of use (eg maximum spray number, harvest interval) and to minimise the risk of fungicide resistance are shown in Table 3. Programmes A, B, C and D are for management of smoulder and white mould; programmes E and F are for leaf scorch, smoulder and white mould. Please note:

- Numerous other programmes could be devised using these and other products

- Cultivar susceptibility, crop age, disease occurrence in a crop and forecast weather should also be used to inform product choice and spray timing
- The interval between sprays will be determined by interval since last treatment, disease pressure and opportunities to spray
- Where early lifting or an autumn herbicide treatment is required, it would be prudent not to apply a late spray of a fungicide that delays leaf dieback
- Signum is suggested for use pre-flowering because it has an EAMU for use on outdoor ornamentals and no stated harvest interval; any stated harvest interval on a label applies to flower harvest as well as bulb harvest
- Leaf scorch, smoulder and white mould all tend to increase in severity the longer a crop is down. Crops intended to be left down for many years for flower production should be checked carefully for foliar diseases each year
- Levels of smoulder are generally low in a first-year-down crop, but fungicide treatment around and after flowering can reduce the risk of a high incidence of smoulder primaries the following season. However, severe white mould can occur even in a first-year-down crop, especially where the crop is downwind of other narcissus crops affected by the disease.

### Avoiding fungicide resistance

There are no published reports of fungicide resistance in either *B. narcissicola* or *R. vallisumbrosae*. However, field trials on white mould control suggest that some strobilurin fungicides (eg azoxystrobin) have become less effective in recent years than when they were first used. Some growers have also reported reduced efficacy of chlorothalonil. To preserve the effectiveness of fungicides, growers should follow the guidelines outlined in the Fungicide Resistance Action Group technical leaflet: 'Fungicide resistance', which can be downloaded from [frac.info/publications/downloads](http://frac.info/publications/downloads). The main points to consider are:

- Devise a programme using fungicides from two or more different fungicide groups
- Alternate products based on their chemical group or use two fungicides from different groups in mixtures, where both fungicides are active against the target fungus
- Make full use of multi-site protectant fungicides (eg Bravo 500, Dithane 945), as these tend to be less prone to resistance development
- Recent work on fungal foliar diseases on cereals indicates that use of mixtures of several fungicides, each at a reduced dose, is more beneficial in reducing selection of resistant strains than use of a single fungicide at full dose.







## Further information

BOF 072 – Narcissus: evaluation of fungicides for improved control of smoulder and white mould.

BOF 072a – Narcissus: improved control of foliar diseases and the effect of fungicide sprays on flower production.

BOF 076a – Understanding the physiological disorders in daffodil – BOF 076 project extension to study the three-year-down crop.

Factsheet 14/03: 'Control of narcissus smoulder and white mould'.

Factsheet 01/13: 'Practical measures to prevent and manage insecticide, fungicide and herbicide resistance for horticultural crops'.

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