Grower Summary

BOF 076

Understanding physiological disorders in narcissus

Annual 2013

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Project Number:	BOF 076
Project Title:	Understanding physiological disorders in narcissus
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Report:	Annual report 2013
Publication Date:	22nd December 2014
Previous report/(s):	None
Start Date:	01 June 2012
End Date:	31 January 2015
Project Cost:	£62,459

GROWER SUMMARY

Headline

Daffodil rust, a physiological disorder with no known cause, may be associated with high soil water content in the months before flowering.

Background

Starting in the early-1990s UK daffodil growers became concerned about rust-like lesions appearing on daffodil stems. The symptoms occurred sporadically, sometimes presenting as a few insignificant spots, but in more serious cases the lesions were numerous, forming coalescing areas of damage that disfigured stems and caused the product to be downgraded. In severe cases stems showed transverse cracking and became brittle and unmarketable. Despite the convincingly disease-like lesions, initial testing apparently failed to reveal a primary pathogen associated with the lesions, so the condition was classed as a physiological disorder. It soon came to be called ‘physiological rust’, or more recently ‘stem rust’ (though similar lesions may occur on leaves). In this report the disorder is called ‘daffodil rust’.

To gauge the extent and economic cost of daffodil rust, the HDC organised surveys of growers in 2002 and 2003 and again during the period 2011 to 2013. The responses confirmed that daffodil rust had caused - and continues to cause - commercially significant losses that would justify research into its cause and management. The responses highlighted that growers and advisers had submitted affected (a) plant samples for diagnostic examination and (b) soil and plant samples from affected and ‘healthy’ crops for mineral analysis. No pathogenic or nutritional cause was found, though neither should be ruled out entirely because sampling had been opportunistic and non-replicated, whereas more structured sampling could have provided more robust conclusions. The surveys also revealed ideas circulating in the industry about other causes of daffodil rust: suspected predisposing conditions often involved rapid changes in temperature, alternating cold and warm periods, and adverse weather.

Daffodil chocolate spot is another physiological disorder of daffodils and has parallels with daffodil rust, though it has not been known to have had any serious effects. As with daffodil rust, pathological and nutritional causes were ruled out, while an association with increasing ambient temperatures was suggested. Several physiological disorders of other horticultural crops are characterised by the appearance of brown or black spotting and have been linked with adverse environmental conditions. Apple leaf spot and drop, for example, has been associated with dry, hot summer weather and a sudden change in temperature, while lettuce

dry (or marginal) tip-burn has been linked to water stress when transpiration exceeds water uptake, promoted by sudden checks in growth such as low temperatures.

In the light of this evidence daffodil rust could be a physiological disorder brought about by adverse environmental conditions. The objective of project BOF 76 is to test the proposition that the soil-water environment (soil structure, water availability, soil temperature, nutritional status, etc.) affects the level of daffodil rust. One practical way of assessing the effects of the soil-water environment on the disorder would be to monitor rust development and environmental factors and search for associations between them. Therefore plots of the rust-susceptible daffodil cultivar 'Golden Ducat' were planted in ten daffodil fields at varied locations through west Cornwall, the region where it seemed crops were most prone to the disorder. This scheme should maximise the likelihood that daffodil rust would occur naturally in at least some of the experimental locations, potentially enabling the predisposing factors to be identified through association and regression analysis.

Since the project would supply a structured set of affected and 'healthy' samples, the opportunity will be used (in 2014) to examine further the pathological and nutritional theories of daffodil rust. Samples of plants will be taken for plant clinic examination for fungal or bacterial pathogens, for sequencing viral RNA, and for the analysis of macro- and micro-nutrients. Soil samples will be taken for the analysis of macro- and micro-nutrients.

Summary

Surveys of growers

In 2002 68% of respondents reported having seen daffodil rust on their crops during the previous five years or so, and this figure rose to 86% by 2011, this being cited as the worst 'rust year' so far. In 2002, 36% of respondents had seen some product downgraded and 25% could not supply their preferred customer or had product that was completely unmarketable; in 2011 the corresponding figures had increased to 71 and 57%. For both survey periods the loss of turnover due to daffodil rust was estimated at between 0 and 3% in a good year but up to 15% in a bad year.

Many cultivars were reported as being subject to daffodil rust, though 'Golden Ducat' and 'Mando' were cited a disproportionate number of times. 'Carlton', 'Kerensa' and 'Tamara' were also likely to be affected. Plants showed symptoms of daffodil rust in their first-, second-, third- and subsequent crop-years. Predisposing factors for daffodil rust cited by growers included repeated frost and thaw, alternating mild and cold weather, rapid snow melt with subsequent fast growth, and the end of cold or adverse weather. Where samples had been sent for disease diagnosis or nutrient analysis, no pathogen identification had

been made, nor any associations identified between nutrient levels and the level of daffodil rust.

Field-work

In autumn 2012, 50 kg-plots of bulbs of the rust-prone cultivar ‘Golden Ducat’ were planted in bulb fields at ten sites across west Cornwall, the locations being chosen to represent different situations, topographies, soil types, etc., increasing the likelihood that daffodil rust would occur on at least some of the sites. The locations were (from west to east) Kelynack, St Buryan, Tregiffian, Rosevidney, Roseworthy, Bodilly, Mawla, Penventon, Fourburrow and Goonhavern. At each site a weather station was set up, logging soil water content (SWC) at three depths (0-100, 100-200 and 200-300 mm), soil temperature (at 150 mm depth), air temperature, relative humidity (RH) and precipitation. This would enable the level of daffodil rust to be studied in relation to the soil-water and other features of each site, to identify associations between these factors and the level - of daffodil rust.

The main assessments of crop development and daffodil rust were carried out about two weeks before, around, and two weeks after flowering (flowers were not picked so that their development could be followed). In spring 2013, at the first assessment (early-February), no characteristic daffodil rust lesions were seen on stems or leaves, with the exception of the site at Tregiffian where two small, rust-like spots were seen on each of two stems. At Penventon inconspicuous depressions and pitting of stems were noted, subsequent observations suggesting these were a widely occurring early-stage of daffodil rust lesions.

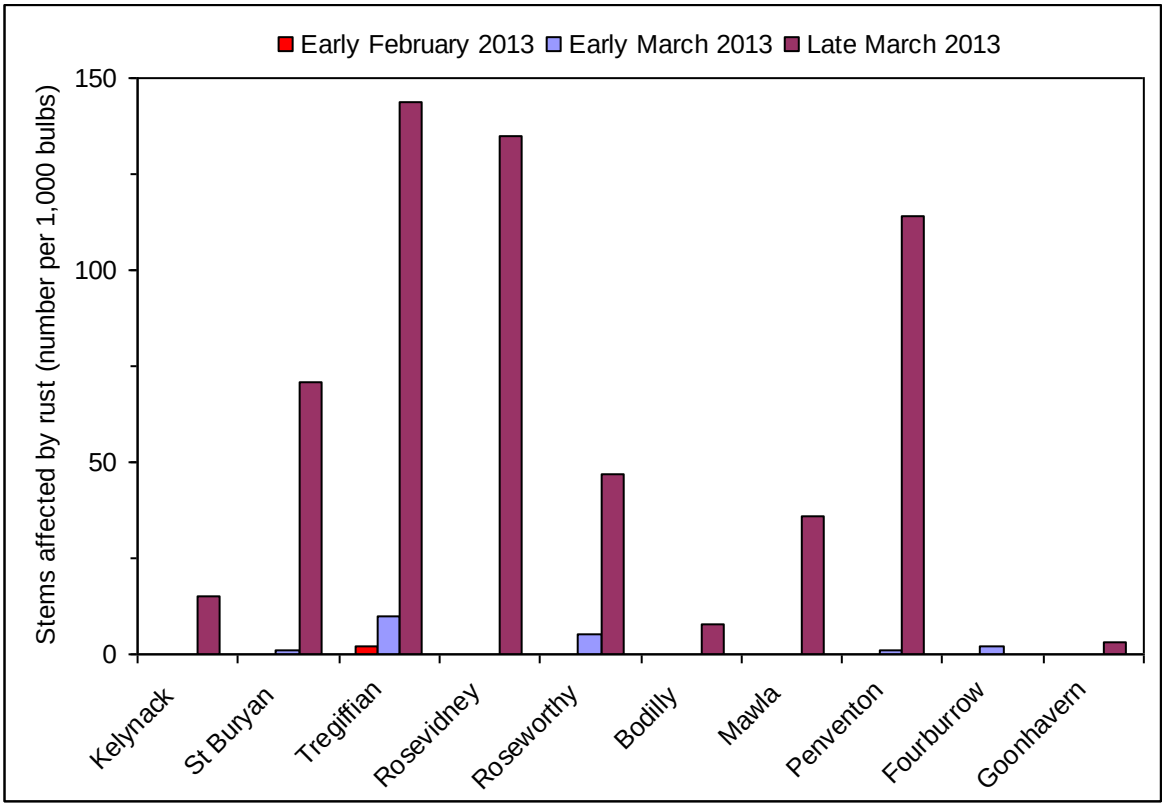
At the second assessment (early-March, close to flower-picking at most sites) only infrequent, small and isolated daffodil rust lesions were found, and at only five sites (St Buryan, Tregiffian, Roseworthy, Penventon and Fourburrow). At Tregiffian ten stems bore either a single lesion or several spots. In addition, many stems bore the fainter marks seen earlier at Penventon, with lengthways pitting or blistering, pale or yellowing spots or longitudinal tracks. No characteristic daffodil rust lesions were found on the foliage, though the leaves at several sites had occasional brown, rusty streaks, the occurrence of which did not always correspond with that of the stem lesions.

At the third assessment (late-March) larger numbers of daffodil rust lesions were seen and all were small and typical. Daffodil rust severity varied from one or two small spots or occasionally streaks per stem at Goonhavern, to individual small spots and groups of up to about 15 small spots at Tregiffian. Similarly rust incidence varied from <10 affected stems/plot at Goonhavern to more than 50% affected at Tregiffian. The presumed early lesions were seen at all sites. Rust-like spots or streaks- were also found on leaves at all sites, usually with low severity and low incidence. At Kelynack, St Buryan and Tregiffian the

severity of leaf lesions was greater, with more extensive marking and greater incidence (more than 50% of leaves affected).

The progress of daffodil rust development on stems over the three assessment dates is shown in the figure below. Tregiffian had both the earliest appearance of daffodil rust and its highest final incidence, and incidence was also high at St Buryan, Rosevidney and Penventon. Levels were lower at Roseworthy and Mawla, while the plots at Kelynack, Bodilly, Fourburrow and Goonhavern remained virtually free of the disorder.

Different severity of rust symptoms. Top: increasing rust severity with blistering (left), a few rust lesions (middle) and larger, coalescing lesions (right). Bottom: close-up of blistering (left) and rust lesions with cracking (right).



Incidence of daffodil rust at ten sites assessed on three dates in winter-spring 2013.

Associations between daffodil rust and soil-water and other factors

The levels of daffodil rust seen in this first crop-year were low in both incidence and severity, and would not have constituted a 'rust problem' in a commercial sense. Nevertheless, daffodil rust levels at the ten sites varied considerably, allowing them to be assessed in respect of the various differences between sites. The flowering stage was over at all sites by the end of March 2013 and, by implication for a picked crop, the maximum expression of daffodil rust on stems would have been reached by that time. SWC and weather data had been logged from 1 November 2012, providing five months' logged soil and weather data to explore for associations with daffodil rust levels. The plots showed that the values for soil and air temperatures, RH and precipitation were rather uniform across the ten sites, making it unlikely that these factors could be associated with the varying levels of daffodil rust across sites. However, there were substantial differences between sites in SWC measured at individual depths in the soil (0-100, 100-200 and 200-300 mm) or averaged or totalled across all depths (0-300 mm). Comparisons of these data with rust levels showed that three of the four sites with the highest incidence of daffodil rust were associated with the highest SWC – St Buryan, Tregiffian and Rosevidney (the exception being Penventon). The effect was most clearly seen by plotting SWC averaged over the three depths, perhaps because this draws

on a larger number of individual data-points. If this association can be confirmed, the rust-promoting effect of high SWC could be a short-term effect (say, high SWC affecting stem growth at the time of rapid shoot growth immediately preceding flowering) or a longer-term one (perhaps an accumulating effect of high SWC over the previous months, or at some earlier key-stage of development). To investigate these possibilities, SWC was examined across shorter periods (months and weeks). The results showed that the key-period of the putative SWC effect was November to December, where the effect was significant, rather than January to March.

Potential associations between the levels of daffodil rust and other factors were sought through regression analysis. Examining geographical data- failed to show any associations with rust levels. Soil structural factors – a Visual Soil Structure Quality Assessment -, ADAS soil texture assessment, soil depth and the proportions of clay, silt, sand and stone particles - likewise failed to show any association with the levels of daffodil rust.

Some husbandry factors were also assessed. As a result of continuing wet weather in autumn 2012 when the plots were planted, planting was delayed at three sites, which might have affected plant growth. However, there was no association between planting date and rust levels. Before bulb planting, fertilisers were applied at most sites, generally P and K, but also N at Roseworthy and organic fertiliser at Penventon. At seven sites brassicas (which leave high N residues) were the previous crop. There was no evidence that high or low levels of daffodil rust were associated with the type of fertiliser applied or with the previous cropping of brassicas. Correlation analysis confirmed there was no evidence for associations between levels of daffodil rust and the concentrations of soil N, P, K or Mg or soil pH in pre-planting, autumn and spring analyses. The same was true for micro-nutrient concentrations (analysed in spring 2013 only), except for a weak effect of aluminium concentration whereby higher rust levels occurred at lower aluminium concentrations. To investigate the possibility that daffodil rust levels might be associated with the rate of plant development and growth in the run-up to flowering, rust levels were examined in relation to shoot/leaf and stem length in early-February and their increase in length during February. The only significant association, was between rust levels and shoot/leaf growth, with higher rust levels where growth was greater.

There is a trend in these data to support a positive association between high SWC in the months before flowering with relatively higher levels of daffodil rust at flowering. However, this held at only three of the four high-rust sites, so there may be an interaction with another factor or factors. The non-conforming site, Penventon (low SWC but high rust level), is notable as being on a steep and freely-draining south-facing slope. These results cover the first year of the project only, with low levels of daffodil rust, and so should be treated with caution. The work is continuing, and the indications from the second year of the crop are that

higher rust levels are developing across most sites. These rust levels will be examined with the benefit of a longer run of weather data and further soil and plant nutrient analysis.

Financial Benefits

On the basis of information provided by growers, daffodil rust results in a 3% average annual loss of revenue from cut-flowers (spread across all years), or losses of 10% in one year in three (with negligible losses in the intervening years). A 3% annual loss is estimated to amount to about £0.7 m annually to UK growers, or around £2.3 m every three years. These are direct monetary losses resulting from daffodil rust, from reduced flower yields and (or) downgraded product, and in reality there would be additional cost savings associated with eliminating unpredictable yields and poor quality due to rust. These losses could be largely eliminated if the project succeeds in understanding the causes of daffodil rust and leads to the provision of solutions, avoidance or risk management. Perhaps more importantly, solving the rust problem would remove the likelihood of a gross loss of markets through lowered customer perception of the product.

Action Points

Forward planning should take account of avoiding planting rust-prone varieties in poorly draining sites.

At this early stage in the project no other action points can be suggested.