Grower Summary

BOF 076

Understanding physiological disorders in narcissus

Final 2015

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

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Project Number:	BOF 076
Project Title:	Understanding physiological disorders in narcissus
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Report:	Final report 2015
Publication Date:	10 July 2015
Previous report/(s):	Annual report 2013
Start Date:	01 June 2012
End Date:	28 February 2015
Project Cost:	£72,459

GROWER SUMMARY

Headline

Increased levels of ‘rust’, an unpredictable physiological disorder of daffodils that degrades cut-flower quality and makes some produce unmarketable, was associated with high soil water content in the months before flowering.

Background

The physiological disorder known as daffodil ‘rust’ degrades stem quality and can make affected cut-flowers unmarketable. With commercial daffodil growing in the UK more dependent on the sales of cut-flowers than of bulbs, it is vital to avoid anything that might harm customers’ perception of product quality or damage the reputation of this important UK cut-flower crop.

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 and could form coalescing areas of damage that disfigured stems sufficiently to cause downgrading. In the worst cases stems showed transverse cracking and became brittle and unmarketable.

Despite rust’s convincingly disease-like lesions, initial testing apparently failed to reveal a pathogen associated with them and the condition was classed as a physiological disorder or abiotic disease. It soon came to be referred to as ‘physiological rust’ or, more recently, ‘stem rust’. For simplicity, this report refers to daffodil rust’ or simply ‘rust’.

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).

To gauge the extent and economic cost of rust, AHDB Horticulture organised surveys of daffodil growers in 2002 and 2003 and again in 2011 to 2013. The survey findings were summarised as part of this project, and confirmed that rust has continued to cause commercially significant losses that justify research into its cause and management. The surveys also revealed the ideas circulating in the industry about the cause of rust: suspected predisposing conditions often involved rapid changes in temperature, alternating cold and warm periods and adverse weather. The responses told us that growers had submitted affected plant samples for diagnostic examination, as well as soil and plant samples from affected and ‘healthy’ crops for the analysis of nutrients. No pathogenic or nutritional cause was found, though neither should be ruled out entirely because sampling has been opportunistic and non-replicated - more structured sampling could have provided more robust conclusions.

‘Chocolate spot’ is another physiological disorder of daffodils and has parallels with rust, though it has not been known to result in any serious damage. As with rust, pathological and nutritional causes were ruled out, and an association with increasing ambient temperatures has been 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 temperature.

In the light of this evidence daffodil rust could be a physiological disorder brought about by adverse environmental conditions. The objective of AHDB Horticulture project BOF 76 was to test the proposition that the soil-water environment (soil structure, water availability, soil temperature, nutritional status, and so on) affects the development of rust. One practical way of assessing such effects is 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 commercial daffodil fields at varied locations through west Cornwall, the region where (at the time) it seemed crops were most prone to the disorder. This scheme should maximise the likelihood that rust, despite its unpredictability, would occur naturally in at least some of the test locations.

Since the project would supply a structured set of samples of rust- and non-rust-affected plants, the opportunity was used to examine further the pathological and nutritional theories of rust. Samples of plants were taken for plant clinic examination for fungal and bacterial pathogens, for sequencing viral RNA, and for the analysis of macro- and micro-nutrients, and soil samples from all sites were also taken for the determination of nutrient concentrations.

This report and summary cover both the surveys of growers and the results of field and analytical work over the first two years of the test crops, 2012 to 2014. Although this is the final report on project BOF 76, the project has been granted a year’s extension (BOF 76a) so that observations can be extended to cover the whole period of typical three-year-down daffodil growing as practised in the UK.

Summary

Surveys of daffodil growers

In 2002, 68% of respondents reported having seen rust on their crops during the previous five years, and this figure rose to 86% by 2011, cited as the ‘worst rust year so far’. In 2002 36% of respondents had seen some product downgraded, while 25% could not supply their preferred customer or had product that was unmarketable; in 2011 the corresponding figures had increased to 71 and 57%. For both survey periods the loss of turnover due to 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 rust, with the important cultivars 'Golden Ducat' and 'Mando' cited a disproportionate number of times in reports. 'Carlton', 'Kerensa' and 'Tamara' were other significant cultivars apparently prone to being affected. Crops were reported to have shown rust symptoms in their first-, second- and subsequent crop-years.

Field and related work

In autumn 2012, 50kg-plots (comprising about 1,000 bulbs) of the rust-prone daffodil 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. From west to east the locations were 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, soil temperature, air temperature, RH and precipitation. This would enable the subsequent levels of rust to be studied in relation to soil-water and other features of the sites, in order to identify associations between these factors and the incidence and severity of rust.

Each year the main assessments of crop and rust development were made about two weeks before the flower-picking stage (early- to mid-February), around the flower-picking stage (late-February to early-March), and about two weeks after the flower-picking stage (though flowers were not picked in order that their development could be followed) (late-March to early-April).

In spring 2013 no characteristic rust lesions were seen on stems at the pre-picking stage, with the exception of Tregiffian where two small rust lesions were seen on each of two stems. At the flower-picking stage only infrequent, small, isolated rust lesions were found, and at only five sites, though at Tregiffian ten stems bore single lesions or several lesions. At the post-picking assessment larger numbers of small rust lesions were seen, differing in severity between 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), and rust incidence varied from <10 affected stems/plot (Goonhavern) to more than 50% of stems (Tregiffian). By the post-picking stage rust severity scores reached 0 to 2 (out of 5), incidence scores 0 to 4 (out of 5) and the number of stems per plot with rust 0 to 144 (out of ca 1,000 stems).

In spring 2014, rust lesions had increased in severity and incidence. At the pre-picking stage very low levels of rust (up to six stems affected per plot) were seen at four sites

(Kelynack, St Buryan, Tregiffian and Bodilly) and none at the remaining sites. There had been a marked increase in rust by the flower-picking stage, with some rust found on all sites and incidence varying from two to 68 stems per plot, the most affected sites being Tregiffian and Fourburrow. At the post-picking stage all sites had substantial rust, with most or all stems affected at seven sites (all stems at Tregiffian and Bodilly). Tregiffian exhibited the most severe rust symptoms, with some stem-cracking observed. By the post-picking stage rust severity scores reached 2 to 3, incidence scores 4 to 5, and the number of stems per plot with rust 168 to 1,000.

At the start of the project it was expected that affected crops or sites would either be free of rust, or would exhibit rust at the severity and incidence typical of affected commercial crops. None of the project assessments found a commercially-significant level of rust, with the possible exception of the minor stem-cracking observed after picking at Tregiffian in 2014. On examination it soon became evident that rust often occurs at much lower, trace levels that would probably go unnoticed in a commercial situation, and that much development of rust would have occurred only after cropping, again probably going unnoticed. This may change our understanding of rust, from a disorder thought to flare-up around flowering time as a result of some recent stimulus, to one that may exist at an insidious level much of the time - at lease in susceptible cultivars - as a result of some on-going condition.

Inconspicuous lengthways pitting or blistering of stems or pale or yellowing spots were observed at all sites. Observations suggested these were an early stage in the development of rust lesions.

Rust-like spots or streaks were also found on leaves at all sites and were most obvious later in the growing season.

Relationships between levels of rust, soil water content and other factors

Rust was mostly seen in the test plots at lower levels of severity and incidence, and later in the season, than would be of concern in commercial production. In both years of the study, however, rust levels varied substantially enough between the ten sites to justify their examination for relationships or correlations with SWC and other site-, soil-, weather- and husbandry-related factors. The examination of SWC and weather factors was facilitated by the data logged in the months leading up to flowering each year. Information on other factors – elevation, soil type, soil and plant levels of major nutrients and trace elements, previous cropping and so on – were obtained by examination, sampling and analysis or from the growers. This work concentrated on the expression of rust as the number of stems per plot with rust post-picking, since this showed more variability than severity and incidence scores and better reflected the increasing development of rust lesions through the flowering season. After preliminary data assessment, the possible relationships of rust incidence with these factors were examined (where appropriate) through regression analysis. The most striking result was a relationship between rust levels and SWC.

SWC revealed substantial differences between sites whether measured at individual depths in the soil (0-10, 10-20 and 20-30cm) or averaged across depths. In the first crop-year, analysis of SWC and rust levels showed that three of the four sites with the highest incidence of rust were associated with the highest SWC – Tregiffian, St Buryan and Rosevidney, the exception being Penventon (which is steeply sloping). In making these assessments the measure of SWC used was an accumulation of SWC over the five months before flower picking (since the start of data logging). To identify any critical period of high SWC, the data were examined over shorter periods of months or weeks. This showed that a high SWC in November and December was most closely related to high levels of rust at flowering, while high SWC in January, February and March were less so.

Analysis of SWC for the second crop-year was facilitated by the longer run of logged data available. Rust levels at the picking and post-picking stage in 2014 were examined in relation to the cumulated SWC data from April 2013 to March 2014. There was a strong tendency for high rust levels to fall at the wetter end of the SWC scale and for low levels to fall at the drier end, though all sites did not conform exactly using rust scores and counts. This effect was seen at all three sensor depths but was clearest in the 30cm readings, perhaps because these would have reflected water-logging above the deeper impervious layer. In order to see the effects of SWC over other periods, rust levels were plotted against SWC in the periods March 2014 to April 2014, February 2014 to April 2014, January 2014 to April 2014… and so on back to the period November 2012 to April 2014. For all these periods the results were consistent – except for a slightly weaker effect for the one-month period March 2014 to April 2014 - and mirrored those described above, a strong tendency for higher rust scores at the wetter sites and lower rust scores at the drier end. This consistency suggests the effect of SWC on rust levels relates to an ongoing process – perhaps climate-related – rather than to a particular short-term effect.

The main results for factors other than SWC are described below.

Soil and air temperatures and RH were uniform across the ten sites in both crop-years.

Geographical data – longitude, latitude, altitude and distance from the sea in the prevailing wind direction (which would affect the amount of salt-laden air) – failed to show any associations with rust levels in either year.

Soil structural factors – Visual Soil Structure Quality Assessment, ADAS soil texture assessment, soil depth and the proportions of clay, silt, sand and stone particles - also failed to show any association with the levels of rust in either year.

There was evidence for increasing rust incidence with increasing top-soil organic matter, with R^2 = 0.6841 (tested only in 2014). This finding should be treated with caution until it can be confirmed.

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 rust in either year were associated with the type of fertiliser applied or previous cropping.

Because 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 in either year.

There was no evidence for associations between levels of rust in either year and the concentrations of soil N, P, K or Mg or soil pH measured in the same crop-year.

With four exceptions, there was no evidence for associations between levels of rust in either year and trace element concentrations in the soil measured in the same crop-year. The exceptions were that in 2014 increasing concentrations of calcium and of sulphate appeared to be associated with increased rust incidence, while increasing concentrations of manganese appeared to diminish rust incidence; however, these findings should be treated with caution until confirmed.

There was no evidence for associations between levels of rust and the current concentrations of major nutrients or trace elements in the leaves (tested only in 2014).

Fungal and bacterial disease diagnostics

No evidence of bacterial infection was seen in any of the samples during microscopic observation. In some samples the presence of Ramularia sporophores and conidia was very obvious, but no other fungi were noted. Microscopic observation of cleared and stained tissues did not provide any insights in the cause of the rust symptoms. A Stemphylium species was the most consistently isolated fungus, being isolated from samples of eight out of the ten sites. The two samples where Stemphylium was not isolated had either predominantly or exclusively 'streak' symptoms rather than typical rust spots. Stemphylium was also obvious during humid box incubation in five out of the ten samples. Ramularia and Botrytis spp. were also isolated from some samples.

Financial Benefits

On the basis of information provided by growers, rust can result 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 £0.7m annually to UK growers, or around £2.3m every three years. These are direct monetary losses resulting from reduced flower yields and downgraded or unmarketable product. Such losses might be largely eliminated if this project and its extension lead to the provision of solutions for the rust problem and the development of strategies for rust avoidance or risk management.

More importantly, solving the rust problem would remove the likelihood of a gross loss of markets through lowered customer perception of the product - especially at a time when many issues are impinging on the profitability of daffodil growing.

Action Points

A third year of results is desirable to confirm the link between sites with high SWC and high rust levels. Nevertheless, forward cropping plans might begin to take account of possible avoidance strategies, primarily not planting rust-prone daffodil cultivars in poorly drained sites.