Grower Summary

BOF 077

Narcissus: Investigation into the effects of arrange of potential biocides in hot water treatment

Annual 2017

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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.

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

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Further information

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Project Title	Narcissus: Investigation into the effects of arrange of potential biocides in hot water treatment
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GROWER SUMMARY

Headline

Both chlorine dioxide and hydrogen peroxide can be used to control the spread of Fusarium in hot water treatment of Narcissus bulbs, however, their efficacy is severely compromised by tank bioload and neither can be recommended at this time. Therefore, it is recommended to reduce tank bioload to improve the efficacy of chemical biocides (and fungicides). The installation of separation and/or /filtration systems is likely to be straight forward.

Background

Hot water treatment (HWT) of narcissus bulbs is used to control pests and diseases, notably stem nematodes, bulb scale mites and Fusarium basal rot. This has been the standard approach for at least 70 years. For most of that time, formalin was added to HWT tanks as a general biocide i.e. to reduce inoculum in the tank water, however approval for formalin was withdrawn in 2008. Work in BOF 061a (Lole, 2010) identified FAM 30 as a viable alternative and this has since become standard practice in the UK. However, FAM 30 is expensive in comparison to formalin and the result has been that growers do not always use it at the required rate and this issue is exacerbated since FAM 30 rapidly depletes in tanks under a high bioload.

Other biocide alternatives have been considered, notably chlorine dioxide which was demonstrated to be effective against spread of Fusarium (Chastagner and Riley, 2002) and is believed to be currently used by American Narcissus growers. However, in AHDB Horticulture project BOF 061a (Lole, 2010), chlorine dioxide was assessed alongside a number of alternative biocides, but was not considered further as FAM 30 was found to be more effective. The use of chlorine dioxide was further reviewed in BOF 070 (Hanks, 2010) which suggested that additional investigations were required before it could be recommended to growers.

Other biocides previously examined include peroxyacetic acid (Hanks and Linfield, 1999), hydrogen peroxide and UV (Stewart-Wade, 2011) but tank bioload was again found to reduce their efficacy so further commercial scale evaluation is required before they can be recommended. Non-chemical biocidal approaches, e.g. UV and thermal treatment, have been used in other water-based treatment systems and appear to offer a viable alternative to chemical approaches but their efficacy is known to very dependent of water clarity, which is a problem with high bioload HWT (Petit, 2016). The issue of high HWT tank bioload was reported in BOF 070 (Hanks, 2010) and generating a solution to this issue is probably key in improving the efficacy of all biocides and biocidal approaches (and probably fungicides as well).

Project aim

The aim of this project is to examine a range of candidate biocides (chlorine dioxide, hydrogen peroxide and didecyl dimethyl ammonium chloride) and physical approaches (thermal and UV treatment) for their efficacy and ease of use against stem nematode and Fusarium basal rot.

The project has been divided into eight objectives:

1. Review of the literature
2. *In vitro* laboratory tests
3. Assess the feasibility and cost of retrofitting biocide delivery systems to existing HWT tanks
4. Assess impact of different treatments on infrastructure
5. Small-scale tank tests
6. Commercial scale testing
7. Field trials
8. Health and safety considerations

Summary

The study of biocides in HWT is a very specialised area of research and the majority of evidence is to be found in AHDB commissioned research, namely BOF 61a (Hole, 2010) and BOF 70 (Hanks, 2010) and BOF 70a (Hanks, 2012) and the HDC Narcissus Manual (Hanks, 2013). No new scientific articles on this topic have been published since Chastagner and Riley in 2002. Therefore there is no new direct evidence which this project can build on. However, the literature on biocides is slightly more forthcoming as they are used as disinfectants in a number of industries. Perhaps the most useful of these is the treatment of irrigation water, particularly in recirculating systems, where the control of pathogens is critical. Stewart-Wade (2011) reviewed a number of biocides and technological innovations and discussed the advantages and disadvantages of a number of approaches and her work is used to inform this project. At this early stage in this project, given that all the chemical biocides under investigation have some issues relating to either their use or efficacy, the focus will be to consider combinations of treatments, e.g. filtration with UV and/or a chemical biocide, rather than repeating earlier work.

In vitro laboratory testing of candidate biocides

In clean water and under laboratory conditions, all the biocides and biocidal approaches provided greater control of Fusarium in comparison to a clean water control. Of the chemical treatments, almost complete control was provided by chlorine dioxide at 5ppm or greater, by hydrogen peroxide at 1.5% or greater and by DDAC/Boot at 0.5% or greater. However, in dirty water the efficacy of these biocides was reduced dramatically which illustrates the detrimental impact of tank bioload. These results might go some way in explaining why chlorine dioxide, in particular, has not been adopted more widely despite promising results in the past. Its efficacy under laboratory conditions is not in doubt but its efficacy on-farm has been found to be variable especially under high bioload conditions.

These results suggest that some form of filtration or separation must be examined alongside the chemical biocides (and UV and thermal treatments) as evaluation of any biocide (or indeed fungicide) under on-farm commercial conditions cannot be consistent when the amount and influence of bioload cannot be assessed. Since the efficacy of all these biocides (and fungicides) is likely to be improved by reduced bioload/higher clarity water, it is the obvious starting point. Filtration and/or separation will be examined during the second year of the project, under both laboratory and commercial conditions.

Thermal treatment is a very effective biocidal approach with complete control achieved at temperatures above 60°C, however, there are two main practical difficulties involved in its use on-farm. Firstly, many HWT systems have neither the heating nor storage capacity to allow it to work and secondly, since the water temperature cannot be raised with bulbs in-situ, control can only exercised between batches of bulbs, rather than within batch meaning that Fusarium spores can freely circulate within one batch.

Continuous thermal treatment is feasible using similar technology to a flash pasteuriser/separate water heater but this, and UV, cannot guarantee to treat all of the water, unlike a chemical approach, and therefore some spores may remain viable. Continuous thermal treatment may also make maintaining a constant water temperature in the treatment tank more difficult since relatively warm water might be re-entering the tank.

UV treatment was not assessed under in vitro conditions because controlling the intensity and duration of UV exposure was felt to be impractical, however, this will be undertaken during tank scale testing in early January 2017 to provide a comparison. However, as noted earlier, both thermal and UV approaches suffer from only treating partial volumes of tank water at any one time, unlike chemical approaches which treat the whole volume. So, even if UV is shown to be an effective treatment, some doubts must remain whether it could be successfully used at a commercial scale.

In terms of identifying next generation biocides, this work provides mixed results. All the biocides and biocidal approaches show promise but no individual one was outstanding. Filtration or separation to reduce the bioload and improve water clarity appears to be the obvious first step that will benefit the chemical biocides and UV treatment while the practicality and effectiveness of thermal treatments requires further investigation.

Assessment of the feasibility and cost of retrofitting biocide delivery systems

The assessment provides a number of clear outcomes. Firstly, while tank insulation is cheap and feasible for all systems, the potential savings are minor when compared to the overall operational costs. This said, tank insulation can reduce heat-up times and has the potential to reduce the total daily operation time.

Secondly, alternative biocides and biocidal approaches, namely the chemical biocides and UV radiation, demand good and very good, respectively, water clarity to be effective and reducing the tank biological load (bioload) is, we believe, key to the effective use of these approaches. Reducing tank bioload to improve water clarity is likely to be a key step in the use of biocides and probably fungicides. Since it is also a one off cost, it is also likely to be value-for-money. It is therefore recommended that a method of turbidity reduction be employed, through filtration or, preferable, vortex separation. Vortex separation is suitable given the low cost and accessibility of maintenance, although additional pumping may be required to maintain hydraulic pressure throughout the system.

Three case studies were undertaken to assess the viability of retro-fitting dosing and filtration equipment to existing tank systems. All three systems were different and employed different levels of sophistication, but in all three cases, retro-fitting of new equipment was assessed to be straightforward with little, or no, loss in system performance. The only instance where performance might be reduced was using a vortex separator in HWT systems where pump performance /flow rate was only just adequate in the absence of the separator. The capital costs for retro-fitting alternative disinfection methods and improvements to the operational efficiency (e.g. insulation or separation) are relatively small, one-off costs in the order of £10,000 to £20,000 per technology (inclusive of installation) depending on the size and complexity of the chosen devices.

Overall conclusion

The results from the biocide investigation confirm that all the approaches have value to commercial growers in terms of control of Fusarium and stem nematodes in tank water, and ease of operation.

In terms of chemical control, chlorine dioxide, hydrogen peroxide and Boot are all effective biocides in clean water, however, all three have issues as their efficacy is greatly reduced in dirty water. Although Boot is an effective biocide, concerns have been raised in the past about its phytotoxicity effect and it will not be examined any further. Of the remaining two, chlorine dioxide is possibly the better option in the long term since more is known about its use and efficacy in HWT systems, however, both it and hydrogen peroxide will undergo further testing before a final evaluation is undertaken. The key result from this stage of the project is the negative influence of tank bioload on the efficacy of all three chemical biocides. This is undoubtedly a major obstacle in the use of chemical biocides (and probably other biocidal and fungicide approaches) so we suggest that examining the introduction of some form of filtration/separation will be required as a starting position for the next stage of investigations.

Thermal treatment is undeniably effective and its efficacy probably unaffected by tank bioload. The difficulty arises in its implementation since increasing the temperature of tank water either continuously or in batches introduces new problems. Continuous thermal treatment may only provide selective treatment allowing some Fusarium spores to remain untreated while batch treatment will only prevent batch to batch infection and not reinfection within an existing batch.

Both UV and microwave treatment have promise and both will be examined in more detail next year. The efficacy of UV treatment is known to be affected by water clarity which adds weight to filtration/separation being the starting position for many, if not all, of these treatments.

The practicality of retro fitting biocidal technology was also examined. Most of the approaches do not create any special difficulties as automated dosing systems are available for chlorine dioxide and hydrogen peroxide, and the installation of filtration and UV lamps requires only minor pipework modifications.

Financial Benefits

At this stage, it is not possible to make any assessment of the financial benefits arising from this project.

Action Points

No actions should be taken at this time beyond exploring the possibility of fitting filtration or separation units to hot water tank systems.