Integrated Management of Soil-borne Diseases in Flower Bulb Production

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Abstract

Soilborne diseases (e.g. *Rhizoctonia*, *Pythium*, *Botrytis* spp., *Pratylenchus penetrans*) threaten flower bulb production in the Netherlands. Since measures against these diseases do not result in sufficient control or result in a high input of pesticides Applied Plant Research investigates the development of integrated management strategies to control these diseases. Integrated management combines preventive and control measures. Different aspects and results of several preventive and control measures are discussed. The contributions of soil suppressiveness, biofumigation crops, precrops, biological control, pesticides of natural origin in integrated disease management are considered.

INTRODUCTION

Flower bulb production in open fields in the Netherlands is threatened by several soil borne diseases. The main problems are caused by the fungi *Fusarium*, *Rhizoctonia*, *Pythium*, *Botrytis* spp. and plant parasitic nematodes like *Pratylenchus penetrans*, *Ditylenchus dipsaci* and *Tobacco rattle virus* (TRV), which is transmitted by trichodorid nematodes. Measures against these diseases do not always result in sufficient control, result in a high input of pesticides or are not available at all.

At Applied Plant Research Flowerbulbs, integrated control strategies that are less dependent on pesticides are being developed. This paper is an overview of the results of different prevention and control measures tested against several soil borne diseases of flowerbulbs. The possibilities of integrating these measures into a management system to control soil borne diseases of flower bulbs are currently being investigated.

Integrated disease management can be divided into a prevention part and a control part. First the prevention part is discussed and then the control part.

Prevention includes:

- Clean or healthy soil: detection of plant pathogens, good soil structure, soil life/soil suppressiveness, soil fertility
- Healthy plant material: sort out diseased plant material
- Production of the crop: use less sensitive cultivars, broad crop rotation, remove crop residues and remaining bulbs from the soil

Control includes:

- Healthy plant material: hot water treatment against nematodes, insects and fungi, cleaning the plant material by using fungicides or easy degradable antiseptics
- Soil: when soil is infected with pathogens there are several methods that can be applied or are being developed to control these pathogens; use of biofumigation crops, rotation with specific precrops, biological soil disinfestation or flooding
- Pesticides: chemical pesticides, biological pesticides, pesticides of natural origin. These pesticides should be applied in combination with each other and supported by a Decision Support System. Furthermore spraying methods with less emission should be used to apply the pesticides

RESULTS AND DISCUSSION

In this section several examples of the above mentioned preventive and control measures against different diseases of flower bulbs will be presented and discussed. Finally the integration of the different measures will be discussed for one disease, *Botrytis* leaf blight.

Prevention; Soil Suppressiveness

Control of lily root rot due to infestation of *Pratylenchus penetrans* (Pp) is becoming more difficult due to the reduced availability of chemical control methods. The use of wet soil disinfestations with metam-sodium is heavily regulated and only allowed once every 5 years and the compound dichloor-propeen is prohibited. Other chemical alternatives like aldicarb and ethoprofos are only regionally allowed. Advice to control Pp root rot is currently based on soil sampling for Pp and knowledge of the disease history of the fields.

It is known that damage caused by these lesion nematodes is more likely to occur on sandy soils present in the western part of the Netherlands (dune sands), than on soils with a higher level of organic matter in the south and east of the Netherlands (glacial sands) (Conijn et al., 2003). For example, when 100 Pp nematodes/ml are applied to western sandy soil this causes severe root damage, whereas the same amount causes much less root damage in the glacial sands. Research revealed that a biological factor is involved in the natural suppressiveness of the glacial sands. Currently we are investigating which biological factors are responsible for the disease suppressiveness of the glacial soil.

The use of cultivation methods that suppress the biological factor of the soil can lead to less suppressiveness of the soil. To sustain the natural suppressiveness of the soil the measures used to control Pp and other diseases of lily should not interfere with the biological factors involved in the suppressiveness. This demands an integrated approach. Good results have been reported with the use of *Tagetes patula* ‘Singe Gold’. This intercrop makes it possible to control *Pratylenchus* quite deeply in the soil. Another biological control method is flooding of the soil. Minimal duration should be eight weeks. A relatively high water temperature is recommended to achieve good control.

Soil suppressiveness against *Rhizoctonia* and *Pythium* has also been investigated.

Control; Use of Biofumigation Crops

Biofumigation is an alternative method recently put forward. It involves the suppression of soil borne pathogens by vegetative biocidal compounds, released by Brassicaceous green manure crops, when glucosinolates are hydrolysed via myrosinase after cell disruption. Biofumigation could be an attractive method for disease control in flower bulb culture, since the growth of biofumigation crops also facilitates nutrient fixation, prevention of wind erosion and weed control during fallow in between bulb crops, and a green manure effect after incorporation. The effect of *Brassica juncea* var. “ISCI20” and *Cleome hasslerana* sel. ISCI2 (pellets of freeze dried plant material), which were selected, characterized and prepared by ISCI (Bologna), was investigated against several soil borne pathogens and nematodes in separate field experiments.

In a field experiment with *Rhizoctonia solani* AG2-2IIIB in lily, a treatment with *Brassica juncea* ISCI20 was compared to untreated (fallow) and other green manure crops, like *Tagetes patula* and *Trifolium* spp. In uninoculated field plots, incorporation of all crops resulted in yield increase compared to the fallow treatment, probably due to fertilization effects. In inoculated field plots, incorporation of *B. juncea* reduced stem and bulb infection by *R. solani* in lily, resulting in a significant increase of bulb yield compared to the other green manure crops. In tulip, incorporation of *B. juncea* also decreased infection by *R. solani* AG2-t and increased bulb yield (Fig. 1).

Various nematode species are important pests in ornamental bulb crops. Nematodes can cause direct damage or can be harmful by transmitting viruses. *Tobacco rattle virus* (TRV) may infect several bulb crops, but is a major problem in *Gladiolus*. TRV is transmitted by trichodorid nematodes. Another problem is caused by the stem nematode *Ditylenchus dipsaci* that can affect most bulb crops. *D. dipsaci* is a quarantine organism in the Netherlands which has serious consequences for growers dealing with infested lots and fields. In a pot experiment the host plant suitability of *B. juncea* ISCI20 for two populations of viruliferous *Trichodorus similis* was determined in comparison to *Petunia*, fodder radish, Italian ryegrass and fallow. *B. juncea* appeared to be a good host for the nematode *T. similes*, but did not contain any tobacco rattle virus (TRV) in the root system. Pellets of dehydrated *C. hassleriana* ISCI2 were incorporated into the soil and compared to soil tillage only. The effect on *Paratrichodorus teres* numbers and primary TRV diseased plants of a following gladiolus crop was determined. No significant differences between any of the treatments were observed for both *P. teres* numbers and percentage primary TRV. In a semi-field experiment culture and incorporation of *B. juncea* ISCI20, flooding and biological soil disinfestation as measures to control the stem nematode *D. dipsaci* were compared to a fallow control treatment. *D. dipsaci* was not found in the aboveground parts of *B. juncea* ISC20. The crop does not seem to be a host plant for this stem nematode. Incorporation of the crop into the soil had no effect compared to the fallow control, whereas flooding and biological soil disinfestation gave a significant reduction of *D. dipsaci*. A natural infestation of *Paratrichodorus pachydermus* was increased by *B. juncea* ISCI20. Biofumigation with either *B. juncea* ISCI20 or dehydrated *C. hassleriana* ISCI2 seems without prospects for controlling trichodorid nematodes and transmission of TRV and culture and incorporation of *B. juncea* ISCI20 gave no control of *D. dipsaci*.

The use of biofumigation crops against *Pratylenchus penetrans*, *Pythium* and *Fusarium* is currently under study.

Control; Effect of Precrops on Infection Potential of the Soil of TRV Transmitted by Trichodorid Nematodes in *Gladiolus*

Tobacco Rattle virus (TRV) infects several ornamental bulb crops. TRV is transmitted by trichodorid nematodes.

Cultivation of fodder radish during the summer prior to a gladiolus or tulip crop reduces TRV infection when *Paratrichodorus teres* is the vector nematode. The effect of various crops on nematode numbers, infection potential and TRV infection of gladiolus was investigated in a field experiment with a natural infection of viruliferous *Trichodorus similis*.

After cultivation of the crops the infection potential of the soil (IPS) was determined by a most probable number method (MPN) and the number of *T. similis* was counted. The IPS was reduced by a cultivation of fodder radish compared to fallow (Fig. 2). The cultivation of white mustard, maize, Italian ryegrass or westerwolds ryegrass gave an increase of IPS, while dahlia, red cabbage and carrot had no effect. *T. similis* numbers were not reduced after growing fodder radish, red cabbage or carrot. The other crops gave an increase of the *T. similis* numbers. Compared to fallow only the cultivation of fodder radish resulted in a reduction of TRV infection in *gladiolus*. White mustard gave an increase of TRV infection, while dahlia, maize, Italian ryegrass, westerwolds ryegrass, red cabbage and carrot had no effect.

Control; Biological Control of Pythium Root Rot with *Pseudomonas fluorescens*

Root rot caused by fungi of the genus *Pythium* is an important disease in flower bulb cultivation in the Netherlands. Measures to control this disease such as fungicides do not always result in consistent disease control. One of the control methods that is studied at this moment is the effect of antagonistic *Pseudomonas fluorescens* bacteria.

Antagonistic *Pseudomonas* spp. strains producing the antibiotic 2,4-diacetylphloroglucinol (Phl) or producing biosurfactants showed *Pythium* root rot control of different bulb crops (*Iris*, *Crocus*, *Hyacinthus*) in pot experiments under controlled conditions. A biosurfactant-producing strain almost completely prevented *Pythium* root rot in *Hyacinthus* and *Crocus*. A mutant strain, lacking the biosurfactant-production, did not suppress root rot in *Hyacinthus* indicating that this biosurfactant compound is involved in disease control. In bioassays under field conditions both the biosurfactant-producing strain and a Phl-producing strain were able to control disease of different crops (*Hyacinthus*, *Iris* and *Crocus*). In several expanded field trials both strains were able to control of *Pythium* root rot but these results varied by field and year. But since good control can be achieved by the application of these *Pseudomonas* spp. strains under field conditions we are currently optimizing the method of application.

Antagonistic microorganisms like these *Pseudomonas* spp. strains, yeasts and antagonistic fungi are also tested against *Rhizoctonia*, *Botrytis* spp., *Fusarium oxysporum* and *Pratylenchus penetrans*.

Control; New Pesticides of Natural Origin

To reduce the input of synthetic fungicides in the control of leaf blight in lily caused by *Botrytis elliptica* the use of pesticides of natural origin as part of a control strategy is studied. Several compounds that were selected in a laboratory assay at Plant Research International were shown to be effective in reducing *Botrytis* infection on lily in climate chamber experiments. When different compounds were combined in one treatment, additive effects enhanced the control level up to 70% compared to the untreated plants. In a field experiment two pesticides of natural origin that were promising in the climate chamber were tested under more practical circumstances. One of the compounds clearly delayed infection in the field plots. The second compound did not result in control of the *Botrytis* infection. Effects on bulb production have not been measured yet. Improvement of formulation might be necessary to improve the persistency and effect of these compounds under practical conditions.

PNO’s are also investigated for their disease suppressive properties against *Fusarium oxysporum* f.sp. *tulipae*.

Integrated Management of *Botrytis* Leaf Blight

Botrytis elliptica and *Botrytis tulipae* are the causal agents of leaf blight (also called “fire”) in lily and tulip, respectively. These *Botrytis* spp. are responsible for losses in lily and tulip production up to 80% (dependent on cultivar). To control *Botrytis* a significant amount of fungicide (25-40 kg/hectare) is used during the growing season. Continuing use of fungicides is under discussion due to environmental concerns and development of fungicide resistance. Moreover, in biological production of lilies and tulips *Botrytis* leaf blight is one of the big problems. At Applied Plant Research a management system has been developed in which several measures are combined resulting in control of leaf blight with no or as little fungicide as possible. The basis for this management system is a *Botrytis* warning system. Through forecasting infection periods it reduces the number of fungicide applications and improves spray efficacy and therefore *Botrytis* control (van den Ende et al., 1999). With such a system, control methods other than fungicides can also be used to further reduce fungicide input. Different antagonistic micro-organisms (e.g. yeasts, *Pseudomonas* bacteria) and plant extracts, essential oils etc. (PNO’s) are being tested for their *Botrytis* controlling abilities and some have good potential. Furthermore early detection of *Botrytis* in the field may improve the warning system. In addition, other ways to reduce *Botrytis* infection like less dense planting, N-fertilisation (under investigation), and crop residue management will be integrated into the management system in order to achieve good *Botrytis* control with as little fungicide as possible.

GENERAL CONCLUSION

At Applied Plant Research, Flowerbulbs, Lisse, the Netherlands we are investigating the possibilities of integrating several preventive and control measures into a management system to control soil borne diseases. In order to achieve this it is investigated how detection, chemical control methods, alternative control methods, production methods, fertilisation, Decision Support Systems and improving soil condition can be combined into sustainable, integrated disease management.

The discussed methods are examples of the different measures we are investigating at the moment or have been investigated in the past. All these control methods are investigated under controlled as well as field conditions. They are tested in single and combined applications to investigate compatibility and synergism of these methods.

Literature Cited

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<u>Figures</u>

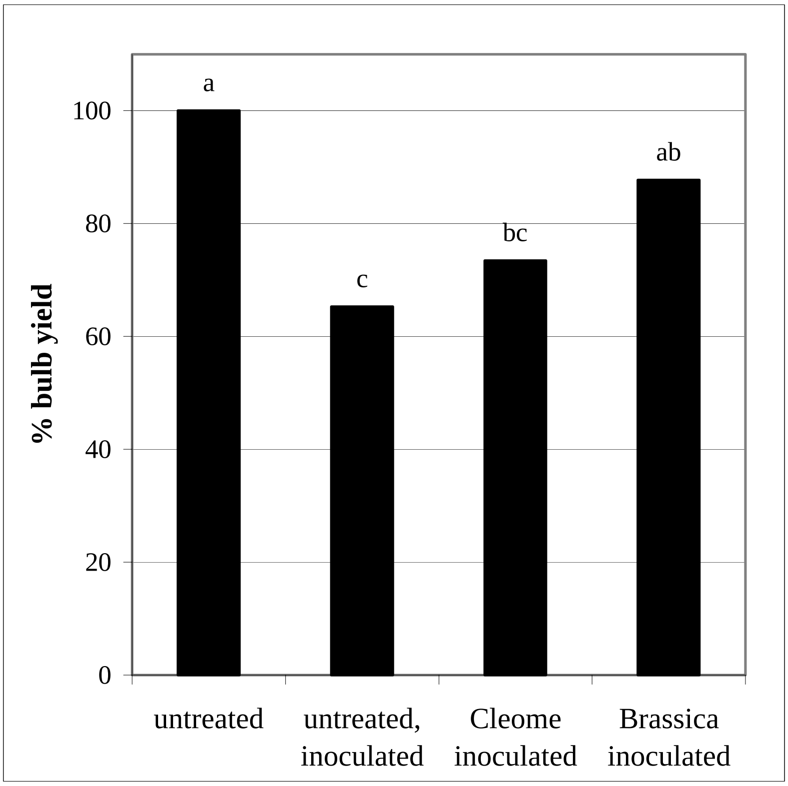

Fig. 1. Effect of soil treatments with *Brassica juncea* var. ISCI20 and pellets of dehydrated *Cleome hassleriana* sel. ISCI2 on relative bulb yield of tulip in soil inoculated with *Rhizoctonia solani* AG2-t compared to the untreated, non-inoculated control (bulb yield set at 100%) and the untreated, inoculated control (means of four replicates per treatment; bars labelled with corresponding letters do not differ significantly, $P<0.05$, Student's two-tailed *t*-test).

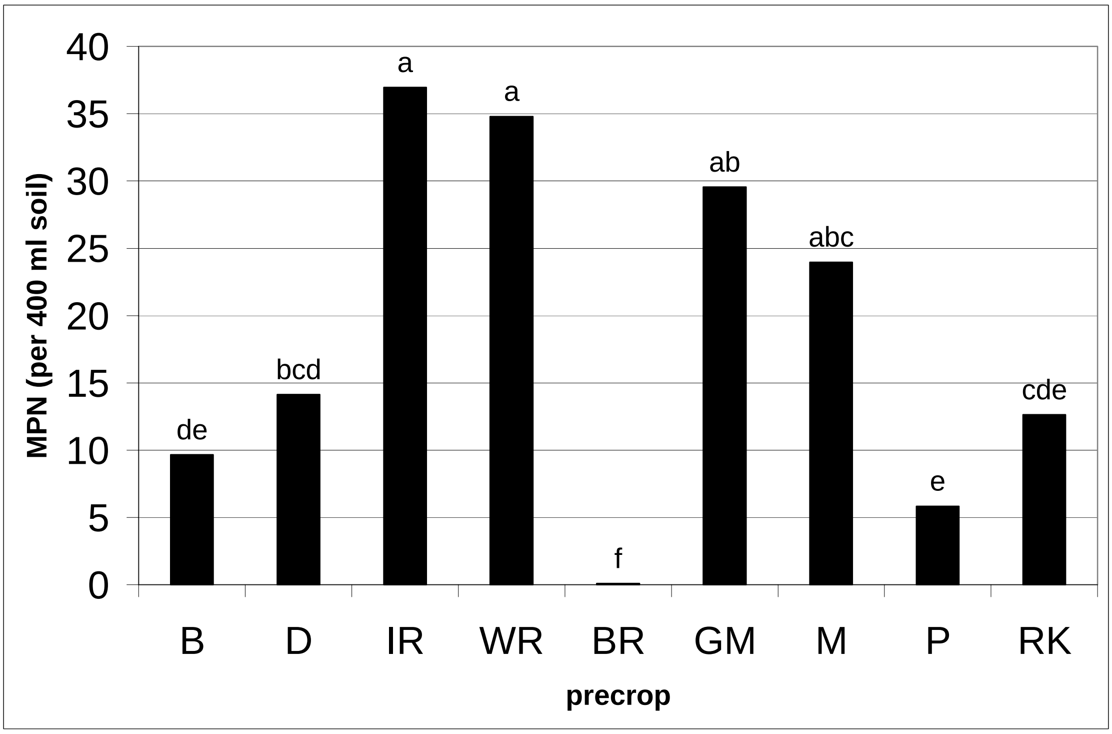

Fig. 2. The effect of precrops on infection potential of the soil of Tobacco Rattle Virus transmitted by trichodorid nematodes determined by the most probable number method (MPN). B = fallow, D = Dahlia, IR = Italian Ryegrass, WR = Westerwolds Ryegrass, BR = Fodder radish, GM = White Mustard, M = Maize, P = Carrot, RK = Red Cabbage.