Biological Control in a Propagation Unit©

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INTRODUCTION

The Guernsey Clematis Nursery Ltd (GCN) is a wholesale nursery that specialises in propagating and raising young clematis plants for export to other wholesale nurseries. Production is exported to 18 countries worldwide although a large proportion of the market is in the U.K., E.U., and North America. Typically a GCN customer will buy either a 13-week-old "rooted cutting" or a 9-month-old 7-cm liner that will be potted and grown on for another 9 to 12 months before being ready for retail sale.

Over the last 10 to 12 years, GCN has modernised its propagation facility from traditional floor-level sand beds with constant manual input to control the environment, to a fully computer-controlled, purpose-built facility with ebb-and-flow benches, a re-circulated water system, top and bottom heat, assimilation lighting, and both shade and blackout screens. The unit allows for good heat and humidity control, while the use of lights and screens enables the nursery to dictate the daylength, shortening the days in the summer to keep the plants vegetative and lengthening in the "shoulder months" to extend the propagation season. The propagation season for GCN now extends from February to October.

Current Propagation Process. Trays are pre-filled and prepared with medium by machine, or Elleguard pots manufactured on site, 24 h prior to use. They are watered up by passing under a boom at a set speed ensuring a uniform quantity of water is applied to each. Cutting material is collected from the liner crop and stored at 3 °C until processed (usually the same day).

Nodal cuttings are made, dipped in rooting hormone and stuck into the pre-made trays or Ellepots. The cuttings are then misted over with clear water, placed on a bench, and sealed under a white polythene tent before being moved into the propagation zone at 21 °C. The polythene maintains a very high humidity (>90%) and shades from direct sunlight.

The cuttings remain in the propagation zone for 4 to 5 weeks, until rooted. From there they are moved to a weaning zone where they will remain for a further 4 weeks, during which time the polythene is gradually cut and opened up before being replaced with green netting and finally no cover at all.

After a final 4 weeks at ambient temperatures in a well-ventilated zone, the cuttings are rooted, fully weaned, and mature enough for either sales or potting on. This three-stage process is completed in a total of 13 weeks. Once rooted (after 5 weeks) the cuttings are generally sub-irrigated with liquid feed included.

BIOLOGICAL CONTROL

While the more modern facility has greatly increased the throughput of plants and improved both labour and heating efficiencies, the challenges of propagating under a new regime have meant a steep learning curve — not least with the approach to pest and disease management.

Re-circulating the water has led to the potential re-circulation of any root disease that might be present, such as *Phytophthora* and *Pythium*. Optimal growing conditions with high heat and humidity also create ideal conditions for foliage diseases such as *Botrytis* to flourish. And by extending the season, pests such as western flower thrips (WFT) have the opportunity to establish early and multiply to numbers that are hard to control by mid-summer and can remain active in the crop until late in the year.

While developing the propagation facility, GCN has been working with crop protection supplier BCP Certis to produce an integrated pest management system with a heavy reliance on biological controls, and a move away from chemical pesticides, to satisfy environmental demands, and because of the reduction in availability of effective chemicals.

A significant proportion of the crop is sold in North America where there are very strict conditions imposed at the port of entry and zero tolerance of pest and disease. Previously, GCN would have used a pesticide at the point of export to ensure that there were no live insects in a consignment. But following a rejected consignment after the discovery of two dead WFT at the U.S.A. border, GCN had to change its procedures to ensure that the pests were controlled to a much lower level on the nursery so that few if any pests (dead or alive) could be discovered during the export process.

These three factors — the change of facility, reduction of pesticides, and low pest tolerance levels — have influenced the development of pest and disease management on the nursery over the last decade.

Early Experiences with Biological Controls. Initially, when embarking on a biological programme, WFT control was left to the predators. This included the introduction of *Amblyseius cucumeris* and *Hypoaspis miles*. The amblyseius — predatory mites that feed on the immature larval stages of the thrips — is introduced in a breeder pack, with two placed on each propagation table at the time of sticking (two packs per 3.5 m^2 table) and remaining in place for the 8-week period that the cuttings are in propagation and weaning. Once all the polythene and net covers have been removed, further applications of amblyseius from shaker packs can be added weekly to the crop (introduced at $50/m^2$). Hypoaspis are also sprinkled over the prepared cutting trays just before the cuttings are inserted at a rate of $250/m^2$. These are aimed at controlling any thrips that may drop to the soil to pupate during their life cycle.

Success of these two agents on their own was very limited. Although the temperature and humidity were thought to be ideal for amblyseius to thrive, in reality the life cycle of thrips in these conditions was quicker than expected and the number of eggs laid meant that the thrips appeared to be out-doing the predators.

At the same time GCN was still relying on a number of fungicides to control *Botrytis*. The installation of a U.V. filter that processed all used and stored water in the re-circulation system eliminated the need to fungicide-drench the cuttings in propagation to control soil-borne root diseases, though the use of foliar fungicide sprays was still necessary. Although no physical evidence could be found to back up the claim, our observations suggested that some of the fungicides being used could have been reducing the effectiveness of the predators — such as Switch (cyprodinil + fludioxonil) on amblyseius.

With reliance on just these two bio-control agents against WFT and the possible effects of the fungicides, chemical back up was often required: Conserve® (spinosad) was applied quite regularly throughout propagation.

Further Development of IPM. In 2005, in addition to use of the predators, GCN started applying weekly sprays of Nemasys-F® (*Steinernema feltiae* nematodes) throughout the propagation period at a rate of 250 million per 1000 m^2. Conditions in the propagation unit are ideal for these nematodes as the foliage should remain wet for at least 2 h after application, enabling the nematodes to move around and find the pests. The nematodes should not be applied in direct sunlight, so the white polythene and the shade screens ensured optimum conditions. This had an immediate impact on the control of WFT, with far fewer applications of Conserve being required over a season.

A further reduction in the use of chemical fungicides came with the introduction of Serenade ASO® (*Bacillus subtilis*). Regular applications of this biological fungicide (a naturally occurring bacterium) have reduced applications of chemical fungicides significantly while controlling *Botrytis* to an acceptable level throughout propagation. There are no known negative effects of Serenade ASO on beneficials. Any impact of fungicide treatments on bio-control agents in the propagation house is now minimal.

Most recently the use of the bio-pesticide Naturalis-L® (*Beauveria bassiana,* an insect pathogenic fungus) as an addition to the other biological agents, has achieved complete control of WFT and incidental control of other pests (applied at a rate of 300 ml in 100 L of water). The warm humid conditions are ideal for this pathogenic fungus to infect both adult and larval stages of thrips species. Recommended conditions for Naturalis-L are a temperature between 15 to 30 °C and humidity greater than 60% RH, again already achieved in a propagation unit.

Current IPM Programme. Throughout the 13-week propagation cycle at GCN, a programme is now in place where weekly sprays alternate between Naturalis-L, Nemasys-F, and Serenade ASO. This is in addition to the hypoaspis mites that target the pupating thrips and the amblyseius parasitic wasps which target the thrips larvae. This programme has led to almost complete control of the major pest and disease problems that used to be an issue in propagation.

The use of chemicals has reduced, mainly a result of the introduction of Nemasys-F in 2005. Before this as many as 20 chemical applications per year were being used to control thrips. Since Nemasys-F became a regular part of the programme the number of chemical pesticide applications has reduced to five over the course of each propagation season to control WFT.

During the 32 weeks of propagation so far in the 2010 season, no chemical insecticide has been used and only three applications of a chemical fungicide have been made. Botrytis control is very acceptable and control of WFT is complete. Even when material has arrived heavily infected with thrips at the propagation house, cuttings have emerged after 13 weeks, rooted, weaned, and matured, and a live thrip is almost impossible to find. Incidental control has also been shown on sciarid larvae — dead larvae were collected and taken to the local pathology laboratory where spores of the fungus *B. bassiana* were identified as the cause of death.

FUTURE DEVELOPMENT FOR IPM ON THE NURSERY

The bio-control programme does now involve high input levels of predators and very frequent applications of biological sprays, some of which are quite costly. However, good control has now been achieved and the benefits are starting to show with increased yields and improved quality.

Having reached this stage in the pest and disease control programme at GCN it is now thought that some of the inputs can be reduced to save cost while continuing to maintain control. For example, it may be that the number of predators introduced at the beginning of the process can be limited or the number of spray applications reduced. Perhaps the biological sprays are now good enough to control the pests without the predators.

Generally it is expected that the predators will be able to control the background levels of thrips with little interference from chemical fungicides, with Nemasys-F and Naturalis-L used as a reactive treatment to an increase in thrips population.

Research on a cucumber crop (Jacobson et al., 2001) showed that *B. bassiana* and *A. cucumeris* were completely compatible with no evidence that control of WFT was impaired by application of Naturalis-L onto plants already treated with *A. cucumeris*. The study suggests that a mycopesticide could be used as a second line of defence to support preventative pest management with *A. cucumeris*. Work for GCN over the next few years will look at ways of reducing the cost while maintaining good control so that pest and disease levels can be maintained at a suitable economic threshold.

Other trial work at GCN involves the use of *A. swirskii*, another predatory mite that feeds on the first larval stage of the thrips but can build up a population with much greater speed to give more effective control. Minimum glasshouse temperatures are required to ensure good activity of this predator.

CONCLUSION

Overall, while the cost of pest and disease management at GCN, including cultural, biological, and chemical control, has remained fairly static over the last 10 years, the cost of chemicals has been reduced dramatically, while the control of pests and disease has improved in the propagation unit. The environmental conditions in the propagation unit now lend themselves to the more recent developments of biological control including nematodes and pathogenic fungi and bacteria. It is now thought that with a little experience, some of the costs of bio-control might even be reduced. Good pest and disease management is now being achieved with very little, if any, input from chemical control, with biological agents proving successful in a propagation unit.

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LITERATURE CITED

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