HORTICULTURE

Grower Summary

FV 441

Celery: Investigation of strategies to control mirid bugs in outdoor crops

Final 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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Project title:	Celery: Investigation of strategies to control mirid bugs in outdoor crops
Project number:	FV 441
Project leader:	Rosemary Collier, University of Warwick
Report:	Final report March, 2017
Previous report:	None
Key staff:	David Norman, David George, Andrew Jukes, Marian Elliott
Location of project:	G's, Warwick Crop Centre, Stockbridge Technology Centre
Industry Representative:	Emma Garfield, G's
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Date project completed (or expected completion date):	31 March 2017

GROWER SUMMARY

Headlines

- Species of *Orthops,* particularly *Orthops campestris* have been confirmed as the pest mirids causing most damage to celery crops in eastern England. *Orthops campestris* appears to feed mainly, or possibly entirely, on wild and cultivated members of the carrot family (Apiaceae).
- Laboratory trials identified a small number of insecticides that were partially effective against adults of this species and a number of potential predators including species occurring naturally in the field.

Background

Recent high incidences of mirid damage in celery suggest that the status of mirids as pests of this crop is increasing, particularly in organic crops. Crop invasion by mirids is unpredictable and relatively little is known about their biology, which would inform the development of an integrated control strategy for celery. Current control of mirids in celery relies on the use of a small number of generally broad-spectrum synthetic insecticides. Options for control of mirids in organic crops are very limited. The aim of this project is to improve current understanding of the complex of mirid bugs that can infest celery crops, identify the key pest species and identify and evaluate approaches to control.

Summary

Objective 1 Develop a clearer understanding of the identity and life cycles of the key species of mirid bug which infest celery crops in the UK.

Crop sampling was carried out regularly in 2015 and 2016 in organic and conventional celery crops. Five plants per week from an uncovered area were carefully pulled up and shaken into an insect-proof bag and mirids were saved for identification. Sampling of field margins was also carried out. At each site four lengths of 5 m along the margin were marked out and one section was swept each week using five sweeps of the net. Further samples were collected from field margins surrounding organic crops by Ela Witkowska from G's since April 2014. The most abundant species of mirid was identified as *Orthops campestris* (Figure A) and this identification was verified by Joseph Botting an expert on plant feeding bugs (British Bugs http://www.britishbugs.org.uk/). There are other species of *Orthops* in the UK (*Orthops kalmii*, *Orthops basalis*) and a specimen of *O. kalmii* was also identified in a crop sample. Only *Orthops* spp. adults were found in the crop samples.

Figure A. Adult *Orthops campestris* and celery plant damaged by mirid bugs

Damage in 2015 was seen particularly in crops of organic celery between early July and the end of August (Figure A). There was no damage in conventional crops in 2016 and the organic crops were covered with fine mesh netting. Adult *Orthops* spp., common green capsid (*Lygus pabulinus*) and European tarnished plant bug (*Lygus rugulipennis*) were found in samples from the field margins. A large proportion of the mirids from the samples from the field margins were nymphs. Figure B compares the abundance of adults and nymphs in samples from field margins around organic crops in 2014, 2015 and 2016. The data suggest that there were three 'peaks' in the numbers of nymphs each year.

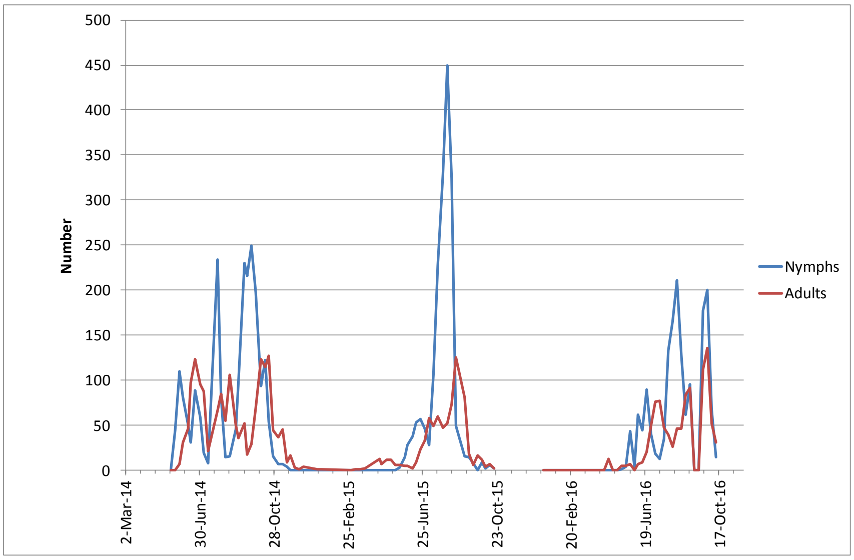

Figure B. Numbers of adults (*Orthops* spp.*)* and nymphs (identification not verified) sampled from the vegetation surrounding organic crops of celery at G's Cambs in 2014-2016 (data provided by E. Witkowska).

The timing of peaks in the numbers of nymphs in 2014-2016 were compared both in calendar time and using day-degrees. Accumulated day-degrees above thresholds of 8 or 10°C were estimated using weather data from G's. The day-degree sums from 1 January to peak numbers of first and second generation nymphs appear remarkably consistent, although the day-degree sum to the third generation is more variable; which might be related to the influence of day-length on the occurrence of adult diapause. This provides a preliminary forecasting system for this pest that requires further field validation. More detailed sampling of potential hosts was undertaken in 2016. The bugs were abundant on wild carrot (*Daucus carota*) and hemlock (*Conium maculatum*) in particular. They appeared to aggregate in the vicinity of apiaceous crops apart from celery and were captured on carrot fly traps in carrot plots at Wellesbourne. To investigate the association with Apiaceae in more detail, carrot fly traps were placed in locations with and without apiaceous hosts – crops and weeds. No *Orthops* spp. were captured in locations where Apiaceae were absent and the largest numbers were captured close to plots of carrot. This suggests that proximity to, and management of, apiaceous weeds will be a key factor.

Objective 2 Once the key species have been identified, determine the feasibility of rearing them in the laboratory or under semi-field conditions, so that more detailed studies can be undertaken on their life-cycle and on methods of control.

Large numbers of mirids were collected at G's in August 2015. The mirids were placed in cages in a controlled environment room at 15°C. Potential food plants were provided. Initially there were a large number of nymphs in the samples, but these appeared to die quite rapidly. The adult population remained relatively constant until late December but after this it declined. The behaviour of the caged adult *Orthops* spp. was observed. At any moment a proportion of the adults were on the ceiling of the cage, suggesting that they were displaying dispersal behaviour; adults were most numerous on the cage ceilings in the middle of the day. Further insects were collected in 2016 and kept in cages in rooms at 15, 18 and 20ºC. Numbers were monitored and in all cases there was evidence of a resurgence in numbers in December, followed by decline in numbers from mid-December onwards.

Objective 3 Using the information from Objective 1, review possible strategies (including the use of insecticides or crop covers) for managing populations of mirid bugs in the vicinity of celery crops.

Approaches used to manage *Orthops* spp. and other pest mirids were reviewed. They included pheromones for monitoring, insecticidal and biological control, management of vegetation (e.g. field margins) and physical removal of bugs with vacuum equipment.

Objective 4 **Evaluate products approved currently for application to celery and novel insecticides and bio-insecticides that might be used to control mirid bugs in small-scale field trials and undertake a small scale study of potential biocontrol agents (predators).**

A replicated laboratory trial was undertaken to compare foliar spray treatments (9 treatments and untreated control) applied to caged potted celery plants that were infested post-treatment with mirids (*Orthops* spp.) collected from wild carrot. Test plants were taken outside and the treatments were applied using a knapsack sprayer. The plants were then placed in cages (one plant per cage) and ten adults were added to each cage. The cages were kept at 20ºC and the numbers of live mirids were assessed 1, 2, 3 and 6 days after spraying (Figure C). Analyses of data collected on Day 2, Day 3 and Day 6 showed that there was a statistically significant effect of insecticide treatment on the percentage live adults on each occasion. The percentage live adults declined over time but none of the treatments reduced numbers rapidly. Two days after spraying only lambda-cyhalothrin had reduced the percentage live adults compared with the untreated control. Three days after spraying HDCI 098, HDCI 105 and HDCI 107 had also reduced the percentage live adults and this pattern was repeated 6 days after spraying. There was little difference between the effective treatments, but 6 days after spraying HDCI 098 had reduced the percentage live adults significantly compared with HDCI 105.

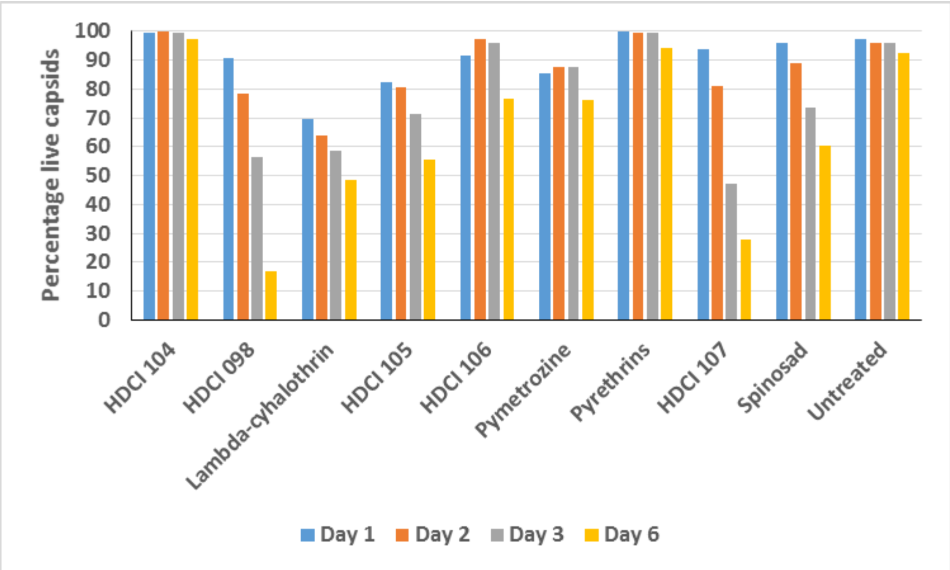

Figure C. The mean percentage live mirids (adults) 1, 2, 3 and 6 days after spraying.

A laboratory screening study was conducted at Stockbridge Technology Centre to assess the impact of various predatory natural enemies on the mortality of *Orthops* spp. Two types of natural enemies were considered: 'commercially-available' and 'wild-caught'. Screening was conducted on juvenile and adult *Orthops* spp., sourced from wild hosts near the Wellesbourne

Campus. Three sets of experiments were conducted within Petri dishes in a controlled temperature room. A pre-determined number of adult and juvenile mirids were placed within each dish with a section of organically grown celery and a small piece of cotton wool soaked in 50% honey solution. Natural enemies and commercially-available biocontrols were then introduced and mortality of the mirids and natural enemies was measured 4 days after predator introduction. The naturally-occurring predators selected in an initial screening consisted of web-forming spiders, ladybirds, soldier beetles, earwigs, sawflies, pirate bugs, damsel bugs, harvestmen and lacewing larvae. The mortality of mirids in 'control' treatments (in the absence of natural enemies) was less than 10%. Initial screening indicated higher mortality of mirids in dishes containing web-forming spiders, earwigs, damsel bug spp. and harvestmen, and to a lesser extent ladybirds, soldier beetles and lacewing larvae. Encouragingly, the most effective natural enemies all appeared to feed on adult mirids as well as juveniles. Nevertheless, as juvenile mirids were at a relatively late stage when used, and matured during the course of the study period in some dishes, it was not possible to reliably separate out which stage had been attacked. Based on these results, certain wild-caught natural enemies were selected for further, replicated screening on adult mirids. Spiders and field damsels both appeared to reduce numbers of adults. However, the data were highly variable. Earwigs and harvestmen did not cause a significant level of mortality in this experiment. When commercially available predators were screened (*Macrolophus pygmaeus* (Mirical-N), *Orius strigicollis* (Thripor-S) and *Atheta coriaria* (Staphybug)), juvenile mirids were available at a younger stage than previously. In general, juveniles were preferred to adults by all natural enemies tested, particularly by *Orius* and *Atheta* and less so by *Macrolophus*. The potential of certain natural enemies, whilst suggested by these results, can only be confirmed with further study under field conditions. There is potential to consider the efficacy of egg parasitoids in future.

Objective 5 Determine the potential and significance of improved monitoring and forecasting of infestations by mirid populations.

The most effective method of monitoring *Orthops* spp. in field margins appears to be through tapping/shaking foliage above a large plastic tray and rapidly recovering/counting insects that land on the tray. Celery crops provide an additional challenge in terms of sampling, which almost inevitably must be destructive and involves either shaking an uprooted plant into a bag or taking the plant apart as quickly as possible *in situ*. The use of orange sticky traps may be a promising approach for monitoring activity when populations are high. Whether such traps could be used to determine the risk of damage to crops would require further research. Any approach to indicate the timing of activity could be useful in terms of targeting treatments. The later generations appear to be more abundant and potentially more damaging and an indication of their timing may be useful.

Objective 6 Identify promising approaches that could be investigated in a subsequent project.

This study and G's own observations and activities have indicated two potential approaches to management, the first is the use of crop covers made of fine mesh netting to exclude all stages of *Orthops* spp. G's have demonstrated that this approach successfully excludes the bugs, although it may have other consequences. For example, the presence of the covers may exacerbate infection by pathogens and reduce crop quality. The use of crop covers also presents challenges for effective weed control, is expensive and labour intensive. However, this approach is particularly important for organic crops where there are currently no effective control options; the trial addressing Objective 2 confirmed that pyrethins are ineffective against adult *Orthops* spp. This study has confirmed the significance of wild Apiaceae in sustaining populations of *Orthops spp.* and the strong association between their presence and the presence of the pests. This indicates that management of vegetation in field margins may be one of the most effective ways of reducing the abundance of this pest. It would be interesting to investigate whether sticky traps could be used to indicate the 'risk' of damaging infestations occurring. Although it has not been possible to rear *Orthops* spp. on a continuous basis and the reasons for this require further research, it does appear feasible to collect adults in large numbers and maintain them over reasonable periods to evaluate control methods in a laboratory setting. Thus it should be feasible to screen other potential control agents as they arise and it may be possible to do this within SCEPTREplus. It would be good to determine a method of producing nymphs or sustaining field-collected nymphs over longer periods so that these could also be tested. Similarly, a reliable method of egg production would be required to evaluate egg parasitoids.

Financial Benefits

Mirid damage has been particularly devastating in organic celery crops with potential annual losses of £2 million. The project has identified the key pest species, provided further information about their biology, and identified ways of improving mirid control. The results are most applicable to celery producers. The findings may also have relevance for the control of additional pests of celery and other crops sharing a similar life-cycle/biology.

Action Points

- Growers should monitor crops and margins using sweep nets/trays to determine levels of *Orthops* spp. activity, which will be useful in helping to time control methods.