Project title:	Perennial field margins with combined agronomical and ecological benefits for vegetable rotation schemes.
Project number:	HortLINK HL0192 (FV 334)
Project leader:	Prof Felix Wäckers (Lancaster University).
Report:	Annual Report, 1st Dec 2010.
Previous report:	Interim Report, 27th Sept 2010.
Key staff:	Dr Patricia Croft (STC Research Foundation). Mr Phil Northing (Food and Environment Research Agency). Dr David George (Lancaster University).
Location of project:	Lancaster University, Bailrigg, Lancaster, LA1 4YW. STC Research Foundation, Stockbridge House, Cawood, Selby, North Yorkshire, YO8 3TZ. Food and Environment Research Agency, Sand Hutton, York, YO41 1LZ (previously Central Science Laboratory).
Industry Representative:	Nathan Dellicott Barfoots of Botley
Date project commenced:	1st December 2008.
Expected completion date:	30th November 2013.

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

The following are members of the Consortium for LINK project HL0192:

Lancaster University
•
STC Research Foundation
•
Food and Environment Research Agency
•
Agriculture and Horticulture Development Board
•
AHDB-HGCA
•
Processors and Growers Research Organisation
•
Westhorpe Flowers and Plants Limited
•
Produce World Limited
•
National Farmers Union
•
Mark H Poskitt Limited
•
D. Westwood & Son
•
J.F.D. Hargreaves Limited
•
Waitrose Limited
•
Sainsbury's Supermarkets Limited
•
Linking Environment and Farming
•
Donald McIntyre (Emorsgate Seeds)
•
Growing Wild Limited
•
Bayer CropScience Limited
•
Syngenta Limited
•
Dow AgroSciences Limited
•
Koppert Biological Systems BV
•
BCP Certis
•
Unilever U.K. Central Resources Limited
•
Birds Eye Limited

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Prof Felix Wäckers
Project leader and overall Project Co-ordinator
Lancaster University

Signature  Date .....14.12.10.....

CONTENTS

GROWER SUMMARY

Headlines

- Seed mixtures have been successfully developed for sowing into experimental seed margins and first year data suggests that the margins are benefitting several groups of beneficial insects.
- A pesticide compatibility matrix has been generated for Brassicas.
- The acceptance of seed mixes/margins to the environmental stewardship scheme is being discussed with Natural England.

Background

The horticultural industry faces a range of issues linked to crop protection. These include:

- A reduction in the available products approved for use
- The potential for increasing resistance in target organisms
- Increasing pressures from consumers and retailers for residue-free produce
- A need to comply with legislation and industry initiatives.

These pressures have resulted in a need for a more rational approach to pesticide use and for the full exploitation of the range of alternative methods available for maintaining pest populations below economic damage thresholds.

The development of stewardship schemes that encourage the management of the farmed environment in a way that increases levels of biodiversity, provides an opportunity to combine conservation objectives with the benefit of enhanced pest control (either through conservation biological control or through other methods such as trap cropping). Current stewardship options include pollen and nectar mixes targeting bees and butterflies, as well as separate margin prescriptions to encourage farmland birds.

Previous work by members of the research team involved in the current project has developed the concept of designing flowering field margins for the specific purpose of optimising biological pest control.

The current project looks to build upon the above research and seeks to combine the biodiversity and pest-control benefits of perennial field margins, providing growers with a direct economic benefit in addition to the expected subsidies from stewardship schemes.

The expected deliverables from this work include:

1. Development of a seed mixture for perennial field margins that has the potential to optimise joint pest control and conservation benefits while minimising potential risks for vegetable rotation schemes.
2. Quantification of the impact of field margins on biological control agents, pests, pollinators and farmland birds.
3. Development of the use of flowering field margins as part of insecticide assisted trap-cropping approach.
4. Development of field margins that support predator population build-up through provision of non-pest prey in field margins.
5. Assessment of the feasibility of using banker plants in field margins and development of these plants as sentinels to monitor levels of biological control agents.
6. Development of a database on the compatibility of available chemical control options with various biological control agents to optimize integrated pest management decisions.
7. Quantification of the impact of perennial field margins on pest levels, crop quantity/quality and pest management costs.
8. Communication of best practice to commercial growers in the form of 'blueprints' for margin establishment and management, drawing upon knowledge generated in the proposed project as well as in ongoing European biodiversity projects.

Summary of the project and main conclusions

Objective 1- Development of the seed mixture.

Following discussions with seed companies involved in the project, international research groups, and an extensive review of the available literature considering some 50 potentially useful flowering plant species and more than 20 specific selection criteria, a seed mix consisting of 22 flowering species was formulated for sowing into experimental field margins. The success of this Objective, and hence any conclusions drawn from it, will be determined with continuing work on margin establishment and performance.

Objective 2 – Establish field margins and quantify margin impact on selected species

Despite harsh winter (cold) and spring (dry) conditions numerous flowering plants have established well. Flowering surveys have shown that the selection of flowering plants sown has provided resources continually from the early Spring to late Autumn. More details are provided in the Science Section.

Though only in their first year, there is some suggestion that flowering margins are already benefitting several groups of beneficial insects, including bees, hoverflies and parasitoid wasps, thus stacking benefits for pollinators and pest natural enemies. However, for additional groups such as carabids further analysis is required. Flowering margins did not appear to benefit any of the in-crop pests considered. In some cases trends for increased aphid parasitism at crop sites nearer to the flowering margins were observed, though these trends were not statistically significant (most likely due to high variation existing between plots in many cases).

There appeared to be a greater diversity of farmland bird species recorded from fields surrounding field margins than from a control field on nearby land. However, it is not possible to relate this to the presence of experimental field margins, as STC is a highly diverse site (with regard to natural vegetation, cropping and landscape features) even without them. Results from commercial-scale testing may, however, prove more conclusive.

Objective 3 - Development of the trap-cropping approach.

Using laboratory-reared populations of both carrot and cabbage root fly, host preference tests using selected potential trap crop species have been conducted to ensure that appropriate (i.e. attractive) trap crop plants will be used in the field in 2011. Results of this suggest that chervil and yellow mustard may limit pest development by providing conditions that are not optimal for the larvae whilst still attracting egg-laying females.

Objectives 4 & 5 – Development of banker plant species.

Some of the plant species included in the final seed mix were selected on the basis of having been identified as potential banker plants, and these have been monitored from April 2010 to confirm this potential. Though aphids were slow to move in on potential banker plants, populations were observed on some plants by mid-July, including a number of species not initially identified as bankers. Of the three originally-proposed banker plants only common vetch was observed to harbour large numbers of aphids, though populations were

observed on both cornflower and yarrow elsewhere on site. It is expected that as the margins mature into 2011, the likelihood of banker plants supporting greater aphid loads will increase. Further details are provided in the Science Section.

Results from an experiment with hoverflies have suggested that banker plants are only likely to provide discernable benefits to pest natural enemies when prey populations on crops are absent or low. It is therefore hoped that in the future banker plants will support aphids early in the season, allowing natural enemy populations to establish before crop pests arrive. This same experiment demonstrated the importance of floral resources to aphid pest control. Further details are provided in the Science Section.

Objective 6 – Development of a compatibility database of chemical control options.

Using data from LIAISON (a Fera-held database on approved products), a list of all active ingredients available for application to the crops relevant to the current project has been generated to inform any pest control interventions that may be required during the study period. A compatibility matrix has been generated for Brassicas and used to inform decisions on spraying (undertaken on Brassicas only in 2010). Gaps in this matrix have been indentified and may be addressed in future years if resources allow. Further details are provided in the Science Section.

Objective 7 - Quantification of margin impact on pests, crops and pest management costs.

Results concerning pests are reported under Objective 2. Initial yield data have been collected, though further analysis is required to assess if margins have had any influence on crop yield/pest management costs.

Objective 8 – Communicate best practice.

A database has been generated compiling experience from functional biodiversity projects and is in the process of being developed into a more user-friendly format. A project website has been developed and can be accessed at www.ecostac.co.uk. Introductions to the project have been presented to the general public and both industrial and academic audiences. Delivery of information has varied to include PowerPoint lectures, poster presentations, publications and televised interviews for the BBC. Further details are provided in the Technology Transfer section.

Financial benefits

In accordance with the Government's longstanding policy of minimisation of the use of pesticides, the boosting of native biological control agents in combination with a trap crop approach for key pest species should make it possible to reduce pesticide inputs while maintaining crop yield and quality through the use of functional field margins. In addition to financial savings associated with reduced pesticide use, economic benefits will also result from the expected development of a functional field margin that can count towards stewardship accreditation. Contacts have been made with Natural England to help ensure that this will be the case.

Action Points

There are no action points at this early stage.

Milestones (Primary)

Year	Milestone	Activity	Proposed target*	Revised target*	Further details of any change in target date	Implications of any change
1	**1.1**	Generate appropriate seed mixture	30.06.09 TR	30.08.09 TM	Delay in appointment of Research Associate due to late confirmation of project funding	None
1	**4.1**	Identify the most appropriate banker plant species for the various crops	30.06.09 TR	30.08.09 TM	As Milestone 1.1	None
1	**6.1**	Using data from LIAISON (CSL held database on approved products) generate a list of all active ingredients available for application to the crops relevant to the current project	31.09.09 TM	31.09.09 TM	NA	NA
1	2.1	Establish field margins at the four 2 acre sites	30.11.09 TR/TM**	20.04.10 TM	Whilst the proposed target was met with an initial sowing, a second sowing was deemed necessary to ensure adequate field margin establishment	None as a complex sward would not have been expected until the summer of 2010 anyway
2	**6.2**	Compile a compatibility matrix of control options and biological control agents relevant to the crops in the project and identify data gaps	30.02.10 TR	30.05.10 TM***	Proposed target delayed in order to gather the most up-to-date information for the 2010 crop season	None, as control options will not be required until after 30.05.10
2	**2.2**	Compile and where necessary develop protocols for all monitoring methods and undertake 1st years monitoring of field margin plants and other relevant biota.	31.10.10 TM	31.10.10 TM	NA	NA
2	**3.1**	**Establish and monitor effect of trap crops**	**31.09.10 TR**	**31.09.11**	**Decision made to omit trap crops in 2010 to allow investigation of flowering margins only and provide a basis for comparison with 2011 data when trap crops will be included**	**None, as effect of trap crops will still be studied**
2	**4.2**	Monitor and assess effects of banker plants	31.12.10	31.12.10	No change to target date at this time	NA
3	**2.3**	Establish field margins at the four commercial scale sites	30.11.11	30.11.11	No change to target date at this time	NA

3	**5.1**	Develop banker plant monitoring tools to facilitate decisions on optional supplementary release of predators from commercial rearings	31.10.11	30.10.11	No change to target date at this time	NA
3	**2.4**	Undertake 2nd year monitoring of relevant biota	30.10.11	30.10.11	No change to target date at this time	NA
3	**8.1**	Draft guide document with 'blueprints' for the successful establishment, use and management of field margins	30.12.11	30.12.11	No change to target date at this time	NA
4	**2.5**	Undertake monitoring of relevant biota in both small and commercial scale sites	31.12.12	31.12.12	No change to target date at this time	NA
4	**3.2**	Establish and monitor effect of trap crops on commercial scale sites	31.12.12	31.12.12	No change to target date at this time	NA
4	**4.3**	Establish and monitor effect of banker plants on commercial scale sites	31.12.12	31.12.12	No change to target date at this time	NA
4	**5.2**	Monitor effect of supplementary releases on the commercial scale sites	31.12.12	31.12.12	No change to target date at this time	NA
5	**3.3**	Complete recommendations on the use of trap crops for those pest species that aggregate around flowering margins (e.g. carrot fly; cabbage root fly).	30.11.13	30.11.13	No change to target date at this time	NA
5	**5.3**	Complete recommendations on the use of banker plants as monitoring tools for natural predator populations and potential release of commercially reared predators	30.11.13	30.11.13	No change to target date at this time	NA
5	**7.1**	Complete the quantification of the impact of field margins and the cost-benefit analysis	30.11.13	30.11.13	No change to target date at this time	NA
5	**8.2**	Finalise and distribute document on the establishment, use and management of field margins combining agronomical and ecological benefits	30.11.13	30.11.13	No change to target date at this time	NA

Un-shaded Milestones in plain font relate to future work.

Lighter shaded Milestones in plain font have been/will be achieved as proposed or otherwise without significant amendment to Milestone dates.

Darker shaded Milestones in bold font have not been achieved as proposed resulting in significant amendment to Milestone dates.

Darker shaded Milestones in plain font were not achieved as proposed, but have since been completed (albeit with significant amendment to Milestone dates).

*TM = Target Met, TR = Target Revised. **TM by initial 2009 sowing, but TR for 2010 sowing. ***TM for *Brassica* crops, which were the only crop requiring treatment in 2010.

Milestones (secondary)

Year	Milestone	Activity	Proposed target*	Revised target*	Further details of any change in target date	Implications of any change
1	**1.2**	Undertake a detailed desk study to generate a list of the plant species that will be considered for use in the project	30.06.09 TR	30.08.09 TM	Delay in appointment of Research Associate due to late confirmation of project funding	None.
1	**1.3**	Consider tailoring of seed mixtures to soil types	30.07.09 TR	30.08.09 TM	As Milestone 1.2	None.
1	**1.4**	Consider tailoring of seed mixtures to crop types	30.07.09 TR	30.08.09 TM	As Milestone 1.2	None.
1	**1.5**	Discuss with seed companies and produce optimum seed mixtures that take into account results from 1.4 – 1.6 along with cost of seed production	30.07.09 TR	30.08.09 TM	As Milestone 1.2	None.
1	1.6	Where necessary, scale up production of seeds for establishment of margins at commercial scale sites (in 2010)	30.09.09 TR	30.09.10 TM	Assessment of seed establishment at STC required in Spring 2010 before the seed mix for commercial sowing is finalized	None, as date of margin establishment should read '2011' and not '2010'
1	**1.7**	Identify additional sources of seeds should partner seed companies not be able to produce spp identified under 1.1	30.09.09 TM	30.09.09 TM	NA	NA
1/2	**1.8**	**Visit seed companies to monitor their crops of wild flowers and grasses for pests, diseases and beneficial insects in order to provide better insight into potential issues surrounding these plant species**	**30.09.09 TR 30.09.10 TR**	**30.10.10 TM 30.10.11**	**Due to the delayed appointment of a Research Associate it was not possible to achieve this Milestone in Year 1**	**None, as assessment will still be completed in 2010 and 2011**
3	**1.9**	Using data from 1.8, 4.6, and 8.1 to amend seed mixtures as appropriate for the commercial scale sites	30.08.11	30.08.11	No change to target date at this time	NA.
5	**1.10**	Finalise detailed seed mixtures and management processes for different soil types and crops	30.11.13	30.11.13	No change to target date at this time	NA

1	**2.6**	Design cages for capturing invertebrates emerging from field margins	30.03.09 TR	30.11.09 TM	As Milestone 1.2	None, cages will still be ready for use
2/3	**2.7**	**Monitor and assess impact of field margins on overwintering insects**	**30.04.10 TR 30.04.11 TR**	**01.02.11 01.02.12**	**Sample collection continues until mid-May, where no time is then available until the Winter to process samples (due to the onset of Summer sampling).**	**None as data will still be collected and processed**
1	**3.4**	**Develop protocols for decision making on the timing, regularity and product for applying insecticides into the trap crops**	**30.12.09 TR**	**30.12.11**	**Target revised to allow decisions to be made during the 2011 field season (i.e. the first trap cropping season).**	**None, as target will still be met in time for use on trap crop**
1	**3.5**	Investigate use of carrot fly predictive model (HDC product in Morph) as guide to pest activity	30.12.09 TM	30.12.09 TM	NA	NA
1	**4.4**	Develop protocols for monitoring non-pest prey and associated predators in banker plants	31.12.09 TM	31.12.09 TM	NA	NA
2-5	**4.5**	Determine the timing and extent of non-pest species populations on the banker plants	30.09.10 TM 30.09.11 30.09.12 30.09.13	30.09.10 TM 30.09.11 30.09.12 30.09.13	No change to target date at this time	NA
3	**4.6**	Review inclusion of banker plant species in light of 4.2 and 4.5	30.08.11	30.08.11	No change to target date at this time	NA
2	**5.4**	**Determine appropriate times of season when supplementary releases could be needed and develop protocols for their release**	**31.12.10 TR**	**31.12.12**	**Target revised to allow data to be collected to inform this Milestone**	**None, as target date was incorrect to begin with**
3	**5.5**	Establish relationship between predator counts on banker plants and population densities of those species	31.10.11	31.10.11	No change to target date at this time	NA

3	**6.3**	Undertake discussions with chemical and biocontrol companies to ascertain the effect of each active on the natural predators	30.08.11	30.08.11	No change to target date at this time	NA
5	**6.4**	In instances where 6.2 has revealed gaps, the matrix will be updated. Where this is vital, additional bioassays will be conducted by Koppert and or other industry partners.	30.11.13	30.11.13	No change to target date at this time	NA
2	**7.2**	Establish structure of cost-benefit analysis for quantification of the impact of field margins	31.12.10	31.12.10	No change to target date at this time	NA
1	**8.3**	Create database compiling experience from functional biodiversity projects	31.12.09 TM	31.12.09 TM	NA	NA

Un-shaded Milestones in plain font relate to future work.

Lighter shaded Milestones in plain font have been/will be achieved as proposed or otherwise without significant amendment to Milestone dates.

Darker shaded Milestones in bold font have not been achieved as proposed resulting in significant amendment to Milestone dates.

Darker shaded Milestones in plain font were not achieved as proposed, but have since been completed (albeit with significant amendment to Milestone dates).

*TM = Target Met, TR = Target Revised

SCIENCE SECTION

Introduction

The horticultural industry faces a range of issues linked to crop protection. These include a reduction in the available products approved for use, the potential for increasing resistance in the target organisms, increasing pressures from consumers and retailers for residue-free produce and a need to comply with legislation and industry initiatives (e.g. Water Framework and Voluntary Initiative). These pressures have resulted in the need for a more rational approach to pesticide use and for the full exploitation of the range of alternative methods available for maintaining pest populations below economic damage thresholds.

Non-crop vegetation in agricultural landscapes can provide a range of important ecological services, including conservation of native flora/fauna and the enhancement of pollination efficacy and biological pest control (Gurr et al 2003). Field margins can be used to harbour such vegetation and margin seed mixes have been developed that target bees (Carvell et al 2006), butterflies (Pywell et al 2004) and farmland birds (Vickery et al 2009). However, the effectiveness of field margins in boosting pest control strongly depends on their botanical composition (Wäckers, 2005). A broad range of biological control agents depend on flowering vegetation as a source of nectar and pollen (Wäckers et al 2005) and often non-crop elements that are typically designed for bird or pollinator conservation are unsuitable for supporting biological control (Olsen & Wäckers, 2007; Campbell et al in prep). In related work by the research team involved in the current project, the concept of designing flowering field margins for the specific purpose of optimizing pest control has been developed (Wäckers 2004). The current project seeks to combine biodiversity and pest-control benefits from field margins, providing growers with a direct economic benefit in addition to expected subsidies from stewardship schemes.

As an alternative to ‘standard’ margin mixes, the current project proposes a multifunctional focus in composing perennial field margins, allowing joint optimization of pest control, pollination and conservation benefits across a crop rotation (Brassicas; carrots; peas; wheat). To achieve these broader benefits the project intends to choose non-crop vegetation based on the ecological requirements of a range of target species including biological control agents, key pest species, pollinators and farmland birds. Pest control will also be encouraged through the use of specific crop elements to trap nectar feeding pests, such as the carrot fly and the cabbage root fly, in designated border rows where they can be controlled by targeted insecticide sprays or other management methods. By combining the leading UK expertise on the use of non-crop elements for the conservation of birds and pollinators with our international experience in the use of field margins for conservation biological control, this project leads the way in this increasingly important area.

Objectives

The project will be conducted in two phases:

1. During the first 2.5 years the establishment and impact of perennial field margins on functional agro-biodiversity in the four selected crops will be assessed in a set of field trials on a relatively small scale. Four plots of around 2 acres will be used, where in each a margin strip of 76 x 2 m will border the plot at one end (where a control 'margin' consisting of naturally regenerated vegetation will be sited at the other). Each plot will contain all of the four crop species to be used, giving four replicates in total.
2. Building on results from this first phase, during the second phase of the project (2.5 years) field margins will be established and their impact assessed on commercial fields (5-20 ha). Assessment of the small scale plots will continue during the second phase to enable longer-term data to be generated.

The objectives of the project are as follows:

1. Development of a seed mixture for perennial field margins that has the potential to optimize joint pest control and conservation benefits while minimizing potential risks for vegetable rotation schemes.
2. Quantification of the impact of field margins on biological control agents, pests, pollinators and farmland birds.
3. Development of the use of flowering field margins as part of a trap-cropping approach.
4. Development of field margins that support predator population build-up through provision of non-pest prey in field margins.
5. Assessment of the feasibility of using banker plants in field margins and development of these plants as sentinels to monitor levels of biological control agents.
6. Development of a database on the compatibility of available chemical control options with various biological control agents to optimize integrated pest management decisions.
7. Quantification of the impact of perennial field margins on pest levels, crop quantity/quality and pest management costs.

8. Communication of best practice to commercial growers in the form of ‘blueprints’ for margin establishment and management, drawing upon knowledge generated in the proposed project as well as in ongoing European biodiversity projects.

OBJECTIVE 1: Development of a seed mixture for perennial field margins that has the potential to optimize pest control and conservation benefits while minimizing potential risks for vegetable rotation schemes

Materials and methods

See Annual Report 2009 for details of the seed mix and initial sowing. Harsh winter conditions coupled with the results of a plant surveys conducted in Feb and April 2010 (see below) led to the decision to undertake a second field margin sowing on the 20th April 2010 to ensure adequate margin establishment. Seed (of the selected flowering species only) was sown at the same rate as used previously into margins that had been prepared by manual weed removal and raking (avoiding those plants that had germinated and persisted from the initial sowing in 2009). Margins were raked again immediately post-sowing, but could not be pressed. Final margin widths of 61.2 m were determined based on the need to conform with bed widths for crop sowing and access strips between crops for farm machinery.

In undertaking the second sowing, fresh seed was sourced for both common sorrel and greater burnet saxifrage after a germination trial conducted by Dr Andrew Cuthbertson (Fera) suggested that seed of these species might not be viable. In addition, seed of borage was replaced by seed of tansy (*Tanacetum vulgare*) after borage was noted to have established particularly well after the first sowing (where due to its large size sowing further borage would present a risk of this species out-competing others in the sward). Tansy was used to replace borage (on a seed for seed basis) as this species is reported to provide numerous benefits to functional biodiversity, particularly for pest natural enemies (whilst also being a native perennial). After relatively good establishment of scorpion weed and perennial cornflower (which like borage are large plants), these species were included at a third and a half of their original rate, respectively. Finally, seed of red dead nettle was omitted from the second sowing in Plot 3, as this species was already naturally abundant in this plot.

Methods for the collection of margin establishment and flowering data have now been finalised as follows:

ESTABLISHMENT: Quadrat sampling in the FM (Flowering Margin) conducted on an approximately monthly basis from April-Sept, with additional sampling in Feb and Nov. Typically eight quadrats were sampled per margin (but see previous Report for exceptions).
FLOWERING: FMs walked on a weekly basis from mid April to mid Oct, where on each sampling occasion the flowering plant species are recorded in each margin.

Results and Discussion

Despite the coldest winter since 1978/79 and the driest 6 month start to the year (Jan-June) since 1929, several flowering plants have fared well in FMs and were present in relatively good numbers in the majority of plots (if not all of them) by April 2010. Casual observations of FMs that had been sown twice (Autumn 2009 and Spring 2010), as compared to smaller blocks that had been sown only once (Autumn 2009), suggested that to Aug 2010 there was some detectable effect of the second sowing on FM plant composition. In-particular, tansy, though not recorded during establishment surveys, was noted in several FM replicates (which had only been included in the second sowing) and buckwheat was present (albeit in relatively low amounts) only in areas that had received a second sowing. Further effects of the second sowing may be detected later in 2010, or into the 2011 season, when conditions for germination of seeds are likely to be improved.
Thus far in 2010 the selection of flowering species sown in FMs has provided resources continually from the early Spring to the time of writing (late Aug). Both borage and red-dead nettle flowered in April to provide crucial early-season resources to bees and other flower-feeders emerging from hibernation, with a selection of seven sown species in flower by the end of May. By the end of June this figure had increased to 11 species, increasing again to 12 and 13 species by the end of July and August, respectively. The number of flowering species fell to 10 by late September and again to nine by the end of October. At the start of Nov this figure was reduced again to eight species, where by this point the density of flowering for most species had also declined. As such margins were mown to 20cm on the 04.11.10.

Flowering plants attained a maximum coverage of around 20% (Fig. 1), with bare earth dominating FMs in May and being gradually colonised by grasses. It is hoped that as some species self-seed and perennials mature into 2011, increased and larger flowering plants will lead to increased floral coverage in FMs in future years.

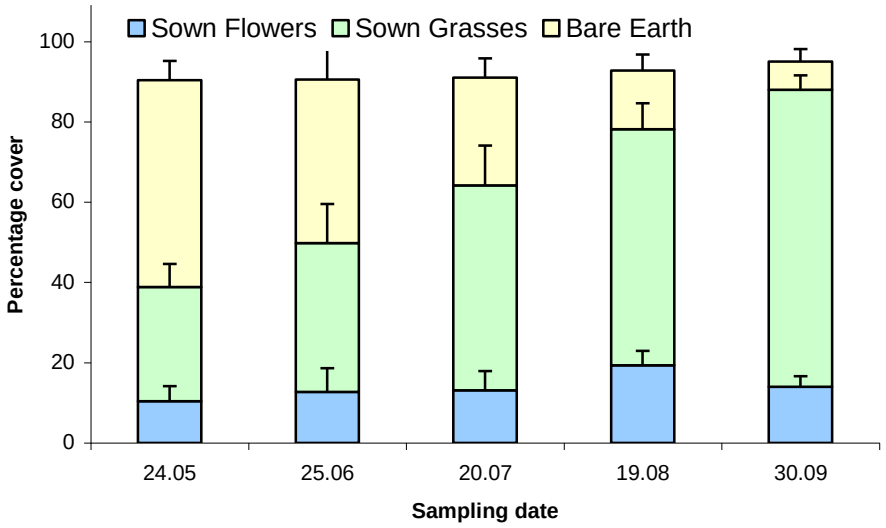

Figure 1. Mean % cover of sown grass species, sown flowering plants and bare earth present in a 25cm² quadrat in field margins on four plots at STC on dates between May and Sept. 2010. Means are displayed with SEs. n = 4 for all means.

Certain species have germinated and established in all FMs (e.g. borage, bishops weed, cornflower (both species), yarrow, fennel, clover (both species), vetches (both species), scorpion weed and tansy (though at the time of writing tansy plants were still small and easily confused with phacelia of a similar size)), though in some cases certain species have fared better, with regard to both establishment and flowering, in some replicate plots than others. It is suspected that these differences, where they exist, are the result of variations in environmental conditions between replicates. It is hoped that maturation of the FMs in future years, in combination with germination of any dormant seeds under more favourable autumn/spring conditions, will lead to improved homogeny between replicates.

Refining of the seed mixture will take place in the summer of 2011, immediately prior to formulating a FM seed mix for commercial-scale testing, when data for plant establishment and flowering in 2011 will be available to better inform this process.

Conclusions

- Despite harsh winter conditions several of the flowering plants sown have survived both the unusually cold winter and notably dry start to the year. However, some species were relatively low in abundance, or even absent from the FMs altogether.
- It is hoped that more typical environmental conditions in the winter of 2010/2011 and spring of 2011 will permit better germination and establishment from dormant seed.
- Data collected thus far suggests that the selection of plants included in the experimental FMs is capable of providing a diverse floral resource throughout the season, with selected species providing benefits when floral resources are otherwise notably scarce.

OBJECTIVE 2: Quantification of the impact of field margins on biological control agents, pests, pollinators and farmland birds

Materials and methods

INVERTEBRATE OVER-WINTERING

Methods unchanged from previous report. Catches from pitfall traps (sited within emergence traps) and emergence traps are now combined in order to increase efficiency of trap processing, sample filtering and sample processing.

INVERTEBRATE SUMMER SAMPLING

PITFALL TRAPS: Methods unchanged from previous report. Catches from pitfall traps and water traps are now combined in order to increase efficiency of trap processing, sample filtering and sample processing.

WATER TRAPS: Methods unchanged from previous report. Catches from pitfall traps and water traps are now combined in order to increase efficiency of trap processing, sample filtering and sample processing.

SWEEP NET SAMPLING: Sweep net sampling was attempted, but found to be prohibitively destructive to FM vegetation. As such, sweep netting has been substituted for visual invertebrate assessments. Visual counts are now made of beneficial insects in the crops, where this is undertaken in conjunction with pre-existing crop surveys for pests, and of both beneficial and pest insects in FMs and CMs (Control Margins), according to the method below:

VISUAL PLANT INSPECTION – MARGINS: Visual counts of pests and biological control agents were conducted in each section of the FMs and CMs corresponding to any crop. Visual counts involved a scan of the aerial parts of plants throughout the whole 2m width of the margin, accompanied by a more detailed scan of all plant parts on those plants at the outer edge of the margin. Insects were recorded as resident in the margin if observed visiting margin plants during this scan. Sections of margin, around 1m in width, were scanned in turn.

VISUAL PLANT INSPECTION - CROPS: Visual counts of pests and biological control agents were conducted on randomly selected plants at three sampling points within each crop (as described in the original protocol): CF1 (5m from the FM), CF2 (in the crop center) and CF3 (5m from the CM). For Brassicas, carrots and peas 10 plants were (randomly) sampled within 1m of each sampling point, and for cereals 30 plants were sampled. Parasitism rates were recorded by estimating the percentage parasitism on each plant. To identify parasitoid species, samples of parasitized pest aphids (i.e. mummies) were collected and reared through in the laboratory. Mummies were collected on the 28.07.10 (from Plot 1 where they were more abundant), where a total of 10 mummies were collected within a ~4m radius of each sampling point in carrots and cereals, 20 mummies were collected from the same sites in peas and 30 mummies were collected in Brassicas.

All of the above sampling has taken place at trapping sites from late May and has continued until point of harvest for each crop, and until late Sept / early Oct in FMs and CMs. In the case of Brassicas the crops in 3 of the 4 replicate plots had to be fleeced to prevent pigeon damage until the week commencing the 05.07.10. Thus, no data was collected from Brassicas until after this time.

HPLC

HPLC analysis will be run as stated in the original project protocol. In 2010 sampling was only conducted once at the beginning of Sept, due to both low wasp numbers early in the season and insufficient time being available to sample at the height of the field season. Resources that would have been used for samples from multiple dates were used to conduct a more detailed analysis of samples from one date. In future years improved early season resources for wasps, and increased staff time devoted to the project, should allow sampling to be conducted earlier in the season and at multiple points throughout.

EMORSGATE INVERTEBRATE ASSESSMENT

Methods unchanged from previous report, where sweep netting and observation of plant diseases was conducted on the 08.06.10.

POLLINATOR AND BIRD SURVEYS

BIRD SURVEYS: Methods unchanged from previous report, where surveys of farmland birds where conducted in the fields encompassing and surrounding each experimental plot at

STC, and a field equating to a similar overall area on a nearby site in Kelfied (i.e. the control site, see Appendix II).
POLLINATOR SURVEY: Methods unchanged from previous report.

GENERAL PLOT DESIGN AND MANAGEMENT

In order to test experimental field margins, four plots were arranged according to a randomised block design and managed as required. Plots measured approximately 61m x 104 m. FM and CM where 2m wide at each end of a 100m long cropping area. Cropping areas were split into four sub-plots for each of the four crops. Each crop was sown in a sub-plot approximately 12m wide with a buffer zone of 2m between all crops and at either end of the cropped area.

Results and Discussion

INVERTEBRATE OVER-WINTERING

Though all samples have been filtered and stored in 70% ethanol, insufficient time has been available since collection of samples ceased in May 2010 to process all sample contents. Full results of invertebrate over-wintering are expected by Spring 2011.

INVERTEBRATE SUMMER SAMPLING

TRAPPING: As in the case of over-wintering samples above, contents of pitfall and water traps could not be fully processed until the end of the field season. Nevertheless, casual observations were made on selected sampling dates of the number of larger carabid beetles trapped. Results (Fig. 2) have not been subject to statistical analysis as counts will be super-seeded by more accurate data once samples have been fully processed.

On average, carabid counts were higher in FMs than CMs for all crops on around half of the sampling dates shown, where higher average counts in FMs were typically seen earlier in the season (though it remains to be seen if this is also the case for trapping conducted before the 02.07.10 and after the 26.08.10). Mid-way into the season, carabid effective-abundance appeared to level out across the sampling area, possibly as a response to crops having closed in and cropped areas becoming a more attractive habitat for foraging beetles as a result. CMs would have also been more attractive to carabids at this time, by which point most had developed a relatively dense grassy sward.

Though unlikely to have been statistically significant in many cases (due to high variation), carabids often peaked in the crops during the trapping season. For cereals such a trend was observed in 3/4 of sampling dates, which may reflect the species composition of the samples (where certain carabids preferentially inhabit cereal crop interiors). In peas, carabid counts similarly remained relatively high throughout the crop in all weeks and in all weeks where sampling in the crop was undertaken a peak at CF3 was observed. This probably reflects the uneven nature of weed distribution noted in the pea crops in some plots. Carabid distribution in both crops in early weeks may also reflect attraction by microclimate during the notably dry trapping period (especially 02.07.10 – 08.07.10), where higher humidity might be expected in crop centers (cereals) or at certain trapping sites after non-homogenous irrigation (peas).

Overall, counts of carabids were higher earlier in the season. It is likely that this represents a natural peak in carabid effective-abundance during foraging/mating/oviposition of spring-reproductive species. This is supported by data from late May (not shown), in which carabid numbers could not be immediately ascertained in the time available to do so as very large numbers of individuals were trapped in most samples. An apparent resurgence of carabids in mid-late Aug probably also reflects natural population fluctuation.

Further information on carabids will become available as samples are fully processed over the winter.

Casual observations of the catch in water traps suggests that altering the colour of traps from yellow to green (see previous report) has succeeded in making them less attractive to flying insects. However, this has resulted in water trap catches being lower than expected in 2010. In order to resolve this problem, whilst still maintaining a ‘passive’ sampling technique, clear water traps have been sourced for use in 2011.

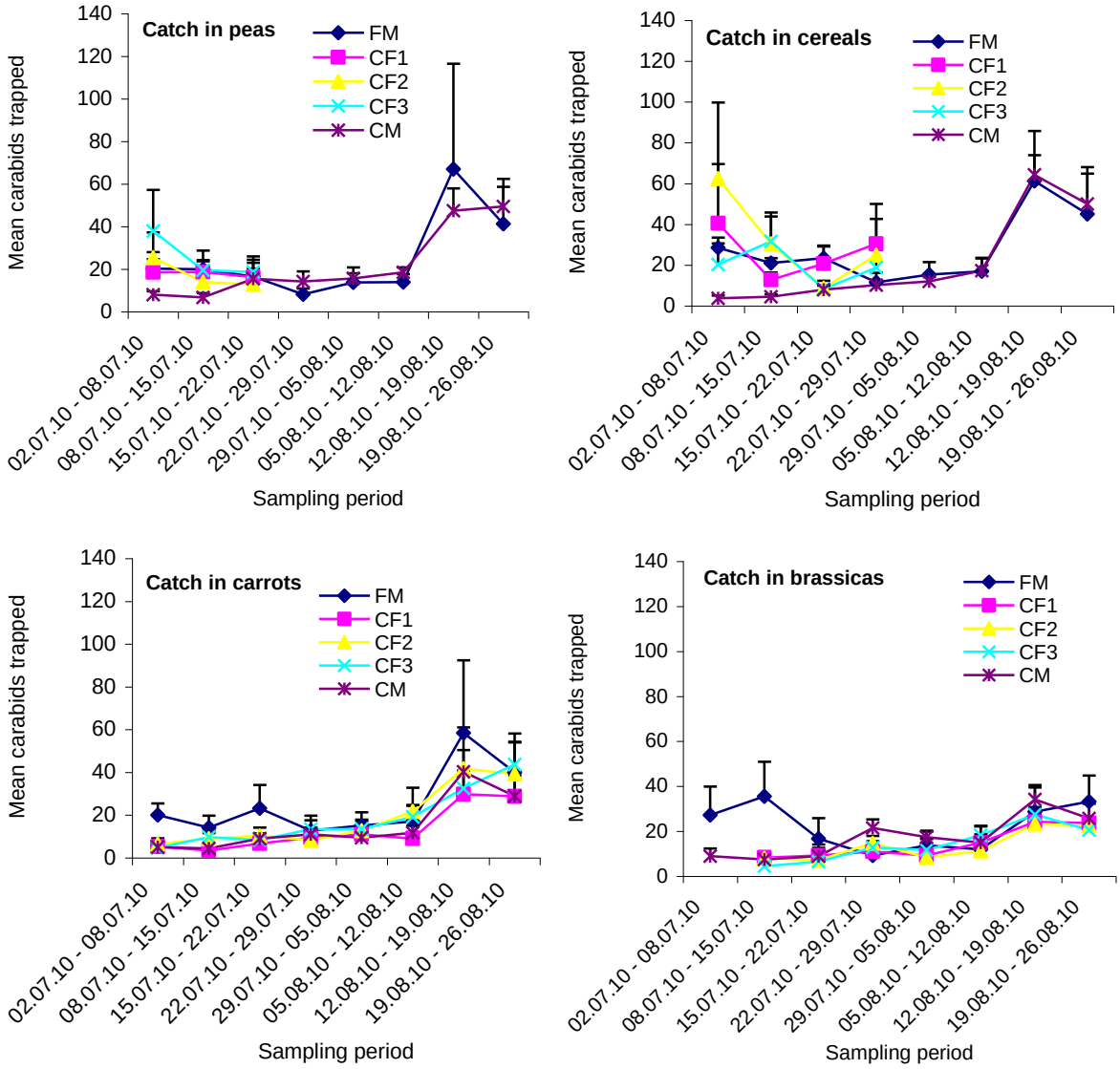

Figure 2. Mean larger carabid counts from pitfall trapping at different sites in different crops. Means are displayed with SEs. n = 4 for all means. Br = Brassicas; Ce = cereals, Ca = carrots; Pe = peas. FM = Flowering Margin, CM = Control Margin, CF1 = Crop Field 1 (5m from the FM), CF2 = Crop Field 2 (in the crop center), CF3 = Crop Field 3 (5m from the CM).

VISUAL PLANT INSPECTION - MARGINS: Visual inspection of FMs and CMs consistently provided good data for selected target assemblages of invertebrates (Fig. 3). Cumulative counts of the target groups were analysed (Fig. 3) and showed that all groups (except ladybirds) were significantly more abundant over the season as a whole in FMs.

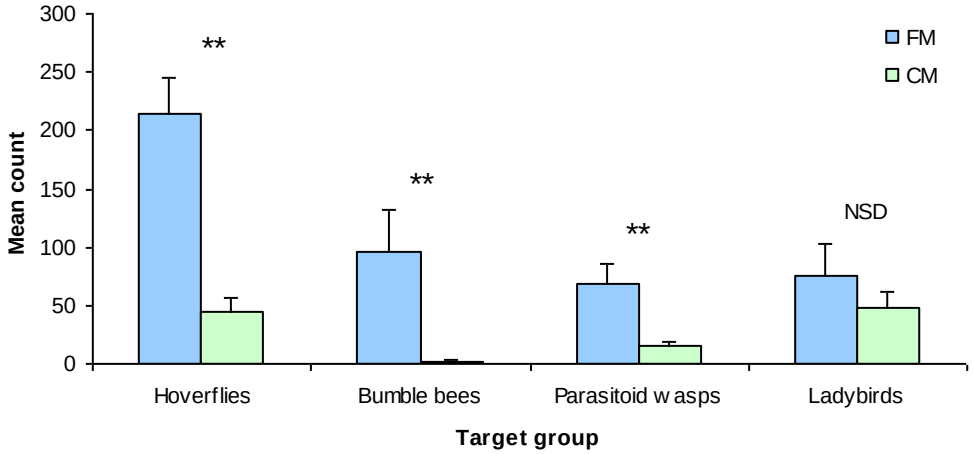

Figure 3. Mean cumulative counts of target beneficial insect assemblages from visual observation of flowering and control field margins. Means are displayed with SEs. n = 4 for all means. Data analysis was run on each target group using one-way ANOVA. Data for parasitoid wasps were log transformed and those for bumble bees were sqrt transformed to fit the assumptions of the test. NSD = No Significant Difference, *, ** and *** = $P < 0.05$, 0.01 and 0.001, respectively. For hoverflies, only adults were observed. For ladybirds counts include both adults and juveniles.

VISUAL PLANT INSPECTION – CROPS: Results for visual inspections of aphids in the four crops showed that absolute numbers did not vary between trapping sites for any of the four crops considered. However, further analysis will be attempted with 2010 data, where consideration of percentage distributions in crops, rather than absolute numbers, will be considered as a possible means to reduce high variation between plots which in many cases is likely to have obscured differences that would otherwise have been statistically significant. Consistent trends were noted in some crops for aphid parasitism to be improved nearer to the FM.

Nevertheless, trends were not significant statistically.

Parasitism rates *per se* reached 100% in both carrots and Brassicas, though such high values may be explained by low aphid numbers in the crop and chemical treatment, respectively. In peas and cereals parasitism peaked at lower levels of around 40% and 15%, respectively. However, it is likely that the overall percentage parasitism would have been higher in these crops, as only aphid mummies (and not parasitized aphids yet to form mummies) were considered when estimating the percentage of the aphid population that had

been parasitized. Samples of parasitised aphids will be processed with other 'stored samples' after the field season finishes to provide data on parasitoid species composition.
Crop counts of non-aphid pests and natural enemies *per se* tended to be low, with the possible exception of Brassicas in which increased abundance and diversity of these groups was to be expected. Though such low counts make analysis more problematic, in no instance did FM appear to be benefitting pest species. It is hoped that for many of these groups data from pitfall and water traps will provide for a more robust analysis. For certain groups, amendments to sampling protocols may be implemented to improve data for 2011, where, for example, it would be possible to count groups such as adult hoverflies and cabbage whites on the wing in the vicinity of trap sites, rather than recording only those individuals resident on selected plants.

HPLC

Samples of parasitoid wasps and floral sugars are in storage awaiting analysis at Lancaster University.

EMORSGATE INVERTEBRATE ASSESSMENT

Samples of invertebrates collected by both water trapping and sweep netting will be processed with other 'stored samples' after the field season finishes. Results of the plant diseases inspection revealed no diseases listed as a threat to any of the four crop species being used in the study.
To date around half of the species (flowers and grasses) included in the experimental field margin seed mix have been sampled at commercial sites. Further species will be sampled in later years.

POLLINATOR AND BIRD SURVEYS

Results for pollinators are shown in Fig. 4. In all, 198 individual bumblebees from seven species of *Bombus* (encompassing the 'big six' most common UK species) were recorded from FM across the five sampling dates shown. A mix of both short and long-tongued species were recorded, with *B. lapidarius*, *pratorum*, *pascuorum* and *terrestris* accounting for the vast majority of sightings on all dates. Only one individual (*B. pascouorum*) was observed in CMs during sampling.

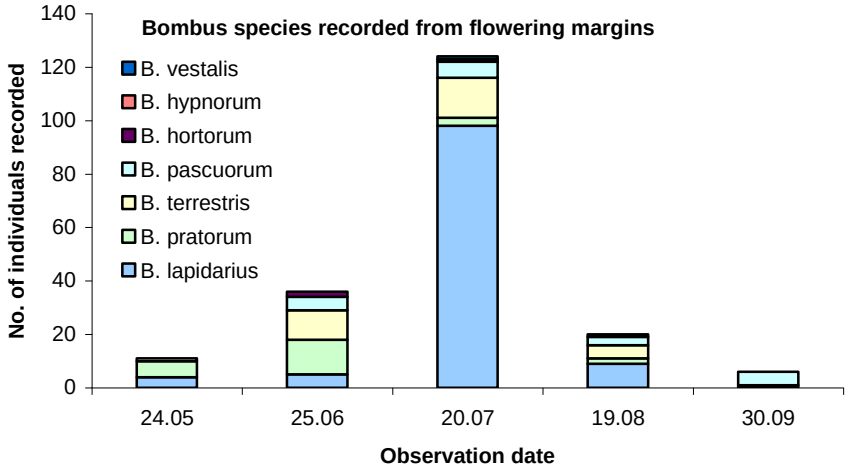

Figure 14. Total counts of *Bombus* species observed across all flowering margins at STC on five dates between May and Sept 2010.

Results with farmland birds suggested that there appeared to be a greater diversity of farmland bird species recorded from fields surrounding FMs than from a control field on nearby land (Kelfied). However, it is not possible to relate this to the presence of FMs as STC is a highly diverse site (with regard to natural vegetation, cropping and landscape features). Thus, even without FMs it is likely that the fields sampled at STC would compare favourably against more conventional farmland when considering bird diversity. Results from commercial-scale testing may prove more conclusive when considering any effects of FMs on farmland birds, where FMs will be installed on a larger scale into a less initially diverse setting, with baseline data also being available for comparison (following collection in 2011).

Conclusions

- For certain trapping techniques, the lag time between data collection and processing is too great to allow conclusions to be drawn at this stage. However, it appears that the presence of experimental FMs may be promoting certain groups of beneficial insects, at least in the FM itself. Bees, hoverflies and parasitoid wasps were all recovered in greater numbers in the FM as opposed to the CM, showing that the seed mix used is capable of stacking benefits for pollinators and pest natural enemies.

- Live aphid numbers varied little across sampling points in crops, though in some cases it is possible that FMs may have had a positive (albeit statistically non-significant) influence on aphid parasitism, especially when considering the rate at which aphids were parasitised on entering the crop. In no instance did FMs appear to have benefitted pests within any of the crops used.

- Sampling at a control site in Kelfield vs FM sites at STC suggested that FMs had an apparent beneficial effect on farmland bird diversity. However, it is likely that differences in farmland bird diversity and abundance between the two sites were pre-existing and could have been expected had FM been sown or not. More robust conclusions for farmland bird response to FM may be obtainable from commercial testing in future years.

- To date, none of the plants featured in the experimental field margin seed mix have been identified as a disease risk to the crops being used, though further sampling is required of species that were not being grown commercially in 2010.

OBJECTIVE 3: Development of the use of flowering field margins as part of a trap-cropping approach

Materials and methods

A series of trials were developed to assist in selecting trap plants for use alongside FMs in 2011 to control two key pests, carrot fly (*Psila rosae*) and cabbage root fly (*Delia radicum*) in carrots and Brassicas, respectively.

The first trial looked at egg laying in potted plants, with a second trial considering adult emergence from the same plant species. Results obtained, along with a review of previous research (e.g. George et al., 2007), have led to the selection of two trap crop species (one for use in carrots and one for use in Brassicas) to be used in 2011. Data obtained suggest that both trap plant species may limit pest development by being sub-optimal for larval development, whilst still attractive to egg-laying females, although this remains to be confirmed in the field.

Conclusions

- Trap crop species have been selected for carrot fly (*Psila rosae*) and cabbage root fly (*Delia radicum*) in carrots and Brassicas, respectively.

OBJECTIVE 4: Development of field margins that support predator population build-up through provision of non-pest prey in field margins

Materials and methods

FIELD ASSESSMENTS:

Flowering plants in FMs were assessed for aphids on a weekly basis during June, July, August and Sept by observing plants during flowering surveys and conducting more detailed sampling once aphids were observed. This more detailed sampling involved taking five plants at random from each FM (from all species present) and assessing them for aphid presence. If aphids were observed records were made of the approximate percentage infestation rate and number of aphids per plant. When found, samples of aphids were collected from FM plants and stored in 70% ethanol for later identification.

CAGED STUDY:

Twenty field cages were erected and used to house broccoli plants infested with aphids under four different treatments, where barley was used as the banker plant:

1. Broccoli only (x9)
2. Broccoli (x9) + flowering buckwheat (x3 pots of 6 plants)
3. Broccoli (x9) + non-flowering banker (x6 pots of 6 barley plants, infested with rose-grain aphid)
4. Broccoli (x9) + flowering buckwheat (x3 pots of 6 plants) + non-flowering banker (x6 pots of 6 barley plants infested with rose grain aphid)

Wild hoverflies (*Episyrphus balteatus*; mixed ages) were caught by hand, sexed and added to cages, where each cage received two males and two females. Populations of cabbage aphids and hoverflies were then monitored on a regular basis.

Results and Discussion

FIELD ASSESSMENTS:

Though aphids were slow to move in on potential banker plants, populations were observed on some plants in mid-July, including a number of species not initially identified as bankers. Nevertheless, any

populations present on FM plants were short-lived, where aphids were only recorded on one date throughout the sampling period (19.07.10).

Of the three originally-proposed banker plants only common vetch was observed to harbour aphids, though populations were seen on both cornflower and yarrow elsewhere on site. Aphids were also observed in FMs on borage, clovers and bird's foot trefoil. Even where they were observed, aphids were only recorded from plants in FMs in a single plot (Plot 3 for all plants except borage, where aphids were observed in Plot 4), and often at low infestation rates / densities.

The inconsistent occurrence of aphids across plots, and unexpectedly low infestation rate of plants such as cornflower and yarrow, may have resulted from the early developmental stage of the FM having allowed insufficient time for aphid populations to locate and establish themselves on FM plants. It is therefore hoped that non-pest aphid abundance in FMs will increase in 2011.

CAGED STUDY:

Fifteen days after adult hoverflies had been added to cages, average aphid numbers had risen in all treatments. Nevertheless, numbers in cages containing flowering buckwheat (both treatments) appeared lower, though only counts from cages containing buckwheat only differed statistically to the control. One week later this apparent treatment effect was even more pronounced, with cabbage aphid numbers in the control treatment being 36x higher than in treatments containing flowering buckwheat, and significant differences between both treatments containing buckwheat and both of those without. Numbers of hoverfly larvae/pupae recovered were relatively variable, though significantly more individuals were present in cages containing buckwheat than those without on both sampling dates.

When considering adult hoverflies there did appear to be advantage in including banker plants alone, or in combination with flower resources, earlier in the study. However, where adult hoverflies were present in cages containing banker plants alone they were unable to reproduce to the same degree as those in cages containing buckwheat flowers. By the final sampling point, just over a month after hoverflies had been added initially, around 16x more adult hoverflies were recorded from cages containing buckwheat flowers than those containing barley alone, with numbers in the banker-only cages not differing significantly from those in the control. This implies that rose grain aphid honey-dew alone was an insufficient sugar source to allow adult hoverflies to maintain optimum reproductive capacity and confirms that without a suitable flower source, banker plants are unlikely to promote prolonged pest control.

Conclusions

- Aphid load on banker plants in FMs was relatively low and short-lived in 2010. It is hoped that aphid populations on banker plants will increase in 2011, with aphids moving onto more established plants earlier in the season.
- Supplying alternative food/hosts for pest natural enemies on banker plants is likely to be most important when these are not available on crops.
- Though banker plants may support predatory stages of pest natural enemies, in order to promote optimum growth of the natural enemy population flower resources must also be present, at least in the case of hoverflies.

OBJECTIVE 5: This objective refers to future work.

OBJECTIVE 6: Development of a database on the compatibility of available chemical control options with various biological control agents to optimize integrated pest management decisions

Materials and methods

Using data from LIAISON (a Fera-held database on approved products), a database of all active ingredients available for application to the crops relevant to the current project has been generated. A compatibility matrix plotting these actives against commonly-used biological control agents relevant to Brassicas (the only crop that required treatment in 2010) has been generated using an existing database (Koppert).

Results and Discussion

The compatibility matrix was used to identify and eliminate treatment options for Brassicas in 2010, where compatibility matrices for other crops will be generated as required in future field seasons to ensure that the most up-to-date information is used (where if crops do not require treatment, matrices for commercial use will be generated toward the end of the project). For Brassicas, gaps in the compatibility matrix have been indentified and may be addressed in future years if resources allow.

Conclusions

- A compatibility matrix of chemical control options has been generated for Brassicas and has been used in 2010 to make decisions on which treatment to apply, and which treatments not to apply, to *Brassica* crops in the field.

OBJECTIVE 7: Quantification of the impact of perennial field margins on pest levels, crop quantity/quality and pest management costs

Materials and methods

Pest monitoring is reported on under Objective 2 (Science Section, current Report). Initial yield and crop quality data have been collected, though these have yet to be fully processed into a format suitable for presentation, where this objective refers to future work.

Results and Discussion

Pest monitoring is reported on under Objective 2 (Science Section, current Report). The remainder of this objective refers to future work.

Conclusions

Pest monitoring is reported on under Objective 2 (Science Section, current Report). The remainder of this objective refers to future work.

OBJECTIVE 8: Communication of best practice to commercial growers in the form of 'blueprints' for margin establishment and management, drawing upon knowledge generated in the proposed project as well as in ongoing European biodiversity projects

Materials and methods

As previously reported, information already generated in compiling the margin seed mix (Objective 1) will be used to partially address this Objective where a database has been generated compiling experience from functional biodiversity projects and is in the process of being developed into a more user-friendly format. This information will be added to as the project progresses, when future data collection and further developments/research from similar/related projects in progress elsewhere will permit 'blueprints' for margin establishment and management to be generated.

A project website has been developed and can be accessed at www.ecostac.co.uk. and features confidential pages accessible only to consortium members by the use of a password.

Results and Discussion

Results for this Objective have yet to be finalised, where as a result there is no scope for Discussion on this Objective.

Conclusions

There are currently no conclusions that can be drawn from this work.

OVERALL CONCLUSIONS

- FMs have established relatively well, especially in light of the harsh winter conditions and notably dry start to the year.
- Data collected thus far suggests that the selection of plants included in the experimental FMs is capable of providing a diverse floral resource throughout the season, with selected species providing benefits when floral resources are otherwise notably scarce.
- For certain trapping techniques, the lag time between data collection and processing is too great to allow conclusions to be drawn at this stage. However, it appears that the presence of experimental FMs may be promoting certain groups of beneficial insects, at least in the FM itself and perhaps into the crop, though further analysis is required to confirm statistical effects for some groups.
- The above point in mind, it appears that the seed mix selected is able to provide multiple benefits for pollinators and pest natural enemies, having the potential to stack ecosystem services as a result.
- Live aphid numbers varied little across sampling points in crops, though in some cases it is possible that FMs may have had a positive (albeit statistically non-significant) influence on aphid parasitism. Across several crops there were consistent trends for improved parasitism nearer to the FM. In no instance did FMs appear to have benefitted pests within any of the crops used.
- Sampling at a control site vs FM sites at STC suggested that FMs had an apparent beneficial effect on farmland bird diversity. However, it is likely that differences in farmland bird diversity and abundance between the two sites were pre-existing and could have been expected had FMs been sown or not.
- To date, none of the plants featured in the experimental FM seed mix have been identified as a disease risk to the crops being used, though further sampling is required of species that were not being grown commercially in 2010.

- Aphid load on banker plants in FMs was relatively low and short-lived in 2010. It is hoped that aphid populations on banker plants will increase in 2011, with aphids moving onto more established plants.
- Supplying alternative food/hosts for pest natural enemies on banker plants is likely to be most important when these are not available on crops.
- The results of a caged study with hoverflies suggest that though banker plants may support predatory stages of pest natural enemies, in order to promote optimum growth of the natural enemy population flower resources must also be present.
- Based on both the experiments conducted and previous work trap crops have been selected for cabbage root fly and carrot fly for use alongside FMs in 2011, with some suggestion that these plants may act as ‘dead-end’ trap crops.

Knowledge and Technology Transfer

A project website has been developed (www.ecostac.co.uk). Details of the project are also featured on the Project Database section of the European Learning Network on Functional AgroBiodiversity (ELN-FAB) website.

Overviews of the project via platform presentations have been/will be presented at the following:

- Open Horticultural and Potato Board Meeting, 26th August 2009, STC, York, UK.
- HDC Members Meeting, 5th October 2009, STC, York, UK.
- Waitrose Innovation Forum, 16th February 2010, Harper Adams, Newport, UK (invited lecture).
- IOBC Meeting – BioControl in the Americas, 11th - 13th May 2010, Niagara Falls, Canada.
- IOBC/WPRS Working Group for Landscape Management and Functional Biodiversity, 29th June - 1st July 2010, Cambridge, UK.
- European Congress of Entomology, 22nd - 27th August 2010, Budapest, Hungary (plenary lecture).
- Sustainable Agriculture Initiative Platform Meeting, Berlin, 27th Sept.
- VLM International Biodiversity Meeting, 13th October 2010, Bruges, Belgium (plenary lecture).
- Waitrose Agronomy Meeting, 1st – 5th Nov 2010, Cumbria, UK (invited lecture).
- AAB Conference – Advances in Biocontrol and Related Topics, 17th Nov 2010. Grantham, Leicester, UK.
- Functional Agro-biodiversity Meeting, 11th -12th Nov, Slovenia.
- Greening the CAP, 12th Nov, Bled, Slovenia.

The Project was also presented and discussed at a meeting of the ELN-FAB, May 2010, Copenhagen, Denmark.

Poster presentations providing an overview of the project have been displayed at:

- Lancaster University's Faculty Christmas Conference (Dec 2009).
- A Growers Meeting at STC on the 18.05.10.
- A Bayer Open Day at STC on the 22.06.10.
- A HGCA Cereals Event in July 2010.
- RES Insect Parasitoid SIG, 26th November 2010, York, UK

A scientific publication outlining the project has appeared in the 'Bulletin of the IOBC/wprs' and an overview of the project featured in the July 2010 issue of HDC News.

The project was featured as part of a general open day at STC on both the 18.06.10 and the 17.10.10 and received mention on BBC1s Look North (Yorkshire) on the 13.07.10. The projects field margins and Research Associate have also been filmed for inclusion in a BBC2 documentary, due to air in the autumn of 2011.

A Press Release outlining the project was sent to all project partners, as well as Lancaster University's Press Office, on the 06.09.10.

Finally, a project 'Friends List' has been initiated where interested parties may provide their contact details and receive non-confidential project reports, notice of project open-days, etc. To date this list remains relatively small, though it features a number of notable contacts including the RSPB, Natural England and Conservation Grade.

Glossary

FM = Flowering Margin
CM = Control Margin
CF1 = Crop Field trapping site 1 (5m into the crop from the FM)
CF2 = Crop Field trapping site 2 (in the middle of the crop, equidistant from the FM and CM)
CF3 = Crop Field trapping site 3 (5m into the crop from the CM)

References

Carvell C, Westrich P, Meek WR, Pywell RF, Nowakowski M, 2006. Assessing the value of annual and perennial forage mixtures for bumblebees by direct observation and pollen analysis. Apidologie 37: 326-340.

George DR, Port G, Collier RH, 2007. Selection of trap crop and companion plants for the management of pest insects in field vegetables. IOBC/WPRS Bulletin 30: 113-121.

Gurr GM, Wratten SD, Luna JM, 2003 Multi-function agricultural biodiversity: Pest management and other benefits. Basic and Applied Ecology 4: 107-116.

Olson D, Wäckers FL, 2007. Management of field margins to maximize multiple ecological services. Journal of Applied Ecology 44: 13-21.

Pywell RF, Warman EA, Sparks TH, Greatorex-Davies JN, Walker KJ, Meek WR, Carvell C, Petit S, Firbank LG, 2004. Assessing habitat quality for butterflies on intensively managed arable farmland. Biological Conservation 118: 313-325.

Vickery JA, Feber RE, Fuller RJ, 2009 Arable field margins managed for biodiversity conservation: A review of food resource provision for farmland birds. Agriculture, Ecosystems and Environment 133: 1-13.

Wäckers FL, 2004. Assessing the suitability of flowering herbs as parasitoid food sources: flower attractiveness and nectar accessibility. Biological Control 29: 307-314.

Wäckers FL, van Rijn PCJ, Bruin J (eds.), 2005. Plant-Provided Food for Carnivorous Insects: A protective mutualism and its applications. Cambridge University Press, Cambridge, UK. 368p.

Wäckers FL, 2005. Suitability of (extra-) floral nectar, pollen, and honeydew as insect food sources. In: Plant-Provided Food for Carnivorous Insects: a protective mutualism and its applications (eds Wäckers FL, van Rijn PCJ, Bruin J). Cambridge University Press, Cambridge, UK.

For further information:

Dr. David George

Lancaster Environment Centre

Lancaster University

Lancaster

LA1 4YQ

www.ecostac.co.uk