Project title:	Perennial field margins with combined agronomical and ecological benefits for vegetable rotation schemes.
Project name and number:	HortLINK HL0192.
Project leader:	Prof Felix Wäckers (Lancaster University).
Report:	Annual Report, 1st December 2009.
Previous report:	None.
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).
Project coordinator:	Prof Felix Wäckers (Lancaster University).
Date project commenced:	1st December 2008.
Expected completion date:	30th November 2013.
Consortium members:	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 Ltd, Produce World Ltd, National Farmers Union, Mark H Poskitt Ltd, D. Westwood & Son, J.F.D. Hargreaves Ltd, Waitrose Ltd, Sainsbury's Supermarkets Ltd, Linking Environment and Farming, Donald McIntyre (Emorsgate Seeds), Growing Wild Ltd, Bayer CropScience Ltd, Syngenta Ltd, Dow AgroSciences Ltd, Koppert Biological Systems BV, BCP Certis, Unilever U.K. Central Resources Ltd, Birds Eye Ltd.
Government sponsor(s):	DEFRA.
Key words:	Field margins, pest control, functional biodiversity.

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

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.

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 coordinator
Lancaster University

Signature  Date .....25.11.09.....

Report authorised by:

Professor Graham Harris
Co-Director of the Lancaster Environment Centre
Lancaster University

Signature ..... Date .....

CONTENTS

Grower Summary

Headlines

- An extensive database on candidate field margin plants, classifying 50 candidate plant species on the basis of more than 20 criteria, has been generated. A perennial seed mix that combines plants with the potential to increase bird and pollinator biodiversity and plants that enhance natural pest control in Brassica, carrot and pea rotations has been developed.
- The seed mix also includes banker plants to build-up populations of biocontrol agents in the absence of pests. Four field margins have been successfully sown using the above seed mix.

Background and expected deliverables

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, and 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 have developed the concept of designing flowering field margins for the specific purpose of optimizing biological pest control. The current project looks to build upon the above research and seeks to combine the biodiversity and pest-control benefits of perenial 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 optimize 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 an 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. Among others, the benefits of each plant species to pest natural enemies, pollinators and farmland bird species were considered in the selection process. Priority has been given to plant species native to the UK and where non-native species have been included in the seed mix, these have all been species that can be found growing in gardens and in areas such as roadside verges. Details of all attributes taken into account in the final seed selection, and the final margin seed mix (including fine grasses), are provided in the Science Section.
The success of this Objective, and hence any conclusions drawn from it, will be determined with later work on margin establishment and performance.

Objective 2 – Establish field margins and quantify margin impact on selected species
Margin seed mixes were prepared and sown at STC Research Foundation between the 17.09.09 and 21.09.09 at an overall rate of 42 kg/ha. Four experimental margins (76 x 2 m) were sown by hand, raked over by hand immediately after sowing and then pressed. A further complete margin was sown to allow an additional experiment to be conducted to determine the most appropriate/beneficial margin management regime. Further small plots (1 x 1.6 m) were sown to determine whether or not the non-native species in the mix are essential to the functional agro-biodiversity benefits.
At this stage no conclusions can be drawn on this Objective.
Quantifying margin impact refers to future work.

Objective 3 - Development of the trap-cropping approach.
This Objective refers to future work.

Objective 4/5 – Development of banker plant species.
Some of the plant species included in the final seed mix have been selected on the basis of having been identified as potential banker plants. Banker plants, through provision of high levels of alternative prey/hosts, are likely to be especially beneficial to pest natural enemies in allowing naturally occurring predators and parasitic wasps to build up populations before the pest arrives. In addition, it is hoped that they can be used as sentinels to monitor the abundance/activity of parasitic wasps and insect predators in the system. Details of those species selected as banker plants are provided in the Science Section.
At this stage no conclusions can be drawn on this Objective.

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. Further details can be found in the Science Section.
At this stage no conclusions can be drawn on this Objective.

Objective 7 - Quantification of margin impact on pests, crops and pest management costs.
This Objective refers to future work, although establishment of crop quality criteria is underway in preparation for next years field season.

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 is being developed and is expected to be online in late Dec/early Jan.
At this stage no conclusions can be drawn on this Objective.

Financial benefits
In accordance with the Government's longstanding policy of minimization 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.

Action points for growers
These will be expected as the project progresses.

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	30.08.09	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	30.08.09	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	31.09.09	NA	NA
1	**2.1**	Establish field margins at the four 2 acre sites	30.11.09	21.09.09	Sowing date brought forward to maximize seed establishment	None.
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	30.02.10	No change to target date at this time.	NA
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	31.10.10	No change to target date at this time.	NA
2	**3.1**	Establish and monitor effect of trap crops	31.09.10	31.09.10	No change to target date at this time.	NA
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 relate to future work. Shaded Milestones have been achieved as proposed or otherwise without significant amendment to Milestone dates.

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	30.08.09	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	30.08.09	As Milestone 1.2	None.
1	**1.4**	Consider tailoring of seed mixtures to crop types	30.07.09	30.08.09	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	30.08.09	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**	**30.09.10**	**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 species identified under 1.1	30.09.09	30.09.09	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 30.09.10**	**30.10.10 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	30.11.09	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 30.04.11	30.04.10 30.04.11	No change to target date at this time.	NA

1	**3.4**	Develop protocols for decision making on the timing, regularity and product for applying insecticides into the trap crops	30.12.09	30.12.09	No change to target date at this time.	NA
1	**3.5**	Investigate use of carrot fly predictive model (HDC product in Morph) as guide to pest activity	30.12.09	30.12.09	No change to target date at this time.	NA
1	**4.4**	Develop protocols for monitoring non-pest prey and associated predators in banker plants	31.12.09	31.12.09	No change to target date at this time.	NA
2-5	**4.5**	Determine the timing and extent of non-pest species populations on the banker plants	30.09.10 30.09.11 30.09.12 30.09.13	30.09.10 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	31.12.10	No change to target date at this time.	NA
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	31.12.09	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 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.

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 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.

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

Following an extensive review of the literature, more than 50 flowering plant species were selected for potential inclusion in the field margin seed mix to be tested. These species were initially chosen on the basis that they could be expected to provide multiple functional agro-biodiversity benefits in terms of encouraging pest natural enemies, pollinators and farmland birds *per se*. From this initial list, a final seed mix consisting of 22 flowering species was then formulated. This was achieved by considering both additional selection criteria and more detailed analysis of the potential benefits of each plant species to individual natural enemies, pollinator and farmland bird species. This final selection process was based on both the available literature and discussions with consortium-based seed companies and EU-based academics working in the area of field margin development. At this stage species were either included or excluded from the final mix by weighing their positive attributes against any negative or undesirable attributes they could potential bring to the field margin through their inclusion. Details of all attributes considered in the final seed selection are provided in Table 1. Relative amounts of each plant seed to include in the seed mix (see Table 2) were then determined based on whether the species under consideration was desired in the sward at a low, intermediate or high level. In deciding these relative inclusion levels additional factors, such as cost and seeds per gram, were taken into consideration.

Table 1. Plant species attributes considered when formulating the field margin seed mix. PNE = pest natural enemy.

Attribute	Criterion supporting inclusion*	Criterion weighing against inclusion*
Provenance	Native or naturalised species	Introduced species
Life history	Perennial	Annual
Flowering season	Prolonged or late/early	Short or typical of multiple species
Establishment likelihood	Moderate-high	Low-moderate
Environmental tolerance	Moderate high	Low-moderate
Competitive dominance	Low-moderate	Moderate-high
Weed status	Low-moderate	Moderate-high
Cost	Low-moderate	Moderate-high
Nectar provision *per se*	Moderate-high	Low-moderate
Pollen provision *per se*	Moderate-high	Low-moderate
Bird food provision *per se*	Moderate-high	Low-moderate
Beneficial to pest parasitoids	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to hoverflies	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to bees	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to other PNEs	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to insect diversity	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to farmland birds	Demonstrated in literature[1]	Not demonstrated in literature[2]
Beneficial to PNE wintering	Demonstrated in literature[1]	Not demonstrated in literature[2]
Potential food source for pests	Low-moderate[3]	Moderate-high
Potential host for pests	Low-moderate[3]	Moderate-high
Potential source of crop diseases	Low-moderate[3]	Moderate-high

*Satisfying the criterion for inclusion or exclusion under any given attribute does not automatically imply that a plant species was included or excluded from the final seed mix. In order for a species to be included or excluded, the criteria for inclusion or exclusion for ALL attributes of a given plant species were weighed against one another (where it should also be noted that all attributes were not considered equal).
[1]Preferably from multiple sources for multiple species. [2]Includes examples where plant species may have a negative impact on a specific attribute. [3]Only if previous criteria suggest inclusion.

Having determined the composition of the flowering part of the margin seed mix, fine grasses were selected for inclusion (see Table 2). Following a review of the literature and discussion with consortium seed companies, four grass species were chosen to represent those most suited to the aim of the study. It is envisaged that the selected species will provide cover sufficient to minimise weed emergence in the sward, but without being so highly competitive that they compromise the establishment of the sown flowering species.

Results

Full details of the seed mix sown are provided in Table 2.

Table 2. Details of plant species included in the field margin seed mix. Flowering plants and grasses are displayed separately, but were sown together (see Objective 2) as a single seed mix at 42 kg/ha (26 kg/ha grass : 16 kg/ha flowering plants).

Flowering plants					
Common name	**Family name**	**Latin bi-nomial**	**Desired level**	**% seed used by weight**	**% predicted in sward**
Fennel	Apiaceae	*Foeniculum vulgare*	Moderate	3.51	5
Greater burnet saxifrage	Apiaceae	*Pimpinella major*	Low	0.75	2.5
Yarrow	Asteraceae	*Achillea millefolium*	High	0.20	10
Perennial cornflower	Asteraceae	*Centaurea montana*	Low	3.07	2
Oxeye daisy	Asteraceae	*Leucanthemum vulgare*	Low	0.15	2.5
Bird's foot trefoil	Fabaceae	*Lotus corniculatus*	Low	0.61	2.5
Red clover	Fabaceae	*Trifolium pratense*	Moderate	1.07	6.5
White clover	Fabaceae	*Trifolium repens*	Moderate	0.91	6.5
Bush vetch	Fabaceae	*Vicia sepium*	Moderate	10.25	5
Oregano/wild majoram	Lamiaceae	*Origanum vulgare*	Low	0.03	2.5
Common sorrel	Polygonaceae	*Rumex acetosa*	Moderate	0.37	6
Cornflower	Asteraceae	*Centaurea cyanus*	High	6.15	10
Sunflower	Asteraceae	*Helianthus annuus*	Moderate	19.67	4
Borage	Boraginaceae	*Borago officinalis*	Moderate	10.25	5
Scorpion weed	Boraginaceae	*Phacelia tanacetifolia*	Moderate	0.59	2.5
Common vetch	Fabaceae	*Vicia sativa*	Moderate	18.44	7.5
Red dead nettle	Lamiaceae	*Lamium purpureum*	Low	0.29	2.5
Yellow rattle	Orobanchaceae	*Rhinanthus minor*	Low	1.02	2.5
Buckwheat	Polygonaceae	*Fagopyrum esculentum*	Moderate	20.49	7.5
Bishopsweed	Apiaceae	*Ammi majus*	Low	0.26	2.5
Viper's bugloss	Boraginaceae	*Echium vulgare*	Low	0.88	2.5
Teasel	Dipsacaceae	*Dipsacus fullonum*	Low	1.02	2.5

Grass species					
Common name	**Family name**	**Latin bi-nomial**	**Level wanted**	**% seed used by weight**	**% predicted in sward**
Common bent grass	Poaceae	*Agrostis cappillaris*	Ground cover	10	Background
Crested dog's tail	Poaceae	*Cynosurus cristalus*	Ground cover	50	Background
Red fescue	Poaceae	*Festuca rubra*	Ground cover	35	Background
Small cat's tail	Poaceae	*Phleum bertolonii*	Ground cover	5	Background

Discussion

The success of this Objective, and hence any discussion made upon it, will be determined with later work on margin establishment and performance.

Conclusions

The success of this Objective, and hence any conclusions drawn from it, will be determined with later work on margin establishment and performance.

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

Materials and methods

In order to maximise margin development an overall sowing rate of 42 kg/ha was deemed appropriate. This translated to 26 kg/ha grass and 16 kg/ha flowering plants. Seed mixes were prepared at Lancaster University on the 16.09.09 and then sown at STC Research Foundation between the 17.09.09 and 21.09.09. The four experimental margins required for the study were sown by hand, raked over by hand immediately after sowing and then rolled using a Cambridge Roller within 24 hours. Prior to sowing, margins had been subject to treatment with Roundup (glyphosate) at the recommended rate (4L/Ha) to kill any weeds (volunteers) present and were then cultivated.
In addition to the four experimental margins sown above, a further complete margin was sown to potentially allow an experiment to be conducted to determine the most appropriate/beneficial margin management regime. Further replicated small plots (1 x 1.6 m) were also sown with the standard seed mix, a seed mix consisting of only native species and selected single margin plant species. It is hoped that these plots can be used to determine if there if there is any functional agro-biodiversity benefit to be gained by including non-native plant species in flowering field margins.
This remainder of this Objective (i.e. quantification of margin establishment and impact) refers to future work.

Results

As data collection has yet to commence, it is inappropriate to include results at this time.

Discussion

As data collection has yet to commence, it is inappropriate to include a discursive chapter at this time.

Conclusions

As data collection has yet to commence, there are currently no conclusions that can be drawn from this work.

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

This Objective refers to future work.

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

Materials and methods

From the 22 flowering species selected for inclusion three individual species have been identified as having the potential to serve as banker plants, based on the density and/or diversity of alternative aphid hosts they are likely to support. Whilst these species will be subject to immediate monitoring as banker plants, other flowering plants in the sward will nevertheless be monitored in case any display similar potential as bankers.

Results

Details of selected banker plants and their associated aphids are provided in Table 3.

Table 3. Details of banker plant species and their associated aphids.

Common name	Latin binomial	Associated aphids
Cornflower	*Centaurea cyanus*	*Dactynotus jaceae*, *Trama troglodytes*.
Common vetch	*Vicia sativa*	*Acyrthosiphon pisum*, *Megoura viciae*, *Aphis fabae**
Yarrow	*Achillea millefolium*	*Aphis vandergooti*, *Coloradoa achilleae*, *Dactynotus achilleae*, *Macrosiphoniella millefolii*, *Macrosiphoniella sejuncta*, *Macrosiphoniella usquertensis*, *Microsiphum millefolii*, *Pleotrichophorus duponti*.

*pest species recorded from relevant host plant, but not expected at high density.

Discussion

As data collection has yet to commence, it is inappropriate to include a discursive chapter at this time.

Conclusions

As data collection has yet to commence, there are currently no conclusions that can be drawn from this work.

OBJECTIVE 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

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.

Results

A summary of the number of active ingredients available for use are provided in Table 4. This database will form the basis of a compatibility matrix (Milestone 6.2) for the beneficial insects targeted within this project. The likelihood will be that there will not be readily available data for all the approved actives, so the next step will be to utilize data from the Pesticide Usage Survey on the most commonly used actives to ensure that efforts can be targeted to the most important actives.

Table 4. Number of each class of active ingredient identified for use in the different crops. An excel file detailing the specific active ingredients included in the Table is available as an attachment to an email on request to d.george@lancaster.ac.uk.

Active Class	Brassica	Carrot	Pea	Wheat
Insecticide	23	15	17	22
Fungicide	13	15	12	55
Molluscicide	3	3	3	4
Herbicide	15	18	22	47
Growth Regulators	0	1	0	8
Biocontrol Agents	20	20	19	18
Other	5	0	5	5

Discussion

As data collection has yet to commence, it is inappropriate to include a discursive chapter at this time.

Conclusions

As data collection has yet to commence, there are currently no conclusions that can be drawn from this work.

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

This Objective refers to future work, although establishment of crop quality criteria is underway in preparation for next years field season.

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

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 data collection in the future will permit 'blueprints' for margin establishment and management to be generated. A website is under construction to aid in communication of 'blueprints' to commercial growers and is expected to be online in late Dec/early Jan.

Results

As data collection has yet to commence, it is inappropriate to include results at this time.

Discussion

As data collection has yet to commence, it is inappropriate to include a discursive chapter at this time.

Conclusions

As data collection has yet to commence, there are currently no conclusions that can be drawn from this work.

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Technology Transfer

A project website is being developed and is expected to be online in late Dec/early Jan. This website will feature both public and private pages, where the latter are to be used for dissemination of data confidential to consortium members.

Overviews of the project and details on seed selection and margin sowing have been 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.
- Project Meeting, 12th October 2009, London, UK.

A poster presentation providing an overview of the work conducted so far has been submitted for display at Lancaster University's Faculty Christmas Conference (Dec 2009).
Any publication expected from the above Technology Transfer activities will be sent to the Consortium for approval prior to release as per the Contract Agreement.