Project title:	Automated Field Margin Design for vegetable crops
Project number:	FV 334a
Project leader:	Pat Croft, STCRF
Report:	Annual report, July 2012
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Date project completed (or expected completion date):	31/01/2013

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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.

Pat Croft
Project Leader
STCRF

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Luke Tilley
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CONTENTS

GROWER SUMMARY

Headline

A database of field margin plant species has been reviewed and is being used to create a website for growers to provide seed mix suggestions tailored to their own crops and management. This will help growers to create evidence-based seed mixes that reduce pests and conserve biodiversity simultaneously.

Background

The horticultural industry faces a range of crop protection issues. Pressures to reduce pesticide use have led to the investigation of many alternative methods for maintaining pest populations below economic damage thresholds. Non-crop plants in farming landscapes can provide a range of important ecological services, including conservation of native flora and fauna and the enhancement of pollination and biological pest control (Gurr et al., 2003). Field margins can contain these plants and can play an important role in meeting current UK conservation targets (Vickery et al., 2004). Margin seed mixes have already been developed that target conservation of bees (Carvell et al., 2006), butterflies (Pywell et al., 2004) and farmland birds (Vickery et al., 2009). The effectiveness of field margins in boosting pest control strongly depends on their botanical composition. Not all flowers are suitable for supporting pest natural enemies, despite many biological control agents requiring flowering plants as a source of nectar and pollen (Wäckers et al., 2005). Often non-crop elements that are designed for bird or pollinator conservation do not simultaneously make resources available to biological control agents (Olsen & Wäckers, 2007). It is even possible that inclusion of certain flowering species in field margins can promote pests and their impact on nearby crops (Winkler et al., 2010).

Research is now being conducted to design multifunctional field margin seed mixes that can be sown to provide benefits to many target groups simultaneously. Such margins still provide desirable conservation benefits to farmland birds and pollinators, but by also providing resources to encourage pest natural enemies (without encouraging pests) these margins can play a much improved role in pest control than they have previously. To achieve this aim, the plants included in a seed mix must be carefully and individually selected based on many criteria and tailored to the crop next to which they are sown.

Ongoing research is also looking to develop field margins that can be employed on a longer-term basis, using perennial species in seed mixes (FV 334 / HortLink HL0192). Such

field margins should offer an improved return in the long-term, where repeat sowing after several years would not be necessary to retain the multifunctional margin.

It has been shown that growers are more likely to sow flowering margins if these can be tailored to their own fields and circumstances, and are designed to provide beneficial pest control, as well as pollination and conservation. Ensuring that margin mixes provide minimal resources to pest species is important to increase grower confidence in, and uptake of flowering field margins, particularly as evidence is emerging to suggest that this is not always the case (Winkler et al., 2010).

Whilst growers commonly construct their own seed mixes, developing mixes that are multifunctional is a knowledge-intensive and lengthy process, unlikely to be embarked upon by the majority of growers. However, an automated system capable of providing details of field margin seed mixes best suited to a grower's crop, management and budget, could make tailored, multi-functional margins available to all.

Summary

The database has been finished but the website is still under development. After a review of the literature, the database contains 109 species that are described using many criteria relating to the agronomy, benefit and general attributes of each species. To create an easy-to-use tool for growers, and after feedback, five criteria from the database were selected as most relevant. These relate directly to questions on the website:

1. lifespan (annual only or perennial)
2. provenance (to include naturalised non-native species or not)
3. soil type (clay, loam or sand)
4. cost of seed
5. pest associations (relating to the accompanying crop).

The remaining criteria from the database were all included in the development of the of the seed mixes but do not directly relate to the questions asked. Instead, they will be included in the information provided once the questions have been answered (e.g. red clover has been included in your mix because it provides nectar and pollen for pollinators, has a lot of extra-floral nectar for parasitoids and hoverflies and typically flowers from May to September).

The website, still under development, can be seen at http://peter.the-branding-iron.co.uk/stc/ and accessed using the password **entomos**. The website is currently being hosted by the IT consultants. Once complete, the site will transfer to the STC server and be

hosted by STC. Growers will be able to access the site through a link from the HDC website or directly through the STC website (www.stockbridgetechnology.co.uk).

There is a welcome page, explaining the background behind the project and the rationale for the website. The top of the page has tabs relating to:

Home – returns the user to the welcome page

Establishment – will contain notes on land preparation and margin establishment. To be developed with further consultation (to be included in best practice guidelines).

Management – will contain notes on how best to manage the margin once establish. Particularly relevant for mixes with perennial species included. Again, to be developed with further consultation with growers (to be included in best practice guidelines).

FAQ – will contain 'frequently asked questions' relating to margins generally and this project more specifically.

Links – will contain links to appropriate seed producers and information on field margins. Also included will be links to the AHDB, HDC, STC and ecostac (FV334 – Hortlink project HL0192) websites.

The workplan and activities of the project have been revised for Year 2. The main aim in the second year is finish the website and obtain grower feedback, thereafter changing the format and content accordingly. A factsheet will then be produced to promote the site.

Financial Benefits

1. Reduced labour costs and seed inputs where perennial rather than annual margin seed mixes are selected (where annual options would still be available if preferred), and through the use of seed mixes tailored to establish well under the conditions present on site.
2. Expected reduction in insecticide inputs as a result of improved pest control where field margins are used.
3. Provision of a quick and easy-to-use tool to generate field margin seed mixes, tailored to a growers crops, site, requirements and budget, for use with vegetable crops in the UK. This will potentially save time and money compared to conducting their own research.
4. Provision of 'best practice' guidelines to assist margin establishment and management, potentially reducing the risk of a flowering margin failing to establish.

Action Points

- Provide feedback on the website, once it is ready.
- Use the ‘automated margin design’ tool, once the final version is constructed.

SCIENCE SECTION

Introduction

This project aims to develop a user-friendly tool (website) capable of generating site-specific multifunctional field margin seed mixes for use in UK vegetable crops (brassicas, peas, carrots and potatoes). The mixes are considered multifunctional because they provide resource for biological control species, pollinators and birds simultaneously. At the same time, the mixes are also designed not to provide resource or host plants for crop pests. This project collates information from multiple sources into a database to generate a detailed prescription of annual and perennial flowering field margin plants. The outcome will be a site-specific suggestion of a seed mix which takes into account the crop, soil and budget of the grower as well as the grower's preference for a perennial mix or for a mix containing only native species.

In order to develop this program a confidential database was obtained from an existing project (FV334 / HortLink HL0192). The database was augmented and amended, and the most relevant criteria were taken forward to be used in the final program, after agronomic consultation. In order to make the database user-friendly for growers, a website has been developed to use the relevant details without revealing the large database at its source.

In summary, during the first year of the project, the database has been developed alongside the program (website), with consultation. The second year of the project will be dedicated to combining the database and program and obtaining feedback from growers. The knowledge transfer outcomes of the project will also be met during the second year (e.g. a HDC factsheet) (see Table 1 and Figure 4 for details).

Materials and methods

The database

The margin species database from HortLink project HL0192 was used as the basis for this project. A literature review was conducted in order to make additions and amendments to the raw database. The most important criteria from the database were selected, through consultation with the industry representative and agronomists from Agrii (United Agri Products Ltd). The original database from HL0192 is protected as intellectual property, and thus, could not be used in its raw state in this project. Instead, the project workers used it as the foundation of the program (website), where it will be converted to a user-friendly

interface for growers. This was done by selecting the criteria considered most important for commercial growers in terms of agronomy, pest reduction and conservation benefits (see Results).

The website

The website was developed by IT consultants under instruction from Luke Tilley and Pat Croft (STCRF) to provide an interface for growers to use, without revealing the confidential raw database from HL0192 and the amendments made to it during this project.

The website pages have now been developed, however, the database content is still waiting to be linked to the site (see Table 1 and Figure 4 for details of the revised activities and workplan, respectively).

Results

The database

The database has been finished. After a review of the literature, it contains 109 species that are described using the following criteria:

- **Provenance**
- Typical height
- **Pollen, nectar, bank plant and extra-floral nectar status**
- **Beneficial insect associations**
- **Bird associations**
- **Weed status**
- **Typical cost**
- **Pest associations (crop specific)**
- Availability from seed companies
- **Soil type preference**
- **Flowering period**
- Typical competitive status and dominance
- pH
- **Lifespan (annual, perennial, herbaceous)**

(**Bold type** indicates those taken into account while developing the program; **red** indicates direct questions for growers on the resulting website):

‘Typical height’ and ‘competitive status and dominance’ were not considered because they have been shown to vary greatly according to environment and management. These will be included as additional information under the headings ‘Establishment’ and ‘Management’.

‘Availability from seed companies’ was universally good and tended to be reflected in the cost of seed anyway.

pH was considered to be a variable that is corrected by growers as part of their land management. All the species in the database could survive over a range of pH values, none of which were at the extremes. Therefore, pH was not included as a website criterion and will be included in the additional information as well.

Five criteria from the database were selected that relate directly to questions on the website (in red above): lifespan, provenance, soil preference, typical cost and pest association (relating to ‘main crop’; see next section ‘The website’).

The remaining database criteria (in black bold) were all included in the development of the seed mixes but do not directly relate to questions asked. Instead, they will be included in the information provided to the grower once the questions have been answered (e.g. red clover has been included in your mix because it provides nectar and pollen for pollinators, has a lot of extra-floral nectar for parasitoids and hoverflies and typically flowers from May to September).

The website

The website is currently being hosted by the IT consultants, The Branding Iron Limited, once complete, the site will transfer to the STC server and be hosted by STC. Growers will be able to access the site through a link from the HDC website or directly through the STC website (www.stockbridgetechnology.co.uk).

At this stage, the web pages are working demonstrations. You will find some links are not working correctly, particularly page links, as content is yet to be included from the raw database.

A method of calculating different combinations and referring growers to the correct seed mix or “landing page” was developed.

From the database and after consultation, five criteria were identified as crucial to the selection of species included in the suggested seed mixes. Agronomic consultation led to

limiting the criteria as much as possible to ensure that each criterion is strongly related to the agronomy of the species in the seed mix or to its role within the mix (e.g. not feeding pests known to be associated with a crop, or flowering period). This limitation allowed the website to be easy to use as well as encompassing the crucial selection criteria. The five criteria chosen will result in 96 different seed mixes, each designed to offer maximum value to the grower for a particular suite of field and crop specifications. The criteria are:

1) **The main crop** grown next to the proposed margin - brassicas, carrots, peas and potatoes were chosen to be included after recommendation from the HDC FV Panel. This answer to this question lead to the omission of plant species known to be associated with pests.
2) **Soil type –** clay, loam or sand. These three broad soil types were chosen because they represent the types of soil relevant to the selection of species from the raw database. Growers will choose the type that best describes their land.
3) **Margin lifespan** – annuals only or perennials included. This allows growers to choose if they wish their margin to persist for multiple years. An annual mix may be more relevant to a grower's rotation. Whereas, a mix with perennials included would have a longer lifespan and allow the margin to become a more permanent landscape feature.
4) **Provenance –** native only or naturalised species included. Growers can use this selection criterion to choose whether they would prefer to sow only native species. No truly exotic species are included in any of the mixes. The naturalised species are those that are already present to an extent in UK habitats (e.g. *Phacelia tanacetifolia*)
5) **Budget** – economy or premium. This will allow growers to reduce costs should they want to. An "economy" mix will exclude or reduce in number those species known to be more expensive. An explanation on the role of the excluded species will be provided with the seed mix to inform the grower of the plant's value in a multifunctional mix. This will allow growers to decide on the balance between cost and function.

There are two more questions on the site, relating to the grower's details and location these will not affect the resulting seed mix; however, it will provide information on the regions where the website is being used.

The website (still under development) can be visited at http://peter.the-branding-iron.co.uk/stc/ . Mozilla Firefox is the preferred browser to view the site whilst it is still being developed.

There is a welcome page, explaining the background behind the project and the rationale for the website. The top of the page has tabs relating to:

Home – returns the user to the welcome page.

Establishment – will contain notes on land preparation and margin establishment. To be developed with further consultation (best practice guidelines).

Management – will contain notes on how best to manage the margin once establish. Particularly relevant for mixes with perennial species included. Again, to be developed with further consultation with growers (best practice guidelines).

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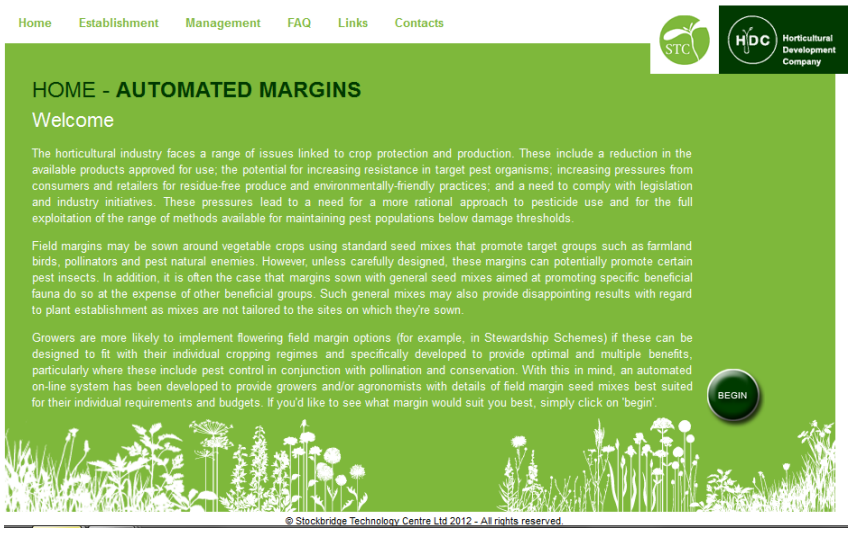

Figure 1. Welcome page for automated margins website

Click "BEGIN" to be prompted for a password. The password to access the site whilst under development is entomos.

You will be taken to the questionnaire page where you can supply the selection criteria listed above.

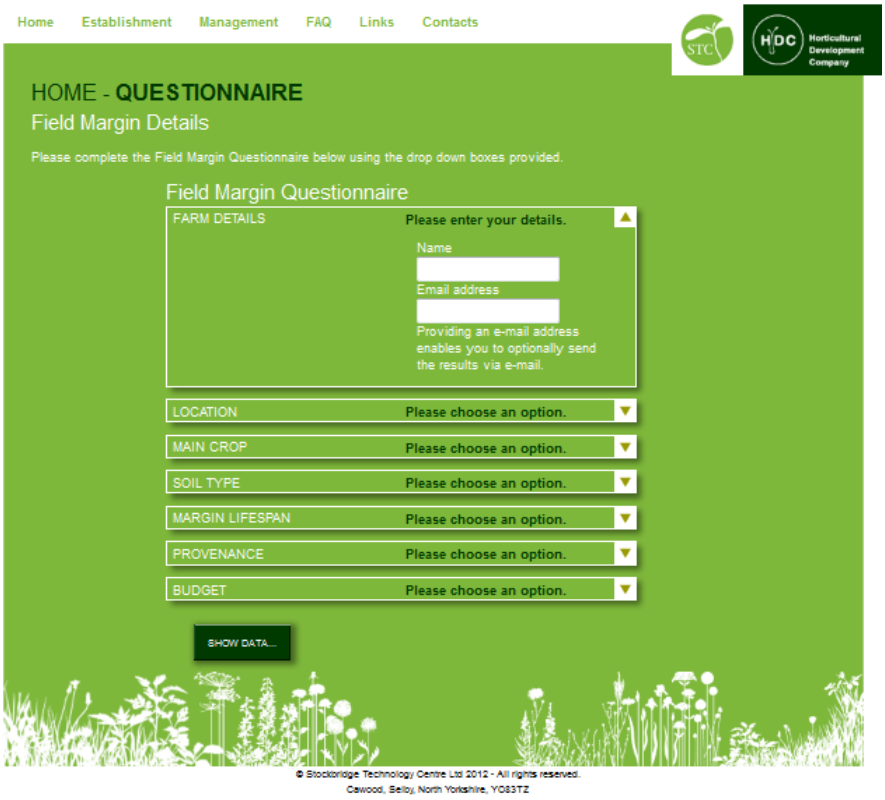

Figure 2. Questionnaire page

At all times, users can be returned to the welcome page or any of the other pages relating to the tabs at the top.

Once all six options have been chosen, click the “Show data” button. You will be taken to seed mix (landing page) which matches the criteria from the database that you have selected.

Whilst under development, the landing pages are not connected to the database. However, the layout can be seen.

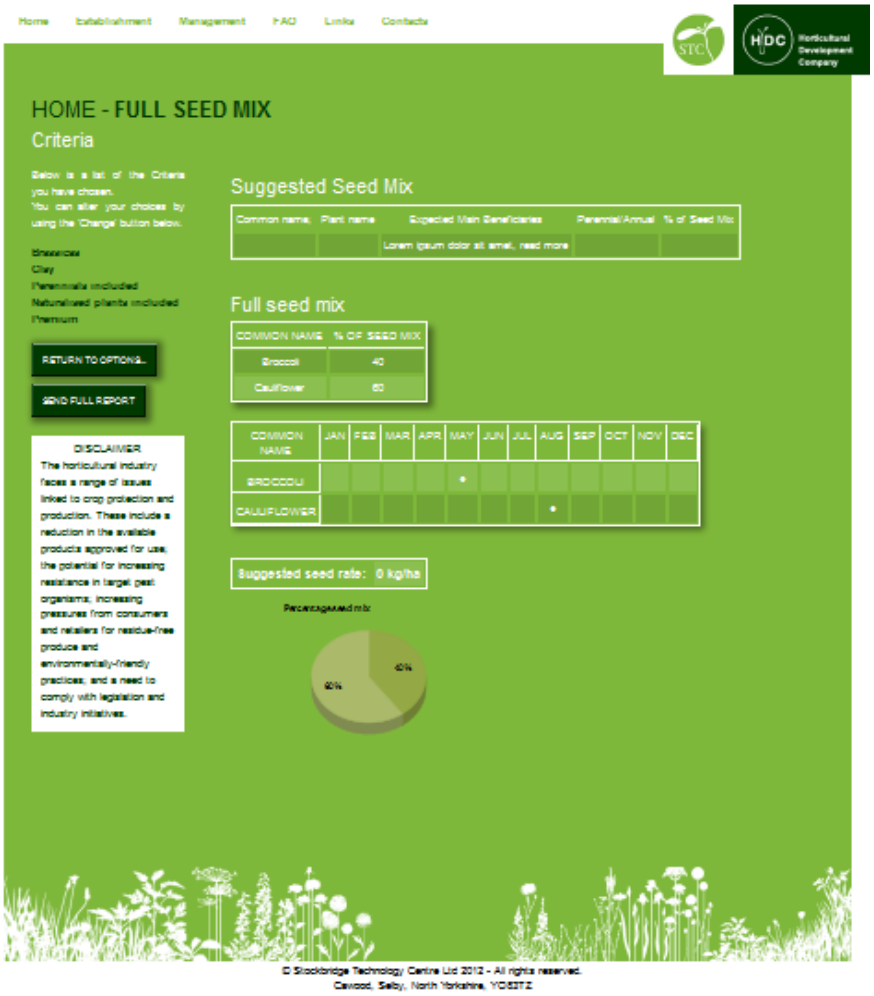

Figure 3. Seed mix page (landing page)

On the landing page there is also an option to have the report sent to an email address for printing. Users can return to the home page to begin the process again.

Feedback

Once the database has been connected to the website and the landing pages are finished, growers, consultants and agronomists will be asked for the following feedback:

- Was the site easy to use?
- How could its usability be improved?
- Did you find the questionnaire to be relevant to your farmland?
- What questions would you change, remove or add?
- Was the information on establishment useful? (found at the top of the page)
- Was the information on management useful? (found at the top of the page)

- What frequently asked questions (FAQ) would you change, remove or add? (found at the top of the page)
- What links would you like to see included? (found at the top of the page)
- Is the final seed mix presented appropriately? If not, how could it be improved?
- What crops would you like to see included next?

Discussion

The nature of this desk study project means that most discussion points have been covered in the preceding sections of the report and the 'Conclusions'. In need of some discussion, however, are the revised activities and workplan (see below).

Table 1 Revised activities for the project. Red indicates activities that are still to be done. Yellow indicates those activities already complete.

	MONTHS 1-12												MONTHS 13-24											
MILESTONE/ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1a. Discussion with academics																								
1b. Literature review (database)																								
1c. Discussion with programmer																								
1d. Grower consultation																								
2a. Program development																								
2b. Usability survey																								
2c. Project publication																								
2d. Project presentation																								
2e/3c. Project press release																								
3a. Package development																								
3b. Production of factsheet																								
3c. Continued development																								

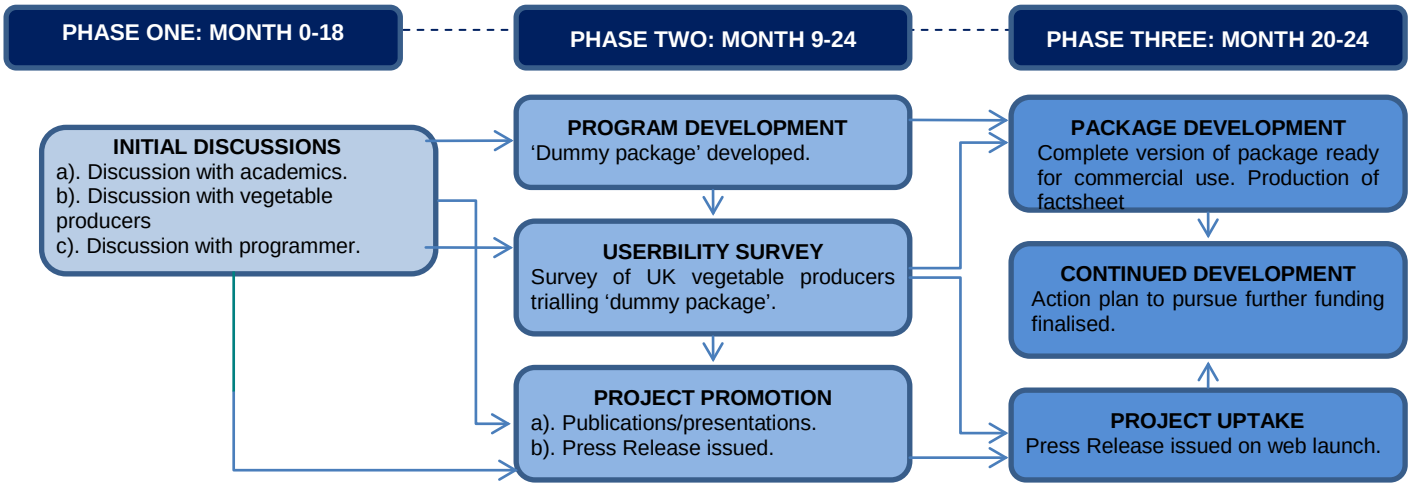

Figure 4. Revised workplan (taking into account the problems with IT contractors)

These revisions have taken place to compensate for the delayed IT support caused by unexpected withdrawals from the project (see material and method).

Conclusions

The project is progressing well, despite some problems with IT. The workplan has been adjusted to compensate for the IT delays. The database is complete and the website is close to completion. Once completed, the website will be provided to agronomists and growers, suggested by the industry representative, for feedback. This feedback will then be used to make changes in order to increase usability and uptake of the website. This, in turn, should lead to an increase in the understanding and uptake of multifunctional flowering margins.

This project will achieve its goal of providing an easy-to-use tool to help growers find information on flowering field margins and provide them with seed mixes tailored to their needs. A factsheet will be produced as a user guide for the website, as well as to provide information on field margin best practice.

Knowledge and Technology Transfer

HL0192 (FV334) project meeting – introducing the project consortium to this “spin-off” project

Invited lecture (Luke Tilley) – Environment Department, University of York

Glossary

Database – The raw and original data, from which the program (website) formulates the seed mixes

Program – refers to the website, the interface to be used by growers to access the information from the database that relates to seed mixes

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, Croft P, Northing P, Wäckers FL, 2010. Perennial field margins with combined agronomical and ecological benefits for vegetable rotation schemes. Landscape Management for Functional Biodiversity IOBC wprs Bulletin 56: 45-48.

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, Bradbury RB, Henderson IG, Eaton MA, Gric, PV, 2004. The role of agri-environment schemes and farm management practices in reversing the decline of farmland birds in England. Biological Conservation 119: 19-39.

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, 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.

Winkler K, Wäckers FL, Termorshuizen AJ, van Lenteren JC, 2010. Assessing risks and benefits of floral supplements in conservation biological control. BioControl 55: 719-727.

Appendices

http://peter.the-branding-iron.co.uk/stc/ - for FV334a project website, in development.

www.ecostac.co.uk – for HL0192 website

