FARM SCALE EVALUATIONS OF GM CROPS:

EFFECTS OF THE MANAGEMENT OF FIELD SCALE RELEASES OF GENETICALLY-MODIFIED HERBICIDE-TOLERANT CROPS ON THE ABUNDANCE AND DIVERSITY OF FARMLAND WILDLIFE

Interim Report

27 March 2002

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EXECUTIVE SUMMARY

1. This is the sixth Interim Report of the Farm Scale Evaluations of Genetically-Modified Herbicide Tolerant (GMHT) crops, covering the period October 2001 – February 2002. This period has covered the over-winter field studies of the second season of winter oil seed rape, site selection of the spring-sown crops for 2002, development of analysis techniques and preparation for the reporting of the spring-sown crops.

2. Seedbank samples have been taken from the winter rape fields sown in 2000, and field sampling form the winter rape sites sown in 2001 has continued on target.

3. Site selection for the spring-sown crops has gone well. At the time of writing, we have 27 spring rape, 34 maize and 17 beet sites, all within our targets for the year. Taken as a whole over the three years of the project, the total set of sites selected represent the required ranges of location and intensiveness.

4. The FSE work has been presented at the OECD conference "LMOs and the Environment," and an invited paper is being prepared for the International Biometric Conference.

5. The work programme up to March 2003 is proposed. This prioritises work on the spring-sown crops, with a view to submitting the papers for the proposed special issue by the end of February 2003.

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1 INTRODUCTION

This is the sixth Interim Report of the Farm Scale Evaluations of Genetically-Modified Herbicide Tolerant (GMHT) crops, covering the period September 2001 – February 2002. This period has covered the conclusion of the second field seasons of beet, spring oil seed rape and maize, and the start of the second field season of winter oil seed rape. It also covers the period of site selection of the spring-sown crops for 2002.

The following major tasks are due to be completed by September 2002:

- Undertake the remaining planned rounds of site selection
- Complete field work for all spring-sown crops and for the 2001-02 round of winter oil seed rape, except for follow-up studies of weed seedbank and seedlings
- Begin field sampling for the final round of winter oil seed rape
- Complete entry and validation of all data collected prior to May 2002
- Have in place a programme of sample sorting, data entry and validation to deliver a finalised database for the spring sown crops by the end of November 2002
- To have completed draft analyses using data from 2000-2001
- To have developed working documents that will form the basis of the final reports of spring-sown crops.

As will be seen below, we have made substantial progress towards these targets, and remain on track to complete the remainder by September.

2 RECORD OF ACTIVITY, OCTOBER 2001 – FEBRUARY 2002

2.1 Field activity

The field programme for this period has been concerned with the recording for the winter rape sites. Seedbank samples were taken between mid-August and the end of September from the 21 winter rape sites sown in 2000.

Thirty winter rape sites were sown in 2001. From these, we have taken seedbank assessments, weed seedling assessments, gastropod verge and field assessments, pitfall and vortis samples.

There have been reports that the field management of some of the winter rape sites have been inappropriate; without prejudging the auditing that will be done on due course, we have no reason at the moment to accept these reports as justified. There has been one incident of damage to sites, at a winter rape field. We applied the hygiene protocol developed to cope with Foot and Mouth Disease until we were given permission to stand this down in March 2002. Precautions against the spread of rhizomania remain in place.

2.2 Protocol development

The data collection protocols are now stable, apart from occasional minor clarifications.

2.3 Health and safety

No health and safety incidents were reported.

2.4 Training

A wash-up session for the 2001 field season took place in November 2001, and survey co-ordinators at the different sites met in March 2002 to agree training requirements for the coming summer.

2.5 Progress in data collation and validation

At the time of writing (mid March), all the data from spring-sown crops from 2000 have been collated and validated except for three batches of forms that are still in the system. Sample sorting for the spring-sown crops from 2001 is complete except for some batches of seed rain, pitfall and vortis samples. This work is due to finish by the end of April at the latest. Completion of the database for 2001 spring-sown crops will be within two weeks of this (see below). Entry of crop management data for 2000 and 2001 crops should be complete by the end of March 2002.

2.6 Progress on procedures for statistical analysis

Suzanne Clark has continued to update the Genstat programs for analysis. The latest version (Version 8) fits models that include the effects of treatment, in addition to year, distance and their interactions with treatment. These programs produce diagnostic plots to check assumptions concerning the error distribution.

In addition, extensions to this program have been developed that allow the fitting of a covariate, either at the half- or whole-field scale, and either in the form of a qualitative factor or a quantitative variate. The output displays several fits based on fitting the most complex model first and reducing the model by leaving out successive terms in all possible sensible combinations. These programs include diagnostic graphs such as partial-residual Cox plots, to allow the identification of systematic effects for inclusion. While it is possible to analyse across crops, using crop as a covariate, each crop will be analysed separately at least to begin with. Versions of all these programs have been written and tested for response variates both in the form of a count or (for vegetation biomass) in the form of a continuous variable. In addition, for each program there is: (i) a version available for individual Consortium scientists to download from the web and use on individual sets of data in an exploratory and interactive fashion, and (ii) a version linked to the database that enables an identical analysis to be generated in an automated form. The latter facilitates the storage at CEH Merlewood of verified results generated by approved analyses, required to satisfy the quality assurance procedures developed for the project.

2.7 Preparation for reporting findings

2.7.1 Crop management

The analysis and presentation of crop management data was discussed at a project meeting held at Broom's Barn on 7 March 2002. Data are to be include within the database will include:

- Previous cropping
- Previous rotation

- advisor type
- fertiliser, pesticide and herbicide treatments and dates
- estimated crop yield
- cultivation practices

2.7.2 Vegetation

A vegetation analysis workshop was held at CEH Monks Wood on the 22-23rd January 2002. After a general introduction, the initial structures and analyses required for the within field vegetation and seed bank papers were discussed. Version 7 of the automated Genststat programme was introduced and explained by the consortium statisticians and following this a 'hands-on' group session allowed attendees to use the programme to analyse some of the preliminary data available. Some basic covariate data was also included in these analyses. The meeting also discussed how best to implement a rolling programme of analyses and acceptable time plans for the delivery of the final report and paper writing.

2.7.3 Invertebrates

An invertebrate analysis workshop was held at Rothamsted on 6th and 7th February 2002 where introductions to the invertebrate data structures were followed by discussions of approaches to analyses. Hands-on group sessions allowed exploration of these approaches, using some of the limited within-field and field edge data from 2000. Limited covariate analyses using some field edge variables (e.g. spray damage, abundance of flowering species) were also done.

3 SITE SELECTION, 2002

3.1 Introduction

Site selection has now been completed for beet, spring oil seed rape and maize crops for 2002, bringing to an end site selection for the spring sown crops. Here we review the 2002 selections as of mid-March, commenting on how well we have achieved our objectives, noting that at the time of writing there will still some changes taking place in the selections. More information on the selection will be published along with the results of the spring-sown crops.

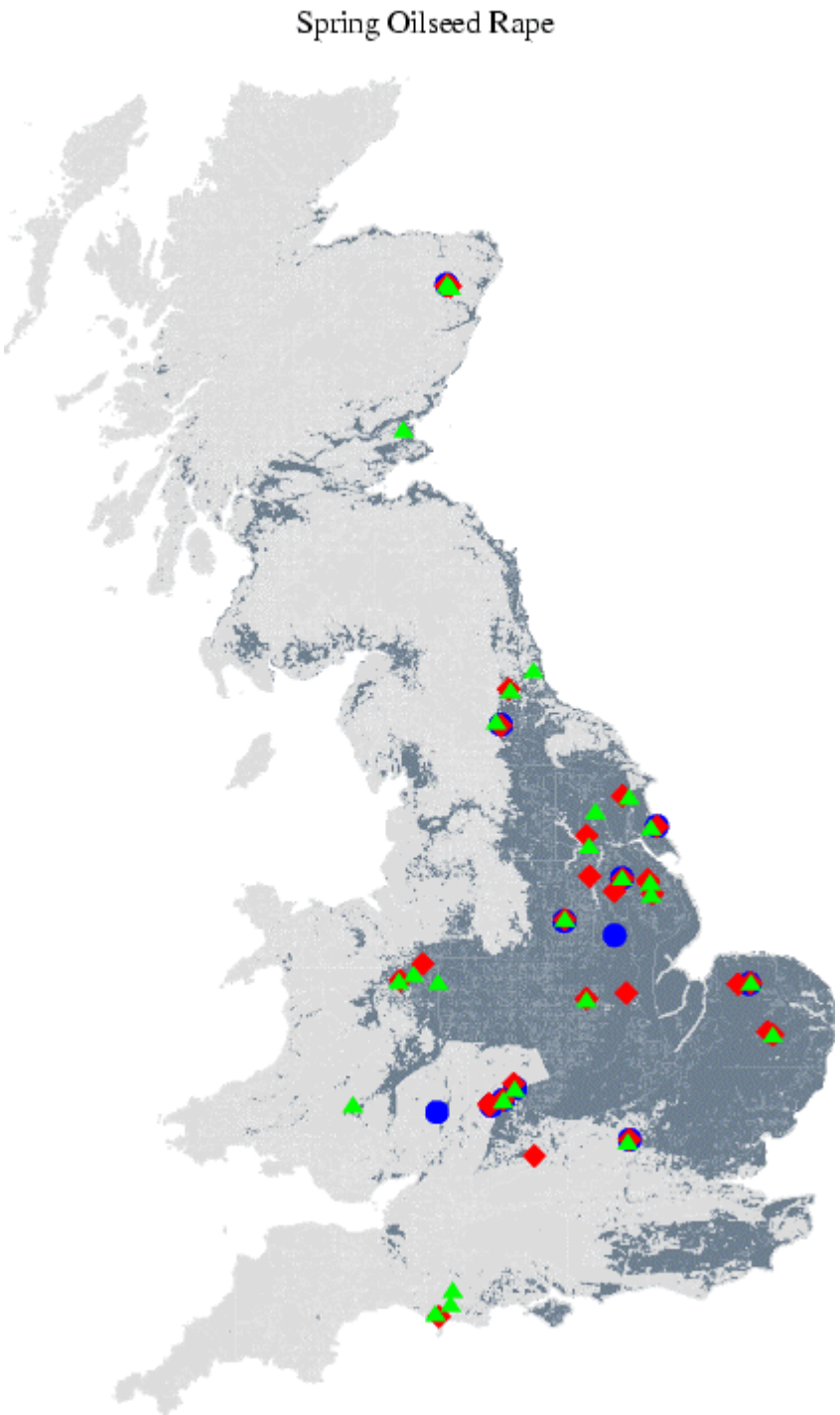

Fig 3.1. *Distribution of spring rape sites in 2000 (blue circles), 2001 (red diamonds) and 2002 (green triangles)*

3.2 Spring oil seed rape

In our previous report, we stated that

"We therefore propose to select around 25-30 sites of spring oil seed rape in 2002, with increased proportions in Scotland, the south-east and north of England."

We have selected 27 sites, with increased numbers in northern and south-western Britain, but without the hoped-for increased representation in south-east England (Fig 3.1). The new sites have a reasonable range of intensity and biodiversity scores (Fig. 3.2).

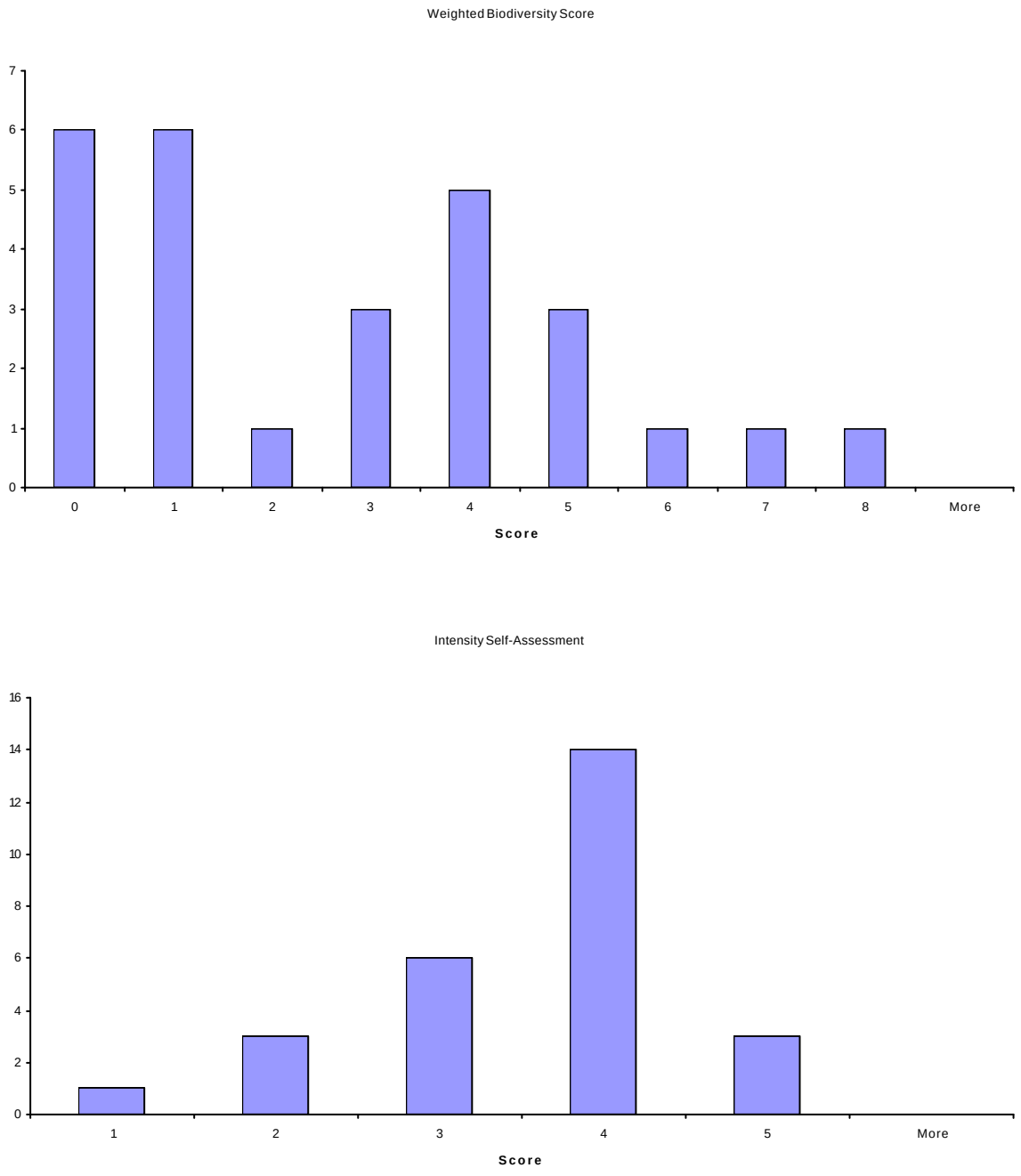

Fig. 3.2 *Biodiversity and intensity scores for spring rape sites, 2002.*

3.3 Maize

In our previous report, we stated that

"Selected sites must be well in excess of 26 since the number of selected sites should allow for some losses, we suggest that 33-40 sites would allow for this. It is important that efforts are made to increase the numbers of growers new to the trial in the last year to ensure a wider variety of types of farms and farm managements. The proportion of sites that include some form of farmland wildlife enhancement should be maintained or even increased."

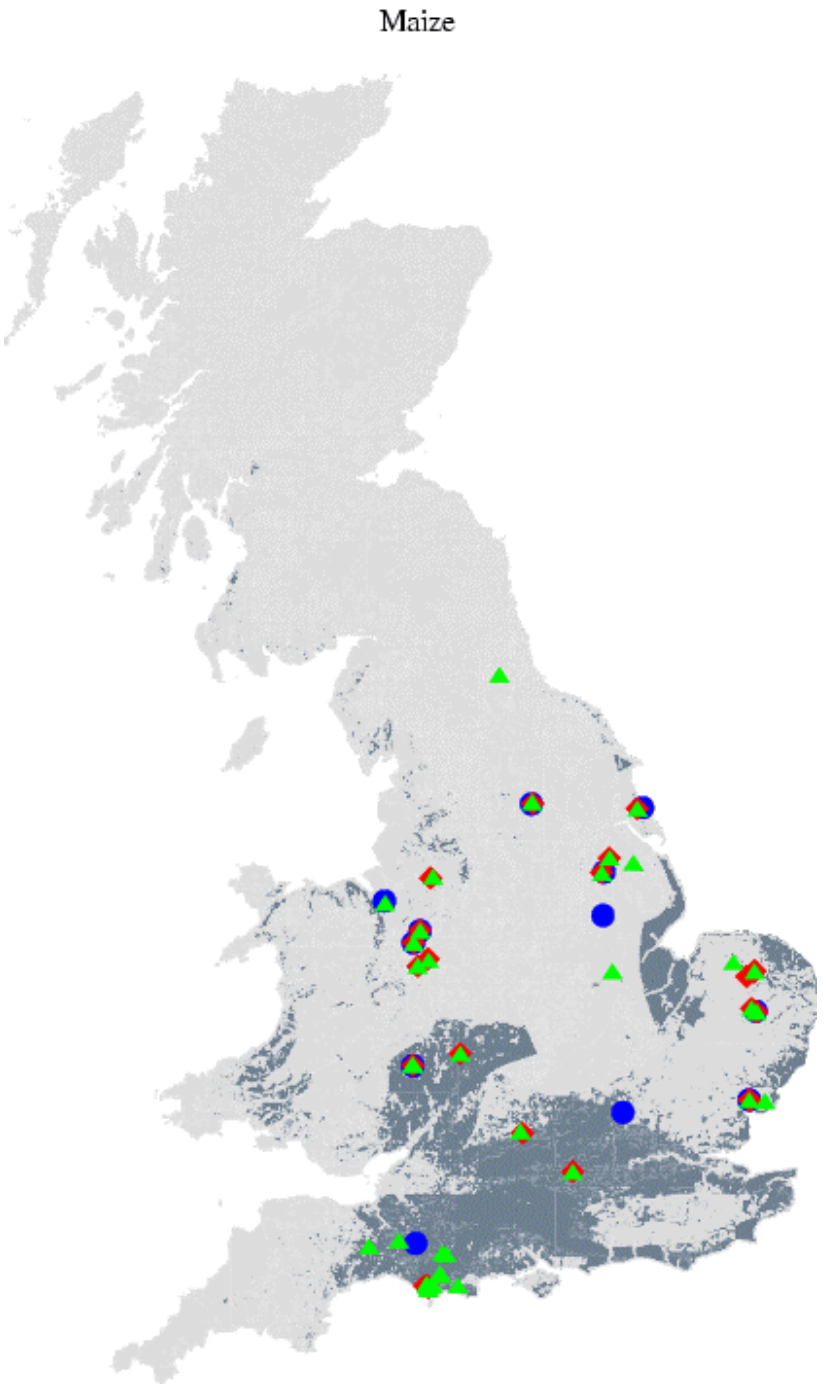

Fig 3.3. *Distribution of maize sites in 2000 (blue circles), 2001 (red diamonds) and 2002 (green triangles)*

We have accepted 34 sites for 2002, with a greater representation of the south-west of England and a much more northerly site than we have had before (Fig 3.3). Also, of these, the biodiversity values include several high scores (Fig 3.4), as required in order to ensure a reasonable range over the whole programme.

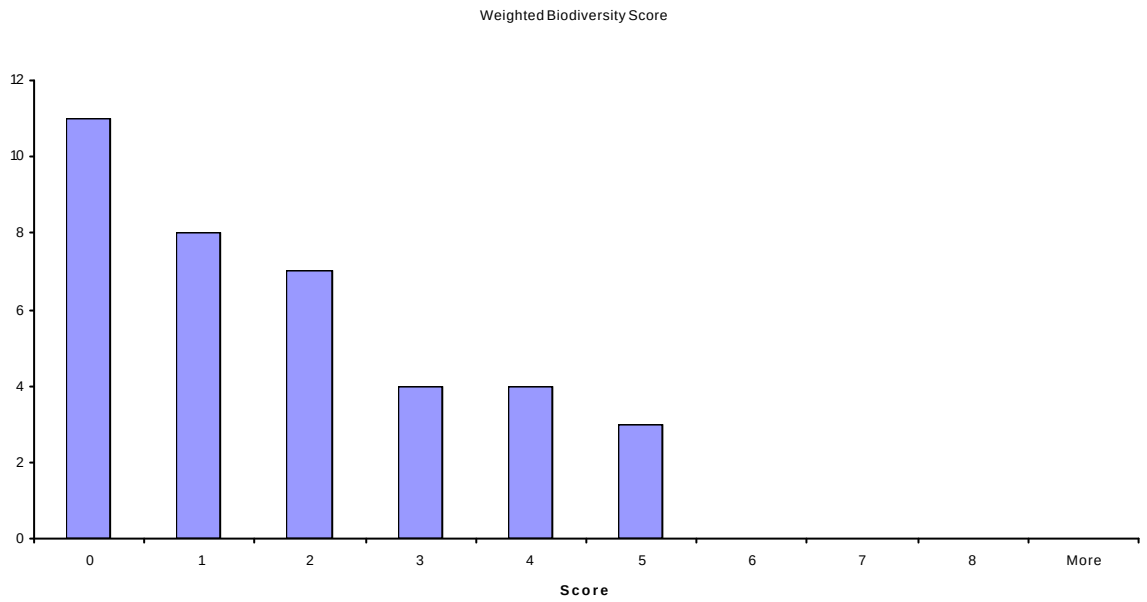

Fig. 3.4 *Biodiversity scores for maize sites, 2002.*

3.4 Beet

In the previous report, we wrote:

"We therefore conclude that around 15-20 beet crops, distributed more or less as the previous sites, will be appropriate to complete this study."

We have actually selected 17 beet sites, more or less retaining the existing pattern of distribution (Fig. 3.5), with, again a reasonable spread of biodiversity scores (Fig. 3.6).

3.5 Site selection, spring sown crops, conclusion

The statisticians have scrutinised the list of offered sites and made various suggestions for selecting the best subset of those proffered, having regard to factors such as reported location, intensiveness of production, previous involvement in the trial. The statisticians are content that the resulting selection represents an adequate balance of these factors. The selection also yields, as far as possible, a representative sample in line with the stated requirements of the SSC expressed in the minutes of their last meeting. Taken as a whole over the three years of the project the total set of sites selected represent the required range of location and intensiveness, as agreed between the Contractors and the SSC.

We are most grateful to SCIMAC and to the farmers for their support of the site selection process.

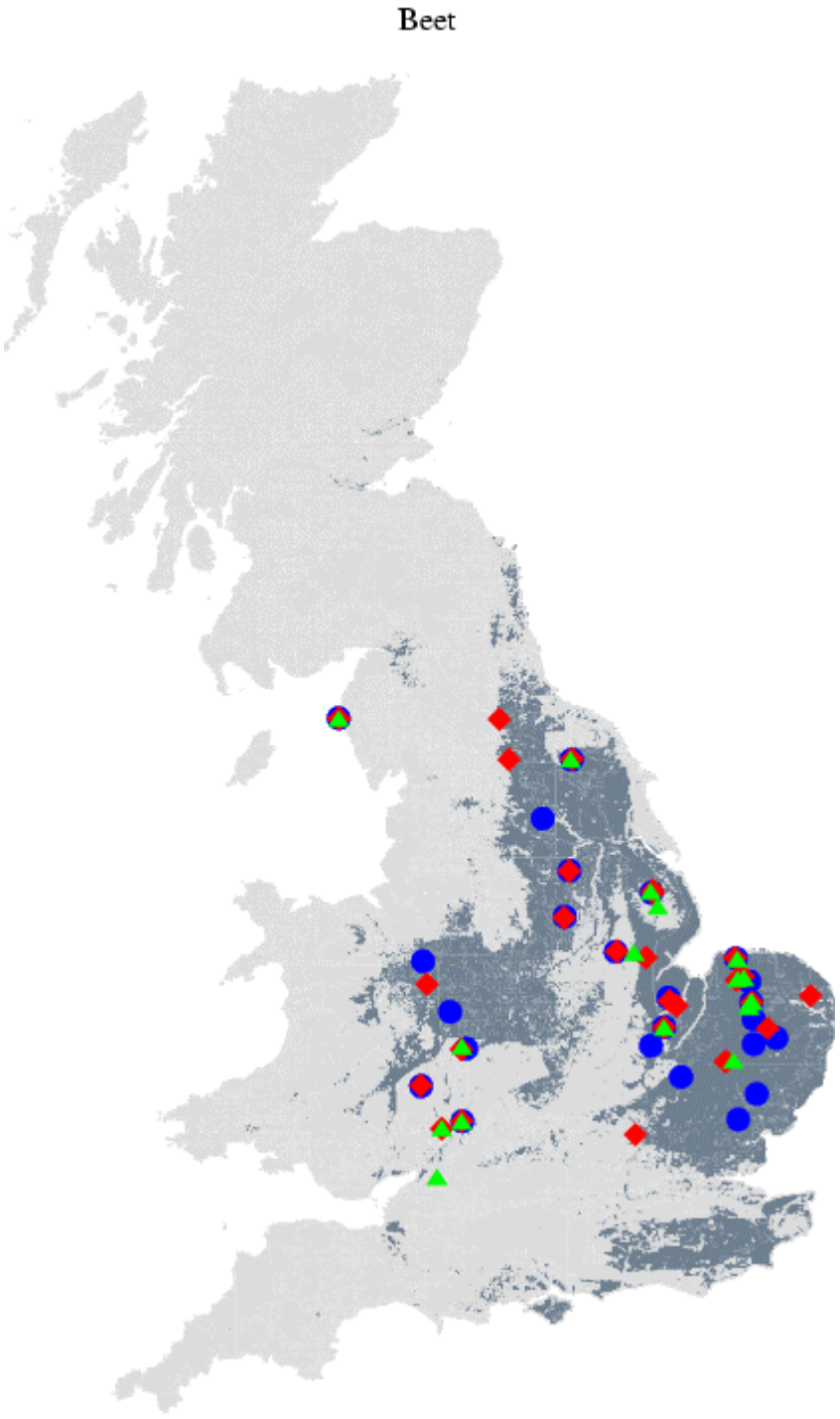

Fig 3.5. *Distribution of beet sites in 2000 (blue circles), 2001 (red diamonds) and 2002 (green triangles)*

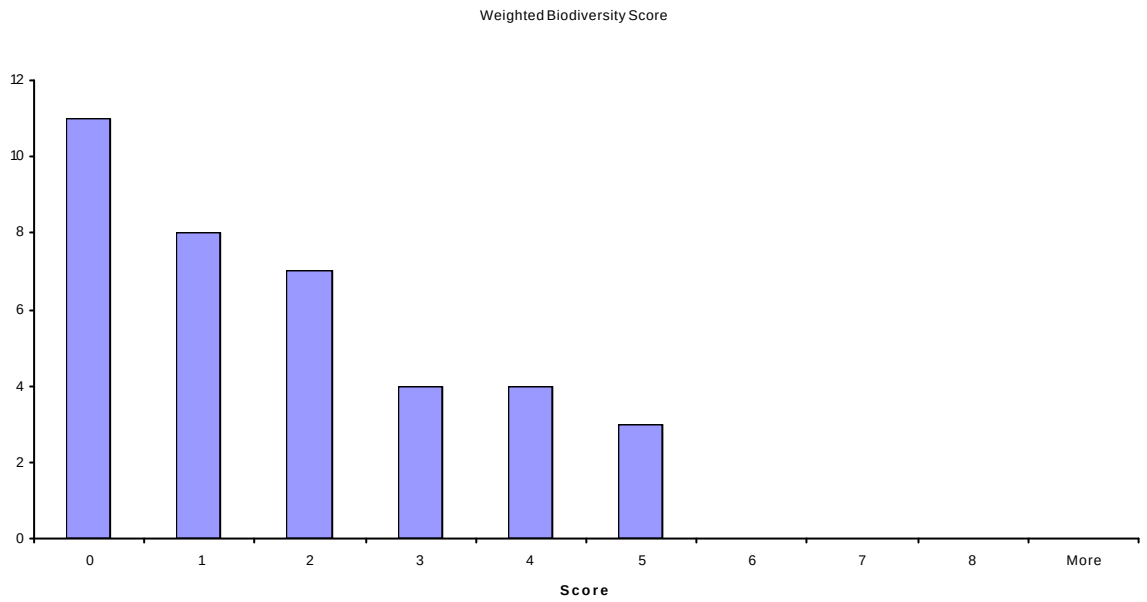

Fig. 3.6 *Biodiversity scores for beet sites, 2002.*

4 PUBLICATIONS AND PUBLIC RELATIONS

4.1 Publications during the period October 2001 – February 2002

There were no new major publications in the reporting period, although there was an item of correspondence in Nature replying to an editorial article. The four papers submitted to the Journal of Applied Ecology have been reviewed, and we have been requested to combine the material in these papers into one or two longer papers. These revisions are now well advanced.

Les Firbank has submitted a paper on the Farm Scale Evaluations as part of the Proceedings of the OECD meeting in Raleigh / Durham (see below).

A manuscript is almost ready to submit for the Proceedings of the International Biometrics Conference, Freiburg, July 2002 (to be presented by Peter Rothery)

> Peter Rothery*, Suzanne J. Clark and Joe N. Perry
> Design and Analysis of Farm-Scale Evaluations of Genetically-Modified Herbicide-Tolerant Crops

4.2 Major presentations, October 2001 – February 2002

Les Firbank

Panel discussant and presentation "Farm Scale Evaluation of GMHT Crops", OECD Conference on LMOs and the Environment, Raleigh-Durham NC, Nov 27-30 2001.

This was an important conference, bringing together expertise on Living Modified Organisms (LMOs) from around the world. The draft rapporteur's report includes the following on the FSEs:

> 25. In ecological impact assessments, in particular it is problematic to extrapolate from small scale field trials to the commercial scale cultivation. The UK approach to this problem has been to hold farm scale field trials that address scale, and integrate regional cultivation practices and farmer behavioural issues. The research process takes into account factors affecting credibility. It is entirely government funded, foresees peer review and public review of results. The science is done to the highest ecological and ethical standards possible. The driving issue of this study was the assessment of the impact of herbicide tolerant crops on farmland biodiversity. An ecological model is being developed using specific species indicators for this purpose.
>
> 26. The cost of these issue-targeted farm scale field trials may be prohibitive for routine case-by-case assessments of impacts of individual LMOs. Current regulatory requirements may impose a cost barrier for development of minor crops (eg many vegetables and fruits).

Further information is available on the OECD website

http://www1.oecd.org/ehs/raleigh/index.htm

and the proceedings will be published in due course.

Also:
Farm Scale Evaluations of GM crops. CSL, York, 12 December 2001

Matt Heard
Matt gave a presentation on the FSEs at Sheffield University in December, 2001.

Joe Perry
In March, Joe will be giving a talk in Cambridge on "GM crops and the environment" for the Cambridge Society for the Application of Research Symposium on GM Food

4.3 Scientific collaborations

We note that the results of the BRIGHT project are likely to be released at a similar time to the results of the Farm Scale Evaluations of spring-sown crops. Exchange visits are being planned by Les Firbank and Dr Mark Lonsdale, leader of the GM crops programme at CSIRO, Australia.

5 THE FUTURE PROGRAMME

5.1 Objectives for the period March 2002 – March 2003

We are scheduled to have reported on the spring sown crops by March 2003. Therefore, it is helpful to present in some detail the work programme for this period, even though we shall produce a further interim report in the autumn of 2002. Note that we are giving data sorting,

entry and analysis to the spring sown crops during this period, deferring work on winter rape as far as practicable.

We remain broadly happy with the reporting outline that we proposed in the previous report, accepting that the contents and numbers of suggested papers will be easier to determine as the process of writing continues. We are therefore dealing with this process by having 5 working groups within the project team, each responsible for a different element of the reporting, with extensive overlap of people between the groups. Three of these have already met for the first time, data exploration has started, and paper structures are being developed. We envisage an ongoing development of these papers, in iterations with members of the SSC, with a view to finalise the reports of the spring-sown crops for submission to the appropriate Journal by March.

Data will continue to be collected on these crops to facilitate further analysis and reporting in due course.

The following major tasks are scheduled for this period:

5.1.1 Undertake the remaining round of site selection for winter rape

The last round of site selection is due during the summer of 2002 for the final round of winter oil seed rape crops. These will be sown in summer 2002 and harvested in 2003.

5.1.2 Complete field work for the 2001 winter rape crop and the 2002 spring sown crops, except for revisits in following crops

All planned field work will have been completed for the crops harvested in 2002, except, perhaps, for late recordings of seed rain.

5.1.3 Begin fieldwork for 2002 winter rape crop

Sites must be marked out, seedbank samples taken, and over-winter records completed.

5.1.4 Complete scheduled re-assessments of 2000 winter rape and 2001 spring-sown crop fields

We are due to revisit crops harvested in 2001 in summer 2002 for re-assessments of weeds within the field. Also, we are due to revisit crops sown in the spring of 2001 in the spring of 2002 for seedbank reassessments, and to revisit the winter rape crops sown in the autumn of 2001 in the autumn of 2002.

5.1.5 Undertake re-assessments of weed seedlings and seedbanks of 2000 spring-sown and winter rape crops (subject to contract)

We have submitted costed proposals to extend the period of subsequent sampling to include revisiting all sites for soil seedbank and summer weed seedling assessments into the second season after the crop. If these are accepted, then we will revisit the fields that had contained the 2000 spring-sown crops for the last time.

5.1.6 Sample sorting, spring-sown crops 2001

A small number of samples remain to be sorted, this will be achieved by the end of April.

5.1.7 Sample sorting, winter rape 2001 – 02 crops

This work will continue as staff are available from other duties. The bulk of the remaining work on sample sorting for winter rape will begin in November 2002.

5.1.8 Sample sorting, spring sown crops 2002

In order to achieve our overall deadline, this work must be completed at the end of October 2002, entailing a programme of sample sorting that is concurrent with the main periods of the field programme, for the first time in the project. Staff are in place to achieve this goal, though the simultaneous requirements for fieldwork and sample sorting will be very demanding on the staff of the project.

5.1.9 Data entry and validation for all samples, spring-sown crops 2001

There remains some work remaining from the data entry and validation of the spring-sown crops of 2001; this is due to have been completed by April.

5.1.10 Data entry and validation for all samples, winter rape crops

This work has now been given low priority, and will only take place when opportunities arise until after the validation of the spring 2002 crop data is complete.

5.1.11 Data entry and validation for all samples, spring-sown crops 2002

This work will run concurrently with the data collection and sorting, and will be completed by November 2002. The aim is to turn around data from field to database within two weeks when no laboratory sorting is required. Emergence assessments of seedbank samples collected in spring 2002 will be complete by the end of August, with data entry and validation complete by the end of September.

5.1.12 Collection and entry of farm management data, 2002 crops

We will concentrate on entering farm management data that is critical to the reporting during and immediately after the field season. Our experience suggests that less-essential data will not be obtained in full until later in the winter.

5.1.13 Finalise automated analysis procedures

A standard program will shortly be developed to analyse data from studies that address differences in time. In these, the recorded count for a particular occasion, N_t is related directly to a similar count from a previous occasion, N_{t-1}. The natural response variate for analysis of such data is $y = \log N_t - \log N_{t-1}$.

The longer-term strategy will be to extend current Genstat software from one covariate to two covariates. For that program, planned for May 2002, fitting will be in the order covariate A followed by covariate B and then vice-versa. The strategy for the final analysis for publication will be to fit the most complex models required, possibly involving three or more covariates and the interactions between them, as one-off models. This final fitting will be done by statisticians in consultation with biologists. For the present, exploration will be by fitting individual covariates on a one-at-a-time basis.

During June or July 2002, a clearer idea of the analyses should emerge that will eventually form part of the final papers. At that stage the statisticians plan to look formally at the output from the diagnostics of each analysis, to compare the three models: lognormal, loglinear and beta=1.5, and to demonstrate that the final selection is robust. This will be done in collaboration with the SSC Statistics subgroup.

The programme of data analysis and reporting itself is being managed as five tasks within the project, namely vegetation, invertebrate, crop management, site selection and integrated assessment. Each of these groups involves an initial workshop that is being used to pilot and scope analyses, followed by a period of development of one or more draft manuscripts, that includes provisional outputs (e.g. using Year 1 and Year 2 data).

5.1.14 Vegetation analysis and reporting

Given the progress that has already been made, it is anticipated that an initial draft of the within-field vegetation paper should be available for discussion with members of the SSC by the end of May 2002, following a second internal workshop. There will then be cycles of feedback with members of the SSC until final drafts are presented to the SSC.

A potential structure of the field vegetation paper has already been submitted (previous report). A structure of the seedbank analyses is as follows:

<u>Comparison with historical data</u>
Comparison of FSE baseline with historical seedbank data – i.e. are there any major differences in our data from what is expected; especially in frequency distributions of abundance across sites, etc.

<u>Baseline diversity</u>
Description of initial seedbanks in terms of

- species, guilds, dominants, abundances (+ possibly within-field aggregation, species-acumulation curves)

in relation to -

- edge versus centre (possibly classified according to dispersal pattern, seed persistence and phenology) – particularly important because this comparison already demonstrates the sampling scheme detects a 40-50% difference (edge has more species and more seeds).
- the treatment halves

and stratified (variously) by –

- region (climatic zones or longitude/latitude), and crop
- management and site history (esp. previous herbicide, rotation, biodiversity indicators)
- soil and other site factors
- weed biomass and seed rain

Comparison of treatment effects on seedbank following the crop

These analyses can only be achieved in 2002 for those crops sown in 2000 and 2001 – i.e. this will not constitute a complete study of effects, that may or may not be typical of the full set of results.

Comparison matrix of

- treatment A and treatment B
- t_o and t_1
- edge and centre

Botanical indicators –

- all species and abundance
- rapid and slow decliners
- phenology groups
- aggregation groups
- community-scale descriptors

Startification categories –

- region (climatic zones or longitude/latitude), and crop
- management and site history, especially herbicide applied in experimental and previous years, rotation, biodiversity indicators
- soil and other site factors
- weed biomass, crop development and seed rain

5.1.15 Invertebrate analysis and reporting (including diversity reporting)

The pattern of reporting invertebrate data (including diversity data across taxa) is similar to that for vegetation, except that the delays in completing the invertebrate database will push this element of reporting slightly later, probably late June/early July. The reporting structure will separate the within-field data from those of the field-edge and will probably include a separate structure for diversity analyses. The following papers will include these approaches to analysis:

Invertebrates and Vegetation of Field Margin

- Characteristics of the field margin will be described using the amount of hedgerow, hedgerow height and width, presence of adjoining semi-natural habitat, flower density
- Effects of treatment on field margin vegetation (cover, flowering and seed production); bee and butterfly species; gastropod species and suction sampled invertebrates (functional group, species, other taxonomic group)
- Effects of margin vegetation and structure on invertebrates using covariates that may be affected by treatment (e.g. margin flower density)
- Effects of margin structure on treatment effects using field margin characteristics that are found to have a strong relationship with invertebrate abundance will be included as covariates in analysis of the effect of crop management on field margin biodiversity

Within-Field Epigeal Invertebrates

- Where appropriate, the effects of crop treatment on the abundance of species, taxonomic and functional groups of suction sampled invertebrates, pests and natural enemies and bees and butterflies will be analysed

- Management effects will include use of pre- and post-emergence herbicide and number of growth days to treatment
- Covariate analyses will include distance into crop, data from seed bank, weed and crop assessments, boundary structures as overwintering habitat and using cohorts of plant species, e.g. species with similar flowering times, food plants, architecturally important species

Within-field Surface Active Invertebrates
- Where appropriate, the effects of crop treatment on the abundance of species, taxonomic and functional groups of pitfall-trapped invertebrates and Gastropoda
- Management effects will include use of pre- and post-emergence herbicide and number of growth days to treatment
- Covariates will include distance into crop, data from seed bank, weed and crop assessments, boundary structures as overwintering habitat and using cohorts of plant species, e.g. species with similar flowering times, food plants, architecturally important species, use of molluscicides, cultivation methods (high/low disturbance)

Effects on Diversity of Plants and Invertebrates
- Diversity indices and species accumulation/species estimation software will be used to analyse the effects of treatment on diversity
- Use all species data: seed rain, weeds, seed-bank, Carabidae, Heteroptera, Gastropoda
- Since a minimum criteria for using a diversity index is a sample size of more than 500 individuals, samples will need to be accumulated across sites. This could be done using the CEH land classes, for example

5.1.16 Crop management reporting

Entry of crop management data will be entered by the end of the calender month following the activity; this is essential, as management data will be covariates for many other analyses. The paper structure will include the following points:

- Introduction

Description of "typical management" – references to papers and surveys – include rotations; recent changes – 5 to 10 y period; draft SCIMAC GM labels (and guidelines) and conventional herbicide labels; possible future changes – for MJM – non-GM situations

- Results

By crop and field; management of previous crops; agronomic operations, interactions with weather; can we identify management scenarios, do management / grower's opinions change between years for the same grower; management audit

- Discussion

Including possible changes noted to management and some of the implications of these changes. Comments re soil structures? As growers set for conventional tillage, no other option in trials? Less option for different use of each half (refer to survey). Growers tend to be mainly "year 1" new users – can be quite different in year 2. Processing of crops/B Sugar = harvest early.

5.1.17 Site selection

An internal workshop is to be held in early May, by which time the data on site location will have been collected, but data on the "biodiversity resources" of the sites, notably in terms of field assessments of weed seedlings and seedbank data, will not be ready. The overall timetable is therefore similar to the previous aspects of the reporting, except that this material may well be the first that is completed. It is anticipated that this analysis will assess the typicality of the sites in terms of geography, field characteristics and vegetation compared with farming associated with the selected crops, as far as possible; the paper structure will be developed at the internal workshop.

5.1.18 Introduction and context

This work is being undertaken under a separate contract by the FSE Consortium to DEFRA, and this is for a literature review placing the FSE work in its wider context of international GM and related agri-environmental research. This contract is due to be complete in October 2002, and may involve review from DEFRA and outside experts as well as from the SSC. It is expected to submit this as the Introductory paper to the results Special Issue

5.1.19 Integrated assessment and conclusions

This work is concatenated because of its reliance on progress on the previous elements of the reporting. In particular, we see no value in a workshop until July, and we suspect that the manuscripts will be developed slightly after the others.

6 PUBLICATIONS TO DATE:

6.1 Refereed Journals

Firbank, L.G., Dewar, A.M., Hill, M.O., May, M.J., Perry, J.N., Rothery, P., Squire, G. & Woiwod, I.P. (1999). Farm scale evaluation of GM crops explained. Nature, 339, 727-728.

Firbank, L.G. & Forcella, F. (2000). Genetically modified crops and farmland biodiversity. Science, 289 1481-1482.

Firbank, L.G. (2001). Industry and evaluation. Nature, 414, 843

6.2 Other publications

Firbank, L.G. (2000) Science meets policy: farm scale evaluations of genetically modified crops. *NERC News, Spring 2000*, pp 10-11.

Firbank, L.G. (2001).
The Farm Scale Evaluations of Genetically Modified Crops: the story so far
Pesticide Outlook **12** 116-117.

Perry, J.N. (2001).
Genetically Modified Crops. pp. 22-91 in: *Genetic Engineering, Volume XV in the 'Christ and the Cosmos' series*. Edited by Brenda Beamond. Proceedings of the Consultation held in London Colney, 20-22 April 2001. ISBN 0953036057.

Perry, J.N. (in press).
GM crops and the environment.
Proceedings of the Cambridge Society for the Application of Research Symposium on GM Food, Cambridge.

Schuler, T. H., Poppy, G. M., Woiwod, I. P. & Denholm, I. (2000) Impacts of GM plants on non-target arthropod fauna. In *WHO Seminar " release of Genetically Modified Organisms in the Environment: is it a health Hazard"*. Rome, Italy, 7-9 September 2000: http://www.who.it/Emissues/GMO/gmos.htm.

Woiwod, I., Dewar, A., Hawes, C. & Heard, M. (2000a)
Farm-scale trials for studying the effects of GM herbicide-tolerant crops on farmland biodiversity in the UK. *Antenna* 24, 66-68.

Woiwod, I. P., Dewar, A. M., Haughton, A., Hawes, C. & Heard, M. (2000b)
UK field-scale trials of GM herbicide tolerant crops to detect the environmental effects on invertebrate abundance and biodiversity. In *XXI International Congress of Entomology*, vol. 1 (ed. D. L. Gazzoni), pp. 314. Foz do Iguassu, Brazil: Embrapa.