HGCA

PROJECT REPORT No. 292

SECTOR CHALLENGE WHEAT PROJECT:

TRANSFERRING NEW CONCEPTS INTO PRACTICE TO IMPROVE THE COMPETITIVENESS OF UK WHEAT PRODUCERS

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TRANSFERRING NEW CONCEPTS INTO PRACTICE TO IMPROVE THE COMPETITIVENESS OF UK WHEAT PRODUCERS

by

[1]D Parish, [1]R Sylvester-Bradley, [2]J Spink
[1]W S Clark, [2]R Clare

[1]ADAS Boxworth, Battlegate Road, Boxworth, Cambridge, CB3 8NN

[2]ADAS Rosemaund, Preston Wynne, Herefordshire, HR1 3PG

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Abstract

Wheat production in the UK is intensive; its competitiveness depends on exploiting a climate that is conducive to growth with highly developed technology. Large increases in productivity have been due to improvements in plant breeding, pesticides and plant nutrition. However, it has proved difficult to resolve how best to use these technologies.

The physical environment for wheat growth in the UK is extremely variable, both in terms of the weather and soils. Crop growth is consequently variable leading to difficulties in optimising husbandry treatments. DEFRA and HGCA have recently been funding research programmes into the interpretation of differences in crop growth: one outcome has been a concept of 'canopy management' to optimise photosynthesis.

In order to maintain and improve the competitiveness of UK wheat production it is essential that the findings from this research are transferred effectively into farm practice. The comprehensiveness of canopy management (it covers variety choice, nitrogen nutrition, seed rate and sowing management, lodging avoidance and disease control) dictates that the transfer must effect *an ability to reason through crop processes*; transfer of husbandry instructions for each of the myriad different growing conditions would not be possible.

This project tested a novel two-tier method of technology transfer:

(1) intensive discussions with and training of selected lead farmers and their advisers, leading to supervised adoption of the new approaches by their businesses, and
(2) farmer to farmer transfer, with lead farmers being actively involved in the transfer of the new approaches to their neighbours.

Over a 3-year period 33 lead farmers (some accompanied by their advisor) went through an intensive training programme in which the researchers presented the key findings from their research. The understanding of 'canopy management' was based on the HGCA's "The Wheat Growth Guide". An initial pilot group of 3 farmers was actively involved in guiding the training programme and in the preparation of a supporting training manual for the project, "A Growers' Guide for Wheat".

The lead farmers then adopted the crop management practices on their own farms, and each farmer set up a group of 15 neighbouring farmers who were invited to monitor the new management practices and to understand the reasons for the changes in crop management practice. At each of the transfers, the farmers were supported by their adviser, the level of support varying according to need. By the end of the project 528 farmers had been involved in the training programme.

Professor Berkeley Hill of Imperial College, London, independently evaluated the project. His key findings were:

1. The project broadly met the objectives set
2. The training generated additionality in the use of the new crop management practices

3. The lead farmers adopted the new practices to a greater extent than those who only experienced farmer to farmer training
4. Application of the techniques continued beyond the first trial (limited numbers involved)
5. The farmers' adviser played a critical role in the success of the programme
6. Farmers were not able to attend all the meetings, due to business commitments, resulting in a shortfall in attendance at some farmer to farmer training sessions
7. The training of the lead farmers appeared to work well
8. The training guide "A Growers' Guide for Wheat" was seen as highly valuable
9. The farmers involved felt that the new crop management techniques had a positive effect on the profitability of wheat growing.

Aims and Objectives

Overall Aim

To improve the competitiveness of UK wheat production through developing the capacity of producers to optimise crop growth and to match management to growth and growing conditions, based on findings of completed DEFRA and levy-funded research.

Objectives

To establish a technology transfer mechanism that enables UK farmers to:

1. Optimise wheat growth through the manipulation of seed rates and nitrogen fertiliser to improve yield and quality.

2. Increase the precision with which the requirements for all inputs are judged according to crop growth, growing conditions and specific local needs with particular reference to pesticides and plant growth regulators.

3. Provide strategic guidance on the suitability of wheat varieties to specific locations.

4. Predict the crop protection requirements from the measurement of key traits of growth and existing information on fungicide response.

The Wheat Research Programme

The project results from the large programme of work which has been aiming to support 'precision decision'. The programme, with the associated benefits, was presented at the HGCA research conference in January 1998. The aim of this technology transfer project was to transfer the key findings of this research programme to the industry.

A summary of the benefits from the research programme is included in the table below (abstracts of research projects at Appendix 1):

CROP MANAGEMENT	£/ha
Avoiding stress through better variety choice, eg drought, take-all (improved yield)	22
Controlling seed rate to minimise seed costs and improve anchorage (20% lower seed costs)	10
Recognising weak anchorage, weak stem bases, and high shoot leverage to target use of PGRs (halve lodging costs)	6
Controlling canopy size through nitrogen and using the canopy to indicate seasons and sites when fertiliser efficiency is unusual	5
Controlling nitrogen to optimise ear numbers, so enhancing yields	9
Timing fungicides to match leaf emergence and according to canopy size so that doses an be minimised	9
Better product choice according to the spectrum of diseases	5
Recognising crops with good or poor buffering against late stress so optimising late fungicides and aphicides	3
TOTAL	69

Methodology

The transfer of technology was done in three stages:

1.

- Identification of leading farmers who are good communicators to act as demonstrators of the new approaches.
- Intensive discussion with and training of these farmers and their advisers on the new approaches to wheat management, supported by field demonstration.
- Intensive training of these farmers in the crop assessment techniques required to adopt the new approaches to wheat management.

2.

- These leading farmers to adopt the new approaches to wheat management on a commercial scale, supported by their advisers and the researchers to ensure solutions to practical problems.
- These farmers to assist in the demonstration of the new approaches to wheat management to other groups of farmers in their area.

3.

- To evaluate through surveys the acceptance, practical advantages and problems of adopting the new approaches.

Planned Programme of Events

The project was in the following stages:

Summer 1998

1. In the summer of 1998 three farmers and their consultants received ‘training’ in the techniques of ‘interactive wheat agronomy’ (decision-making according to crop assessment), from researchers who had developed this approach, covering the areas of:

   - variety choice (by John Spink),
   - nitrogen nutrition (by Roger Sylvester-Bradley),
   - seed rate management (by John Spink),
   - lodging avoidance (by John Spink) and
   - disease control (by Bill Clark),

   but starting with training in growth and development of the wheat crop (by Roger Sylvester-Bradley), as described in the HGCA booklet ‘The Wheat Growth Guide’.

2. A set of ‘training notes’ was produced (A Growers’ Guide for Wheat), which converted the scientific messages discussed in the training into a practical decision-

making guide, suitable for use by all farmers and their advisers in this project. These notes were then used as a training aid for the next stages of the project.

Autumn 1998 to Summer 1999

3. For the harvest year 1999 each of the 3 farmers, with their consultants, grew one or more fields of wheat according to the new principles. These crops were used by the farmers to gain experience in growing the wheat crop according to the principles received during the training sessions.
4. During the spring and summer 1999, 15 further farmers and their consultants received a similar training programme on the technical subjects listed above.

Autumn 1999 to Summer 2000

5. For the harvest year 2000 each of the 18 farmers, with their consultants, grew one or more fields of wheat according to the new principles. These crops were used by the farmers to demonstrate the growing of the wheat crop according to the principles received during the training sessions.
6. During the spring and summer of 2000 all 18 'trained' farmers led a group of 15 selected farmers (18 x 15 = 270) and, with ADAS support, provided three or more training sessions at which the updated principles of wheat agronomy were discussed. The trained farmers used their own field(s) of wheat, in which they were managing the crop using the principles they had been trained in, to demonstrate to the farmer group.
7. Also during the spring and summer of 2000 15 more farmers were trained by the 'trainers' and received a similar training programme on the technical subjects listed above.

Autumn 2000 to Summer 2001

8. Each of the 270 farmers managed at least one of their own fields of wheat according to the new principles seen at the group meetings.
9. In the harvest year 2001 each of the 15 farmers, who had received their intensive training the previous year, grew one or more fields of wheat according to the principles discussed, with the support of a consultant where requested. These crops were used by the farmers to demonstrate the growing of the wheat crop according to the principles received during training.
10. During the spring and summer of 2001 all 15 'trained' farmers led a group of 15 selected farmers (15 x 15 = 225) and provided three or more training sessions at which the updated principles of wheat agronomy were discussed. The trained farmers used their own field(s) of wheat, in which they managed the crop using the new principles, to demonstrate to the farmer group.

Through the operation of this technology transfer programme, 33 farmers were intensively trained by the researchers, and a further 495 received sufficient information to be confident in adopting the updated principles of wheat agronomy on their own farms.

Summary of Project Events

<table>
<tr><th>Harvest Year 1998</th><th>Harvest Year 1999</th><th>Harvest Year 2000</th><th>Harvest Year 2001</th></tr>
<tr><td rowspan="2">3 farmers:
intensive training</td><td rowspan="2">3 farmers:
crop
growing experience</td><td rowspan="2">3 farmers:
further crop
growing experience
and
technology transfer to
groups of 15 farmers
(3 x 15 = 45)</td><td>3 farmers:
more crop
growing experience</td></tr>
<tr><td>45 farmers:
crop
growing experience</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">15 farmers:
intensive training</td><td rowspan="2">15 farmers:
crop
growing experience
and
technology transfer to
groups of 15 farmers
(15 x 15 = 210)</td><td>15 farmers:
further crop
growing experience</td></tr>
<tr><td>225 farmers:
crop
growing experience</td></tr>
<tr><td></td><td></td><td>15 farmers:
intensive training</td><td>15 farmers:
crop
growing experience
and
technology transfer to
groups of 15 farmers
(15 x 15 = 225)</td></tr>
<tr><td></td><td></td><td></td><td>TOTAL = 528</td></tr>
</table>

Appraisal from the Trainers

The research approach, and its value to the levy payer:

The message was developed over ten or so years of research. Whilst, at its simplest, this might be summarised as 'You can save costs by growing thinner crops', the knowledge that farmers need, to adopt this approach, is greater than for many messages. Thus the challenge of this project was large.
The 'pyramid transfer approach' in this project (researcher-to-farmer training, coupled to with farmer-to-farmer transfer) was successful, but expensive (in terms of numbers of messages transferred per researcher). This should be regarded as one of several methods by which such messages may be transferred.

Where farmers adopted the messages to the full, large commercial advantages were apparent, and considerable enthusiasm was evident. The commercial advantages have been quantified elsewhere (see 'Evaluation of HGCA Research' Project Reports 234 and 235), but approximated to £4.40/tonne on an example East Anglian farm.

The requirement of the researcher to form messages:

Even with four days of intensive training, the requirement for researchers to summarise and simplify their knowledge was crucial. The best example was in the transfer of protocols for planning fertiliser applications. This was ineffective when the full research findings were provided (about 70 calculations), but was greatly improved, with the second training group, by reducing their complexity (to about 7 calculations).

This simplification process was not only important in promoting transfer, but also in guiding the degrees of complexity to attempt in further research.

The relative confidence of the message:

Although researcher confidence in the overall message was high, existence of some associated information was inevitably weak or lacking. Effectiveness of transfer depends on confidence and belief in the message. It was found important to clarify this issue with trainees at the outset. For example, trainers would state "I am 90% sure this is right", or "I am 50% certain this is right". As a consequence, the boundaries of current understanding were more properly appreciated, and the mode of communication tended towards 'sharing' rather than 'listening'.

Thus researchers were able to gauge the importance of uncertain issues in practice, and to acquire reactions to research questions from on-farm observers. This has enabled better prioritisation of further research proposals.

The intensive training days:

Whilst the messages were based on fundamental crop science, effective transfer required that theory was transferred mainly in the subtext to the practical messages. For example, appreciation of how light drives growth was best transferred along with the explanations of fertiliser application (fertiliser is understood to increase canopy size, hence to increase light capture, hence to increase yield).

Formulation of the training manual was concurrent with the first two rounds of intensive training. The quality of transfer was markedly assisted by having the completed manual at hand, from the outset of the third phase of intensive training.

The role of the farmer and the consultant; the combined decision making unit:

In general, training of farmer-consultant pairs was more efficient than training of farmers alone. The consultants tended to be the decision-makers for complex inputs such as fungicide applications. They are also more aware of the possibilities and limitations of research results and hence could facilitate the measured transfer of messages, particularly the more complex messages typical of this project.

Future training projects:

In future, it will be important to match the transfer method to the message. The method adopted here was broadly appropriate; transfer of complex technical messages is best restricted to those who have the time and inclination to base their business approach on technical excellence. A college-based environment should be considered for transfer of similarly complex messages in future.

In future it will be best for increased effort to be put into wider dissemination of simpler messages. For this to work, a ‘message distillation’ process must be undertaken, and its products must be tested.

The value of the project to the researchers:

The process of summarising the results of 10 years’ research so that farmers could take appropriate action was valuable to the researcher, in that it forced a judgement of the most telling conclusions from the research, and identified the main uncertainties, which then go to form the next topic for research. Comments and opinions from participants were also helpful in (a) improving researchers’ transfer techniques (especially in maintaining simplicity) and (b) identifying important topics for further research.

Examples of helpful conclusions from the Sector Challenge project included realisation that:

- light interception does not relate easily to apparent canopy size - further research will be needed here.
- the difficulty for farmers in comparing the efficacy of the various commercial plant growth regulators - research required here also.

Even the concept of 'thin' crops being advantageous was itself useful. Scientific reports and papers on this research did not derive the conclusions from the Canopy Management research specifically in terms of 'thin' crops. Rather, an optimum canopy size was identified.

It was clear in this instance, as with other Technology Transfer activities, that 'transfer' is very much a 2-way process.

Project Review

Farmer Commitment

Farmer involvement in and commitment to this project was vital. The farmers involved in the intensive training sessions volunteered to commit 4 or 5 days of their time to attend. Meetings were held in central England requiring the farmers to travel from as far as Scotland and South West England; this made for long days for such farmers. Following that commitment they were then asked to manage crops on their own farm according to the new principles they had been trained in. This involved extra time input in crop management on the farm as well as the logistical difficulties associated with changing management practices on a small number of fields. These farmers were then asked to host 2 to 4 meetings on their farm at which neighbouring farmers were invited to monitor the fields that the host farmer was managing according to the new Sector Challenge principles. This was also a significant commitment by the farmers concerned, not least demonstrating their fields of wheat in which they were managing **for the first time** the new principles of crop management.

Despite all the commitments itemised above we had the full support and involvement of all the farmers concerned, so making that part of the technology transfer the success it was.

Farmer Groups

When setting up the groups of 15 farmers associated with each intensively trained farmer there was a very positive response. Indeed we had several instances of farmers asking to be part of the group when they heard of its existence. So there was never any problem in getting farmer involvement in or commitment to the groups.

Attendance at Group Meetings

When setting up a series of on-farm meetings dates are committed well in advance. Attendance at these meetings is therefore very dependent on the farmers' commitments on that day. Most farmers involved were the key decision makers on the farm any many were also the ones that carried out the on-farm work as well; they were in fact one man businesses. Instances frequently arose where farmers could not attend the meeting we had set up due to commitments on-farm. This was especially noticeable when meetings were held during the growing season - March to June. Full turn out at all the on-farm meetings was rarely achieved for the above reasons despite the full commitment of those farmers to the project.

Conclusion

In conclusion there was full commitment to the project by all the farmers involved. There was no shortfall in farmer numbers in the project or problems in recruiting and maintaining the farmer groups. However, attendance at some meetings was reduced by the on-farm commitments of some farmers. Future technology transfer projects will need to address the issues of the difficulties many farmers now face in finding the time to leave their businesses in order to attend training events. More emphasis needs to be given to 'distance learning' capabilities in any new technology transfer projects.

APPENDIX

Abstracts from the Research Programme on which this Project was Based

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Assessments of wheat growth to support its production and improvement

Volume I: The wheat growth digest; Methods for in-field crop assessment; Forecasting crop progress for wheat

Volume II: How to run a reference crop

Volume III: The dataset

R Sylvester-Bradley

ADAS Boxworth

February 1998

Summary

Eighteen crops of the winter wheat variety Mercia were grown at six locations in 1992-3, 1993-4 and 1994-5, and their development and growth were recorded frequently. The husbandry of these crops aimed to avoid limitations of yield caused by low nitrogen supply, weeds, diseases, pests or lodging through prophylactic use of fertilisers and pesticides, hence attention was focused on effects of site and weather. Techniques of measurement were developed for accuracy and precision. These are presented in Volume II, '*How to Run a Reference Crop*' with sufficient detail for interested researchers or groups of cereal growers to assess soil and weather effects at locations representing their own crops. The resultant data have been summarised to provide comparators for many attributes of wheat performance, and the implications for husbandry decisions are outlined. These have been presented in different ways so that (a) through the section entitled '*The Dataset*', Volume III, crop scientists can study the variation between sites and seasons in the many interconnected facets of development and growth, and (b) through the section entitled '*The Wheat Growth Digest*', practitioners can derive a summary of these same facets against which to compare observations of their own crops. The significance of deviations from the 'norms' is considered in terms of adjustments to husbandry.

Simplified techniques are described to enable wheat growers to assess the most important attributes of individual crops, in '*Methods for In-field Crop Assessment*'. In the section entitled '*Forecasting Crop Progress for Wheat*', 'look-up' tables are provided to allow the forward prediction of stages of development, green canopy size, crop dry weight , weight per grain, and grain yield. The rules on which these tables are based are presented, and their advantages and deficiencies are discussed.

The general conclusions to the project include an assessment of the potential for the wheat industry of further exploiting this research, and an assessment of the feasibility of undertaking similar research on barley.

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An integrated approach to nitrogen nutrition for wheat

D T Stokes and R K Scott, University of Nottingham, Sutton Bonington
R Sylvester-Bradley, ADAS, Boxworth, Cambridge
J Hopkinson and G F J Milford, IACR-Rothamsted, Harpenden
S E Salmon, Campden and Chorleywood Food Research Association, Chipping Campden
R W Clare, ADAS Rosemaund, Hereford

April 1998

Summary

This project developed a new approach to using fertiliser N on winter wheat, and it showed this approach to have economic and environmental advantages over conventional N use. The new approach, which has been dubbed 'Canopy Management', is more sophisticated than the conventional approach to N use, in that it entails field by field measurement of mineral N in the soil, and field by field assessments of the size of the crop's photosynthetic canopy, as opposed to simple identification of previous crop, soil type and expected yield.

The aim of this project was to augment developments from the understanding of soil N supply with developments based upon the understanding of crop N demand. This was possible through (i) accepting that a crop's performance must relate closely to the amount of sunlight its green canopy can use for photosynthesis, and (ii) applying our finding that the size of a crop's canopy relates directly to the amount of N it contains. Thus a 'Canopy Management' approach could be envisaged in which the growers' aim would be to ensure an optimum 'photosynthetic machine', and accepting that the grower has a limited capacity to predict or control grain yield. A theoretical framework was developed to link N application to grain yield through a series of quantitative steps: (i) recovery of fertiliser N by the crop, (ii) use of this N to form the green canopy, (iii) interception of sunlight by the canopy, (iv) conversion of sunlight to crop dry matter, and (v) partitioning of dry matter to grain. From this framework, we estimated the optimum canopy size for light capture to be between 5 and 6 units of green area index; smaller than many conventionally fertilised crops. A series of 'rules' was then developed to help judge the amounts and timings of fertiliser N applications necessary to supplement soil supply and provide for the expansion of the canopy to this optimum size. Additional N was then applied late, at flowering, to prolong the canopy's life during grain filling.

Experiments were designed to compare Canopy Management with conventional N management across the range of conditions in which winter wheat is likely to be grown. Soil mineral N in February varied from 20 to 150 kg/ha N and crop N uptake in February ranged from nil with very late sowings to almost 60 kg/ha N where sowing was early and soil N supplies were large. Soil mineral N in February was often near-uniformly distributed through the 90 cm depth of soil measured, particularly after large applications of N had been made to the preceding crops.

The relationship between soil mineral N in February and subsequent uptake by crops not receiving fertiliser N was remarkably (and conveniently) direct, demonstrating for a wide range of crop conditions that the recovery of soil mineral N can be predicted confidently. Fertiliser N required to make good the shortfall in uptake from soil supply was best estimated by assuming 60% recovery, and applications should be timed before maximum canopy size, allowing for a minimum N uptake rate of 2 kg/ha/day. The recovery of N applied at flowering was generally poor, averaging only 25%, and there was no significant improvement in recovery from using foliar urea

compared to granular ammonium nitrate because a significant proportion of sprayed N either did not reach the canopy or passed through the canopy to the soil.

Canopy expansion rates and maximum canopy sizes were strongly related to the amounts of N taken up. There was direct evidence that the 'canopy nitrogen requirement' for Mercia should be revised from 30 to 28 kg/ha if a green area index of 6 is the target maximum canopy size. The results demonstrated that Beer's Law (which predicts a diminishing increase in light interception from successive increases in canopy size) holds for Mercia wheat grown over a wide range of conditions, and there was little benefit in terms of light interception from increasing canopy size to more than 6 units of green area index. During the early phase of grain filling, the coefficient (k) describing attenuation of sunlight by Mercia is best taken to be between 0.45 and 0.50 when considering all solar radiation, or between 0.50 and 0.55 when considering photosynthetically active radiation. There was more variation than expected in the efficiency with which crops converted solar energy into biomass. Significant variation in this efficiency was attributable to seasonal effects, to a change in sowing date and to use of fertiliser N. Notwithstanding these effects, Canopy Managed crops converted sunlight into biomass with similar efficiency to conventionally fertilised crops.

The partitioning of biomass to grain was significantly improved by Canopy Management. In 17 out of 24 comparisons, Canopy Management produced either the same or larger yields of grain when compared with the conventional approach. Analyses from milling and baking tests on samples taken in all years, showed that Canopy Management resulted in similar concentrations of grain protein and an equivalent quality of grain for loaf production.

Canopy Management resulted in average savings in N of 35 and 10 kg/ha in 1993 and 1994 respectively. However, slightly more N (16 kg/ha) was used in 1995 compared with conventional N management. Comparing the value of the yield improvements and the changes in N use, and taking into account the cost of analysing the soil for mineral N, Canopy Management resulted in an overall economic benefit of almost £10/ha.

These results are sufficiently promising for Canopy Management to be introduced into commercial practice on farms. Probably this could best be achieved in a step by step manner, perhaps through first adopting wider use of soil mineral N analyses, then by changing from a yield target to a canopy target, or alternatively the complete system might be adopted, but on a few selected fields, so that the demand for more intensive management is small at first, allowing the operator to gain familiarity with and confidence in the system. But, Canopy Management is not yet at a stage for *wholesale* adoption by the industry. Further work is needed to show how growers can best accommodate the requirement of Canopy Management for more detailed field by field assessments of both soil and crop on a whole farm scale.

Finally, irrespective of the economic or environmental advantages found for the Canopy Management approach, this project provides strong support of the *justification* that the industry makes for its dependence on fertiliser N.

Research to understand, predict and control factors affecting lodging in wheat

P M Berry, J M Griffin, R K Scott, The University of Nottingham, Loughborough
J H Spink, R W Clare, ADAS Rosemaund, Hereford
R Sylvester-Bradley, ADAS Boxworth, Cambridge
C J Baker, The University of Nottingham, Nottingham
September 1998

Summary

The aim of this study was to lessen lodging in winter wheat by providing a guide to how factors affect lodging and by testing whether spring crop assessments could identify lodging-prone crops.

An aerial survey of 340 fields (2865 ha) in 1991-92, quantified the extent of lodging in a widespread lodging year. 91% of fields had some lodging, resulting in 16% area lodged. From these values it was estimated that a severe lodging year costs the UK wheat industry £60 million through yield loss and a further £60 million due to loss of bread making premium, grain drying costs and delayed harvest. 95% of lodged fields had lodging within the overlaps between the field margin and field centre, but only 2% had lodging immediately adjacent to the field tramlines. Regional differences in lodging were closely linked with soil type, rather than rainfall and wind speed, with most lodging on silt soils. The percent area lodged per field commonly varied from 10 - 90% within individual localities.

A model of the lodging process accounting for weather, soil and crop factors was developed to investigate which factors influence lodging most. Simulations for a wide range of crops and environments expected in the UK predicted root lodging to occur more frequently than stem lodging. Variation in clay content and macroporosity of the soil influenced lodging more than rainfall and wind speed. Importantly, variation in the structure of wheat crops influenced the risk of stem and root lodging as much as variation in soil type and weather. The plant characters which influenced lodging most included shoot height at centre of gravity, natural frequency of shoot oscillation and the number of shoots per plant, which affect shoot and plant leverage; stem diameter and material strength of the stem wall, which affect stem strength; and the spread of the root plate and depth of structural roots, which affect anchorage strength.

A field experiment was used to develop the lodging model and to investigate possible spring predictors of lodging. Two levels for each of sowing date, seed rate and soil residual N were factorially combined. Within each treatment four levels of lodging control, untreated 5C cycocel, 5C cycocel with Terpal and Canopy Management were compared. 13% of the 1993-94 experimental plots root lodged, 33% plots stem lodged in 1994-95 and 82% plots root lodged in 1995-96. Large treatment differences were found for the percent area lodged and in the values of the lodging-associated plant characters. Early sowing produced shoots with a high centre of gravity and slow natural frequency, resulting in greater shoot leverage and increased risk to stem and root lodging. Fertile soils in combination with early sowing reduced stem diameter and material strength of the stem wall, which resulted in weak stems and greater stem lodging risk. High seed rates reduced root plate spread resulting in poor anchorage and greater root lodging risk. Plant growth regulators reduced height at centre of gravity and increased natural frequency, reducing shoot leverage by up to 30%, but had no effect on the strength of the stem base or anchorage system. Reduced N applications with Canopy Management reduced shoot number per plant which

decreased plant leverage. This also improved stem strength on fertile soils. Preliminary investigations showed large genotypic variation in all the lodging-associated plant characters.

Spring crop assessments were proven to be indicative of later developing lodging-associated plant characters and thus lodging risk. Root plate spread and structural rooting depth at grain fill were negatively correlated with spring plant density. Crops with 150 plants m^{-2} had four times the anchorage strength of crops with 500 plants m^{-2}. Stem diameter and wall width at grain fill could be predicted from spring canopy size and shoot number m^{-2}. Crops which were lush in the spring, with canopy green area index (GAI) 3 and 1500 shoots m^{-2}, resulted in narrow thin walled stems which were approximately half as strong as stems in sparse crops with GAI 1 and 500 shoots m^{-2}. Shoot number per plant and plant leverage force were negatively related with spring plant number m^{-2}. Theoretical prediction schemes were developed for shoot height at centre of gravity and natural frequency based on additional spring measurements of soil N supply, final leaf number per main stem and rate of leaf emergence (phyllochron).

This study has shown that taking the correct decisions at sowing can reduce lodging risk without adversely affecting yield potential. Methods of reducing lodging risk include avoiding early sowing which results in tall crops with high leverage, reducing seed rate to strengthen crop anchorage and avoiding excess N supply before stem extension to prevent the production of weak stemmed crops. The importance of structurally strong topsoil to improve crop anchorage is also identified. Furthermore, methods by which growers can assess lodging risk in the spring are given which will help lodging controls to be targeted at the crops with greatest lodging risk. In spring, large canopies with many shoots indicate crops with potentially weak stems which will be prone to stem lodging, and large plant populations with poor structural root development indicate poorly anchored crops which will be prone to root lodging. Thus the aims of this study have been achieved by identifying the main factors which promote lodging and showing that their values during the grain fill period can be predicted from assessments of the spring crop. Some of this work is applicable now, but further work is required to test the lodging model, further develop and test the lodging predictions, identify the lodging-associated plant characters as varietal traits and to investigate the effectiveness of more lodging control methods.

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Appropriate fungicide doses for winter wheat and Matching crop management to growth and yield potential

N D Paveley, ADAS High Mowthorpe
M J Hims, CSL York
W S Clark and R J Bryson, ADAS Boxworth, Cambridge
D B Stevens, Morley Research Centre, Wymondham

June 1998

Introduction to appropriate fungicide doses

There are almost as many opinions on the 'right' way to grow cereals as there are growers and consultants.

This diversity of opinion exists because of the large number of variable inputs that influence the unit cost of cereal production, the complexity of their interactions and the difficulty of quantifying the effect of changing any one of these variables, within the farm system.

One variable input that has a substantial effect on the economic efficiency of production, is the use of fungicides to control foliar diseases. Fungicides applied to the UK winter wheat crop in 1993 cost the industry in excess of £100m, but prevented losses estimated at £400m. More recent survey data suggest that potential losses fluctuate with season, but the fungicide spend remains substantial. Getting disease control 'right' is clearly important.

Growers and consultants use experience to make judgements about fungicide applications. This experience, often accumulated over many years, is a valuable commodity. Nevertheless, consistently good decisions seem more likely where experience is backed up by research information which quantifies responses to changes to individual components of the production system.

This report describes some of the principles behind the manipulation of fungicide dose to optimise the economic efficiency of disease control, and presents research information to support crop management decisions.

The dose-response curve

If the severity of foliar disease is measured in experimental plots which received fungicide treatment, at a range of doses, some time before, the results will typically look like those in Figure 1. Those plots which received no treatment will suffer a level of disease determined by the local 'disease pressure'. Fungicide treated plots will suffer less disease and the higher the dose, the lower the disease severity. However, a law of diminishing returns operates and each successive increase in dose causes a smaller additional effect.

The decrease in disease with increasing dose is commonly represented by a line, rather than bars, and is described as a 'dose-response curve'.

The maximum dose that can be used is specified on the label, as the recommended dose, and must not be exceeded. However, there is no legal limit to the minimum dose that should be applied, and the majority of crops now receive fungicides at doses substantially below those recommended. To understand why, it is helpful to consider how the recommended dose is set.

The recommended dose

Disease control to 100% control is usually either technically unachievable in the field on a consistent basis, or is not cost effective. Furthermore, when the same fungicide is applied to control the same disease at a range of locations, the response to the applied chemical varies from place to place. The dose which gives 90% control in one field can be quite different to that which gives 90% control in another. To allow for this inherent variability and avoid product dissatisfaction, the label recommended dose is usually set at a level which consistently gives a high level of control across locations and seasons, typically 80-90% control 80-90% of the time.

Reduced doses

During the late 1980's and early 1990's, growers recognised the safety margin built into the label recommended dose and, under pressure to reduce input costs, began to reduce the doses of fungicides applied to cereal crops. Survey data suggest that these reductions were and still are often made in an arbitrary manner.

Appropriate fungicide doses

Fungicide cost increases in direct proportion to the dose applied. As the loss of yield and grain quality is proportional to the level of disease, a point can be found on the dose-response curve, beyond which the cost of any further increase in dose would not be paid for by the resulting yield increase. At this point, profit is maximised (Figure 1) and unnecessary pesticide use minimised - by definition the **appropriate dose** to apply.

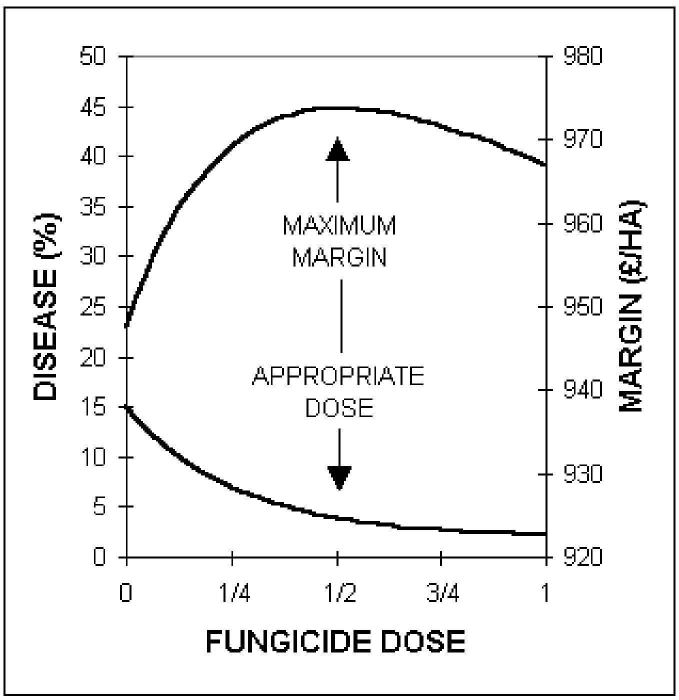

Figure 1. Dose-response curve, margin over fungicide cost and appropriate dose

At doses below the appropriate dose, profit is reduced by ineffective disease control. At doses above the appropriate dose, profit is reduced by excessive fungicide cost. It is important to note that the loss of profit is more severe if the dose is reduced below the appropriate dose than if increased above it. Hence, where there is uncertainty about the appropriate dose to apply, it is prudent to apply more, rather than less. The greater the uncertainty, the greater the safety margin required.

On what basis can a crop manager decide on the appropriate dose to apply - given that, as the shape of the dose-response curve varies from site to site and season to season, so must the appropriate dose? And how can the uncertainty surrounding the choice of dose be minimised, to allow doses to be applied that are consistently close

to the economic optimum, without suffering occasional severe losses due to under-application?
The answers must come from taking account of the causes of the variation in disease control between sites and seasons; otherwise we are not *managing* crops, but merely playing the averages.

Variation in dose-response curves

One of the main reasons for variation in disease control between sites and seasons is that, in the absence of treatment, disease severity varies between sites and seasons. There is a big effect on the dose-response curve and the appropriate dose of different levels of untreated disease. For example, a crop of a disease susceptible variety, that experienced weather conditions favourable to disease development requires a large dose; a more resistant variety or a susceptible variety under conditions less favourable to disease requires a moderate dose; and a variety with complete immunity to disease requires no dose.

Clearly, higher disease pressure justifies higher inputs. However, the appropriate dose also depends on efficiency of control. Figure 2 takes the high disease pressure case (A) and shows the effect of applying alternative products that are more (B), or less (C), effective.

All else being equal, more effective products have lower appropriate doses. However, efficacy is often reflected in price, so the best product/dose combination needs to be selected to do the job.

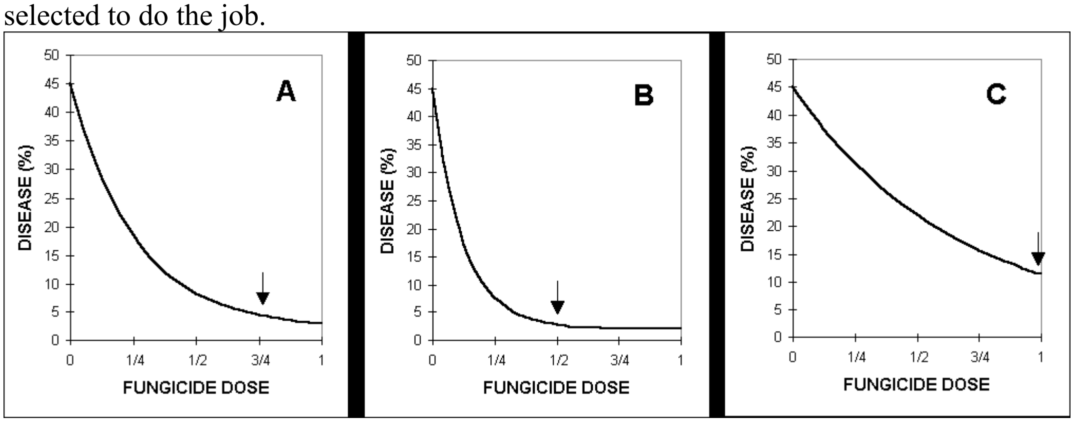

Figure 2. Effect of fungicide activity on dose-response curves and appropriate dose.

Input management for minimum unit cost

It can be seen, from the examples shown above, that the appropriate dose in a range of circumstances can vary between the recommended dose and zero.

A crop manager who is better able to quantify disease pressure and predict efficiency of control, will be able to apply doses that are consistently closer to the economic optimum - to the benefit of unit cost of production and the defensibility of pesticide use.

Experiment 1, reported in this Section, provides information to help predict the efficiency of control that might be expected from a range of widely used conazole and morpholine fungicides.

Experiment 2 measures the extent to which fungicide dose might be reduced by exploiting the reduction in disease pressure brought about by the genetic resistance of varieties.

Experiment 3 describes how individual fungicide applications can be most efficiently combined into spray programmes, and how treatments interact within programmes.

Matching Crop Management to Growth and Yield Potential, integrated within Experiment 3, investigates how responses to disease control (and hence dose optima) vary with the physiological state of the crop.

Research projects to improve the prediction of disease pressure, through understanding of: (i) weather-disease relationships, (ii) the role of within-crop inoculum on future epidemic progress, (iii) the effects of genetic resistance and disease escape, and (iv) variation in the relationship between disease and yield loss, are ongoing as part of the Integrated Disease Risk (IDR) programme (funded jointly by the Ministry of Agriculture, Fisheries and Food and the HGCA).

Introduction to matching crop management to growth and yield potential

Traditionally, disease epidemics have been quantified by measuring disease severity, generally assessed as the percentage of leaf area expressing visible symptoms. Disease epidemics may be defined using the integral model, area under disease progress curve (AUDPC). This model is used effectively in the report to demonstrate the effect of increasing fungicide dose on disease development and progress on individual leaf layers within the crop canopy. By fitting exponential curves to AUDPC values it is then possible to establish optimal timings and doses of fungicide applications. However, measurements of disease severity alone may not fully reflect the effects of disease on the yield forming process in the host. In Figure 4 the relationship between yield and total AUDPC value for leaves 1, 2 and 3 is given for *Septoria tritici* epidemics at Aberdeen, Morley and Rosemaund. AUDPC values relate reasonably well to yields at Morley (R^2 = 0.66) but poorly at Aberdeen and Rosemaund (R^2 = 0.36 and 0.01). AUDPC values of over 1500 at Morley were found to relate to similar yields as values of less than 500 at Rosemaund. If data from a yellow rust epidemic (Terrington) is compared with *S. tritici* (Figure 5) it can be seen that AUDPC values of 4000 for yellow rust relate to similar yields as AUDPC values of between 0 and 2000 for *S. tritici*. Clearly, AUDPC values cannot be used to predict yield between sites. It may be argued that this is a site effect due to environmental conditions. However, when AUDPC values of *S. tritici* epidemics from different seasons on the same site are compared (Figure 6) then again AUDPC values cannot be used as a predictor of yield with values of approximately 300 relating to yields of between 7.5 and 10 t/ha in one year (1996) and 500 relating to 7.9, 9.4 and 8.7 t/ha in 1994, 1995 and 1996 respectively.

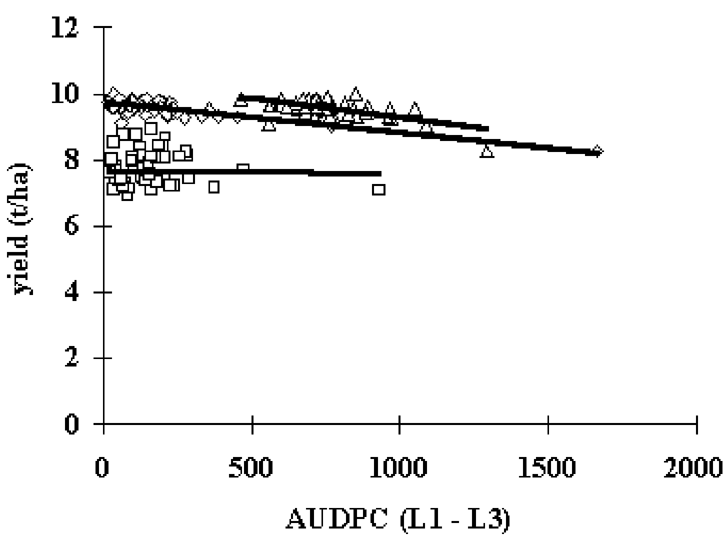

Figure 4. The relationship between AUDPC (L1 - L3) of *S. tritici* and grain yield (t/ha) at Aberdeen, Morley and Rosemaund in 1995.

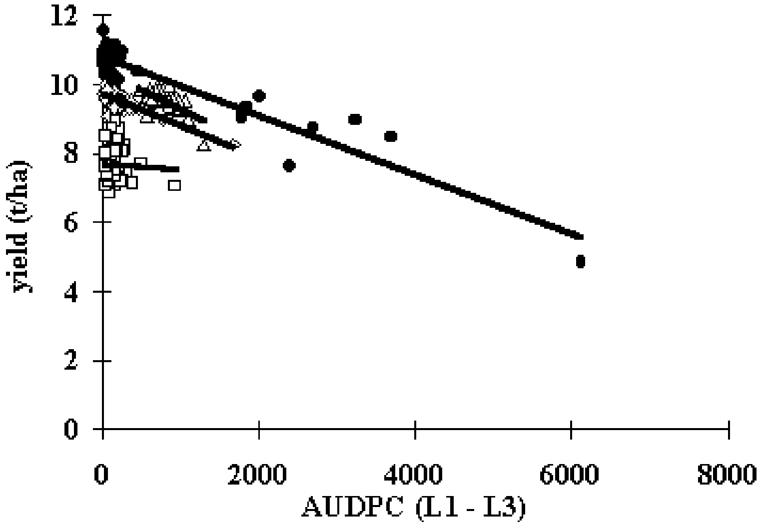

Figure 5. The relationship between AUDPC (L1 - L3) of *S. tritici* and yellow rust and grain yield (t/ha) at Aberdeen, Morley, Rosemaund and Terrington in 1995.

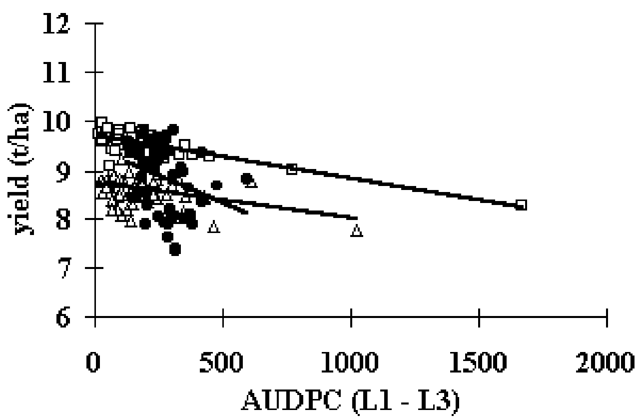

Figure 6. The relationship between AUDPC (L1 - L3) of *S. tritici* and grain yield (t/ha) at Morley in 1994, 1995 and 1996.

The relationship between disease and yield-loss is more complex than is implied by simple AUDPC:yield relationships. A single AUDPC value may describe a severe epidemic for a short time or a minor epidemic for a long time. Single point, multiple point and integral models such as AUDPC all rely on measures of percentage disease severity and as such have only an indirect link to the productivity of the host plant. Also, they do not take account of environmental conditions which affect yield potential. Hence relationships between disease severity and yield have generally proved poor over sites and seasons.

There are two important practical implications of this variation in the relationship between disease and yield. Firstly, the success of a disease control programme cannot be judged accurately by observations of disease later in the season. In crops where the disease:yield loss relationship is steep, even a small amount of disease remaining after treatment may be economically unacceptable. Whereas in crops where the relationship is shallow, even moderate levels of disease would have negligible impact. Secondly, the ability to identify, at the time of fungicide treatment decisions, those crops which will provide an economic yield response, is prejudiced if the physiological state of the crop is not taken into account.

A better alternative may be to base disease management decisions on an understanding of the effects of disease on crop function. Yield is predominantly determined by the crop's capacity to intercept light energy and utilise it for growth. Potential yield is directly related to the amount of photosynthetically active radiation intercepted by green tissue. This can be described formally by an equation derived from Beer's Law: $\boldsymbol{f} = \mathbf{1 - exp\ (-kL)}$, where f = fraction of light intercepted, **k** = extinction coefficient (which is dependent on canopy geometry) and **L** = green leaf area index (GLAI). GLAI is defined as the number of units of planar area of leaves per unit area of ground. The Beer's Law analogy implies that there is an optimal canopy size, considering all green tissues, at which the cost of creating or protecting a further increment in canopy size may prove uneconomic in terms of growth.

In order to explain more fully the effects of fungicide dose and timing on disease development and hence crop yield, experiments were carried out on and within the main Appropriate Fungicide Dose (AFD) experiments at Morley, Rosemaund and Terrington in 1994, 1995 and 1996. Data were also used from the Aberdeen site but intensive crop physiology analysis was not possible due to its location. The hypothesis behind these experiments was that yield loss due to disease can be better explained using measurements of green leaf area and radiation interception than by assessments of disease severity alone.

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Prediction of optimum plant population in winter wheat

J H Spink[1], J Whaley[2], T Semere[1], A Wade[1], D Sparkes[2] and J Foulkes[2]
[1] ADAS Rosemaund, Preston Wynne, Hereford, Herefordshire HR1 3PG
[2]Division of Agriculture & Horticulture, School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire LE12 5RD

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ABSTRACT

Field experiments were set up at ADAS Rosemaund (Herefordshire) and Sutton Bonington (Leicestershire) to examine the effects of reducing seed rate on the yield and yield components of 4 varieties of winter wheat, in harvest years 1996-9. Each variety was sown at six seed rates from 20 to 640 seeds m^{-2} and at 3 sowing dates at ADAS Rosemaund. Sampling, at harvest and at major growth stages, facilitated comparisons of yield, crop growth and yield components. A second series of experiments at ADAS Rosemaund only, investigated interactions between seed rate and variety (using two seed rates and up to 22 varieties).

Economic optimum plant populations were significantly lower than current commercial practice. Increased tiller number per plant was the main compensatory mechanism, although increased grain number per ear and to a lesser extent grain size also contributed. Increased shoot number per plant was not due to increased tiller production rate, but due to an increase in the duration of the tillering phase. A reduction in plant density from 218 to 30 plants m^{-2} increased duration of tillering by 37 days in 1996/7 and by 97 days in 1997/8. There was also an increase in tiller survival with reductions in plant density. When sown at 218 plants m^{-2} there was a mean tiller survival of only 43% but at 19 plants m^{-2} 87% of initiated shoots survived. It was apparent that tiller production and death were not closely linked to the development of the crop, as is currently the perceived wisdom in much of agronomy. The time at which tiller production ceases and tiller death commences appeared to be almost completely controlled by competition for resources between shoots. Increased tillering was insufficient to maintain ear number m^{-2}, but there was an increase in green area per shoot with decreases in plant density. It was calculated that green area index (GAI) of approximately 5.6 would be required to intercept 90% of available photosynthetically-acitive radiation (PAR). To produce this canopy size, 68 plants m^{-2} were required in 1996/7 and 35 plants m^{-2} in 1997/8. Reduced GAI, with a reduction in plant density, was also compensated for by an increase in the efficiency of radiation use at low populations, with nearly 50% more dry matter being produced for each unit of light intercepted. Thus, by the critical phases of yield formation differences in radiation capture between high and low population crops were negligible.

The optimum seed rate was calculated using a grain price of £80 t^{-1} and seed cost of £300 t^{-1}, however, the optima were found to be relatively insensitive to changes in the seed cost to grain price ratio. The economic optimum plant population was significantly affected by the sowing date, due to the reduced ability of the crop to compensate through increased tillering. Other aspects of compensation were unaffected by drilling date. The optimum plant population averaged 62 plants m^{-2} at the end of September and increased by 1.6 plants per day delay in drilling. This gave optimum populations of about 90 plants m^{-2} in mid-October and 140 plants m^{-2} in mid-November. These optima are, however, likely to be higher in the north of the country, this is the subject of an ongoing HGCA-funded project (No 2249). Varietal differences in tillering ability did not have a significant effect on compensation for

reduced plant population. In the absence of lodging, no interaction was found between variety and plant population.

Potentially significant savings in input costs, particularly in earlier sown crops, are therefore available to the grower. Careful account must, however, be taken of likely establishment percentage and of the optimum population applicable to each specific situation, as yield falls rapidly when crops are grown at populations below the optimum. Currently this is best estimated on a site-by-site basis, based on soil type, seed bed crumb structure, moisture content and risk of pest damage. There is the potential for future research to address this issue for cereals using an approach similar to that used in HGCA-funded work on oilseed rape (HGCA Project Report OS31).

EVALUATION REPORT

March 2002

Imperial College, University of London
for ADAS

The staff responsible for this evaluation were

Berkeley Hill
with
Ruth Gasson (1998 to 2000)
Angela Edwards (2000 to 2002)

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EXECUTIVE SUMMARY

- This Sector Challenge project in technology transfer possessed some unusual characteristics. It attempted to use farmers who had been intensively trained by ADAS in new management practices in wheat growing as change agents in the adoption by other farmers (farmer-to-farmer training). It was concerned with a range of techniques, some complex, and some already in partial use; the project was not the only source of information; and the time horizon was long. The project was disrupted by the unusual weather conditions and Foot & Mouth Disease restrictions of the 2000/01 season. These and other factors presented problems in evaluation.

- By agreement, this evaluation was concerned with the effectiveness of the two-stage training programme, not with its economy or efficiency.

- In broad terms, the project met the objectives by which the effectiveness was to be judged, as set out in the Evaluation Plan agreed with the Steering Group.

- There was evidence that the training generated additionality in the use of new management practices. While there were negative changes in the control group, linked to the 2000/01 season, positive changes occurred among the farmers who participated in training.

- The intensively trained farmers adopted new practices to a greater extent than those who only experienced farmer-to-farmer training. The limited evidence from farmers who had two years of experience of applying the techniques suggested that they continued to be used beyond the first trial.

- Crop consultants linked to individual farmers played a large role in the programme, especially at the farmer-to-farmer training stage. This involved the organisation and maintenance of groups of trainees and the explanation of techniques, especially those relating to agro-chemicals. Without their involvement it is unlikely that the project would have been effective.

- Though no specific targets were set for the numbers of farmers who received farmer-to-farmer training, there appeared to be a shortfall compared with expectations. This applied even in the season that was relatively normal in terms of weather and disease restrictions (1999/2000). The problems of recruiting and maintaining groups of trainees present a challenge that this project did not fully meet.

- The method of intensive training (researcher to farmer) appeared to work well; access to a written guide to complement this was seen as highly valuable. A large proportion of farmers intended to use some of the techniques. The farmer-to-farmer training was partially successful; it was less effective at influencing intentions but broadly met the target set in the evaluation plan.

- The perception of farmers was that the new techniques had a positive effect on the profitability of wheat growing.

1 Introduction

1.1 Nature of the project evaluated

This project involved the transfer to wheat growers of information about scientific advances in plant physiology that had a direct relevance to the management of this crop. These advances in knowledge were several, frequently inter-related, and increasing over time. When reflected in actual management practice on farms these advances were assumed to have the potential to improve the profitability of UK wheat growing, at least in some of the circumstances encountered. The decisions were spread over the production cycle of the crop (from choice of variety to applications of chemicals late in the growing season).

The system of technology transfer that formed the subject of this evaluation employed a tiered training approach. The first tier in the transmission consisted of an intensive training course delivered by ADAS to small groups of leading farmers, selected by ADAS on the basis of their interest and perceived ability to transfer good practice to others. The course covered advances in wheat physiology and their practical application and comprised a number of "indoor" sessions held over the winter plus later visits to demonstration crops. Written guides and other literature accompanied this training.

In view of the close association of the chosen farmers with their crop advisors, the training was offered to the combined farmer/advisor management unit. Each group was intended to comprise approximately 15 management units (15 farmers plus a smaller number of advisors, as some shared the same consultant). Following training over the winter and spring of crop year *t*, the intensively trained farmers were expected to apply the new techniques in year *t+1,* during which time they both gained experience and acted as transfer agents by passing on the management techniques to other farmers.

The second tier comprised a less intensive training programme delivered by the intensively-trained farmers on their own holdings. Each intensively-trained demonstrating farmer (plus consultant) was intended to assemble a group of approximately 15 further farmers for this purpose. The training at this level was intended to consist of one session of instruction ("inside"), plus two visits to observe the new management in practice ("field" visits). Farmers who had experienced this farmer-to-farmer training were expected to apply the new techniques in the subsequent growing season (*t+2*).

The training programmes at both levels were replicated over time, duplicates being staggered by one year. An intended doubling of numbers in the second set (that is, the intensive training of two groups of 15 in the second year) was not carried out in order to use the resources elsewhere.

The focus of attention for assessing the success of this system was the extent to which the new management techniques were taken up by participating growers. However, this project's training was not the only way in which information about the techniques reached the industry. Farmers who were not part of the training programme in either tier may have become aware of the management advances in various ways, including access to literature and networking by professional advisors and commercial channels. To assess what was going on in the background a control group was selected and their changing practices monitored.

1.2 The nature of the evaluation

An evaluation plan for this project was agreed between ADAS and Wye College, and given a final form in 17 December 1998. This set out aims and guidelines. The evaluation was to be concerned with the project's particular method of communicating with potential adopters. It would examine the transfer at various stages that had been identified in previous studies (such as awareness, acceptance, intention, implementation).

Explicitly the evaluation excluded other aspects in the process the development and implementation of scientific advances, as follows:

- It did not extend to a formal examination of the **rationale** on which this technology transmission project was based.
- It did not cover any (ex ante) **appraisal** of the project that may have taken place; Wye College was brought into the exercise at too late a stage for this, though, in the event of the transfer mechanism performing poorly, questions regarding appraisal might be raised.
- No attempt was required to evaluate the effectiveness of the **particular training programme** (of the first-tier intensively-trained farmers or the second-tier less intensively trained groups) against alternative training programmes.
- No attempt was required to measure the **impact on the profitability** of those farm businesses whose operators adopted the new techniques
- No attempt was required to compare the costs of developing the scientific advances with the benefit to the agricultural industry (**benefit/cost analysis**)

1.3 Objectives of the technology transfer project

The evaluation aimed to test the degree to which certain objectives, stated or implied in the transfer exercise, were achieved. These objectives were agreed between the evaluators (Wye College) and ADAS and stated in the evaluation plan. In line with good practice, these objectives were designed to be Specific, Measurable, Accessible, Relevant and Time-circumscribed (SMART).

(a) That the first-tier intensively trained farmers will demonstrate that they have understood the new concepts and are in a position to transfer this knowledge to other groups of farmers through group activity.

(b) That 75% of the farmers who have attended the second-tier training programme will accept that the practical adoption of the new approaches to wheat management will lead to crop management decisions that have the potential to increase the profitability of the enterprise.

(c) To test for a positive relationship between the levels of information made available to potential adopters of techniques relating to certain crop management decisions and procedures, and the degree of response of these adopters. This relationship is to be tested using a ranking of degrees of information/training inputs and of degrees of response, to be agreed between ADAS and Wye College.

(d) Within the context of (c) above, and as far as proves practicable, to test for the relative effectiveness of the various forms of information/training involved, including the cumulative nature of these forms.

(e) To test for the extent to which this form of transfer process provides additionality to the awareness of potential adopters who are not directly involved as trainees and have not visited the farms of trainees.

1.4 The mechanism of evaluation

Data for the evaluation were collected from participating farmers (both tiers of training and replications) and the control group using questionnaires, drafts of which were given in the evaluation plan. Information was collected that related to management practices in wheat growing, to the socio-economic characteristics of the farmer and the business, to the decision-making process, and to lines of communication from change agents. Copies of the final questionnaires are contained in the Appendix to this report.

For farmers undergoing training (intensive or farmer-to-farmer), data were collected at various stages:

- *Before training began*; base-line data mainly about awareness of techniques and practices in wheat management
- *After training*; gathering impressions of the training experience and gauging intentions to put the new techniques into practice
- *After experience of application*; to measure which of the new techniques had been applied, with some indication of the outcome on the rewards of using them.
- For the intensively-trained farmers, *after acting as trainers for the second tier,* to gather information on their experiences and the preparation they had been given by the ADAS programme.

For farmers ***not*** participating in training (the control group), data were collected at the following stages:

- *Base-line data,* mainly on awareness and management techniques in use, contemporary with the base-line survey of the first group of second-tier farmers
- *Follow-up data,* mainly of the same variables, contemporary with the survey of what this same second-tier group did in their first year of applying the techniques.

The timings of surveys were carried out as in Table 1.1. Some slippage occurred compared with the planned timings because of changes in the operational timetable of the training programme. All surveys (except to the control group) were followed up by letter one month after the main posting, and by telephone to the intensively trained farmers. In addition, surveys of consultants were carried out about their role in the technology transfer process.

Table 1.1: Summary of contacts with participating farmer management units

	1999				2000				2001				2002	
QUARTER	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**
Reporting				PR				PR				Interim Report	Final report	
Intensively trained Group 1 "15"+"3"	BL-AW	AI + IN					1^{st} APL (+ t.t. exp.)			2^{nd} APL				
Farmer-to-farmer trained "270"					BL-AW		AI+ IN			1^{st} APL				
Intensively trained Group 2 "15"					BL-AW	AI+ IN				1^{st} APL				
Farmer-to-farmer trained "225"									BL-AW		AI+IN			
Controls					BL-AW					IN-AP(C)				

<u>Nature of information collected</u>

BL-AW = Base-line information on Awareness
AI = Acceptance and intentions
IN = Inputs of information and training
APL = Application in the previous season
AP(C) = Control group application (condensed form of AC/INT and APL)
PR = Progress report
t.t.exp. = technology transfer experience

1.5 “Flags” relating to the new management techniques

In view of the wide range of scientific advances and related wheat management techniques that this project encompassed, it was agreed with ADAS that the evaluation should concentrate on a number of “flags”. These consisted of familiarity with pieces of information or techniques that were integral with the training programme and which farmer-participants were unlikely to have knowledge of other than through the training programme. The choice of these “flags” and procedures bore in mind that the use of postal questionnaires meant that a simple set of indicators would be preferable.

On the advice of ADAS these “flags” were as shown below:

Familiarity with the following terms (to which degrees of familiarity have been added)

	Not recognise	Recognise	Familiar with
• soluble stem reserves			
• canopy management			
• root anchorage			
• shoot leverage			
• harvest index			
• green area index			
• canopy nitrogen requirement			
• benchmark value			
• valley of optimal control			
• green leaf area retention			

Selected practices:

Did farmers carry out the following practices?

- **consider** earliness of flowering when choosing a wheat variety?
- **consider** tillering characteristics when choosing a variety?
- **calculate** soil nitrogen (N) reserves?
- **measure** shoot numbers before the first N application?

- **measure** canopy size before the main N application?
- adjust your N rate and/or timing as a result of **measuring** shoot numbers?
- **measure** plant numbers before deciding on Plant Growth Regulator use?
- **estimate** root anchorage when considering whether to use a PGR?
- adjust fungicide rates and timing **relative to canopy size**?
- consider **stem reserves** when deciding whether to apply ear sprays?

1.6 Additionality

In line with stages of innovation identified in the literature (that can be summarised as awareness, mental acceptance, and adoption), this evaluation used questionnaires to

- establish the initial degree of familiarity of growers with the flag terms
- the extent to which they carried out the flagged procedures before training
- detect the changed intentions to carry out the flagged procedures that flowed from the training (questions were specific about the change that was linked to training)
- measure the changes in practice after training

As noted above, the evaluation was more interested in how the actual practices changed among the trained farmers rather than their intentions. However, intentions are (a) an indicator of the effectiveness of the training process itself and (b) a guide to what might happen. They are of particular interest if either the external environment experiences atypical conditions (such as unusual weather conditions, as happened in the 2000/1 growing season) to the extent that normal practices are disturbed, or where no observations are possible because of timing.

Establishing additionality must acknowledge that the impact of training is probably spread out over a number of seasons. On the one hand, initial enthusiasm may lead growers and their advisors to employ techniques with which they are not fully competent, resulting in poor experiences and a withdrawal from some. On the other, confidence may grow with the lessons learned from applying new management techniques to a limited area of the crop, so that in subsequent seasons they are applied more widely, and perhaps some that were initially not used are tried out. To capture such features observation would need to be extended over several seasons. This was not possible within the timespan of the present evaluation, as only the first tranche of intensively trained farmers were surveyed for two growing seasons, the second of which was one of unusual weather conditions. For other groups important to the evaluation (the first tranche experiencing farmer-to-farmer training, and the second tranche of intensively trained farmers) this unusual year was the only one for which data on actual management practices are available. Thus the longer term impact of training is thus only imperfectly captured, and there must be some conjecture about what would happen in more "normal" growing conditions.

But the issue of additionality could not be satisfactorily addressed simply by looking at what happened among the growers (and their consultants) who were trained. Reference needs to be made with what was happening to the control group. These were also receiving information about the developing body of new management techniques via their normal channels of communication (farming press etc.) and from their crop consultants and advisors. They were also subject to the same adverse weather conditions in 2000/1 as the trained farmers. Thus the additionality of the training programmes had to be judged against a moving background and conditions that were, at least in one season, atypical. This was not a simple task.

2 The mechanics of group formation and maintenance

2.1 Planned numbers in the training programme

As first described to the evaluation team, the Sector Challenge technology transfer programme comprised a first tier of intensive training (IT) of groups of 15 farmers, each of whom would go on to train a further 15 farmers in the second (farmer-to-farmer training) tier (FFT). In the first replication, there would be one IT group, which would also sweep up three farmers who had acted as a pilot. In the second (one year later) there would be two IT groups.

Before the evaluation plan was finalised it became evident that each farmer in the first group selected for intensive training would be accompanied in the training sessions by the ADAS consultant who was currently advising that farmer. In effect, the training was to be given to the wheat management team on each farm, comprising the ADAS consultant and client. Thus the session involved about thirty people plus the ADAS staff delivering the training. It also transpired that the consultants would be involved in the farmer-to-farmer training provided by the IT1 group.

Consideration was given to views that the role of ADAS consultants should be reduced in the second replication, with the opportunity for non-ADAS consultants to be involved and for farmers without consultant to participate. As far as the evaluators were aware, in the second round training was given only to farmers though, as will be seen later, there was an involvement by consultants in the farmer-to-farmer training (FFT) stage.

With the agreement of the evaluators, the proposal for intensively training two groups of farmers in the second year of the programme was cut back to only one group, the resources so released being used elsewhere in the project.

An over-view of the anticipated numbers and the outcome is given in Table 2.1

Table 2.1 Anticipated and actual numbers trained

	First tranche	Second tranche
Intensively Trained (IT) Farmers	*IT1*	*IT2*
Anticipated numbers	18	15
Recruited and trained	20	15
Grew crop in first year and provided farmer-to-farmer training	16	14
Grew in second year and retained in group	16	
Farmer-to-Farmer Trained (FFT)	*FFT1*	*FFT2*
Anticipated numbers	270	225
Recruited and trained at least in part	169 (+ c.24 for whom the documentation is not available)	105 (+ c. 12 for whom the documentation is not available, plus two groups that did not meet)

It is clear that, while the numbers in the groups of farmers who were intensively trained was of the anticipated levels, this was not the case for the farmers who underwent farmer-to-farmer training. For the first tranche, whose training took place in 2000, numbers were approximately two-thirds the anticipated levels. For the second tranche, numbers trained were substantially lower, at about half the expected level. However, the impact of Foot & Mouth disease in 2001 played a part in this; for two groups all on-farm training was cancelled and for almost all the others it was curtailed to various extents. Taking this into account suggests a level that was perhaps similar to the first year but still far short of what was anticipated. This suggests that a closer examination of the process of recruitment and retention is justified.

2.2 Recruitment, retention and responses

2.2.1 Intensively trained farmers

ADAS consultants chose and recruited farmers for intensive training. The criteria used depended largely on personal and professional relationships but important factors influencing this choice were the farmer's technical competence, his ability to understand the training material, his communications skills and, to some extent, the size of his wheat enterprise (see later section on responses from consultants).

Initially a pilot group of 3 farmers was used to test the training material. Then 17 further farmers were recruited and intensively trained in 1999, providing a first group of 20. After the initial training sessions the group quickly lost 3 members, 2 who left when their consultant left ADAS and another due to ill health in his family. Another member was included as an observer only. Some 16 remained to deliver the farmer-to-farmer training (FFT) to the second tier.

Data were collected from most but not all of these IT1 farmers. Only 11 completed all the questionnaires at the various stages of the project, but 15 (including the pilots) continued to provide data at the end of the project, by which time they had two years of experience of applying the new management techniques. Stringent efforts were made by follow-ups (post and telephone) to obtain questionnaires from this IT1 group The situation is shown in Table 2.2

A further 15 farmers were recruited and intensively trained in 2000 (IT2). One farmer dropped out early on due to pressure of work. Of the 14 who then applied the procedures for their first growing year and had intended to deliver farmer-to-farmer training, replies were received from 12. Again, follow up was vigorous.

2.2.2 Candidates for farmer-to-farmer training (FFT)

It was intended that the intensively trained farmers would each recruit and train 15 other farmers. The first group had help of varying degrees from their consultant, an input that was seen as part of the transfer programme. According to the replies to questionnaires from farmers and consultants, in the majority of cases farmer and consultant either worked together or selected some trainees each. In no case did the farmer select all the trainees. The most important selection criteria were the (perceived) ability to understand the training material and technical competence. The consultants were almost wholly responsible for issuing invitations, arranging meetings and maintaining attendance.

Once the recruits were at the first farmer-to-farmer session, they were given a baseline questionnaire to complete, which included their name, addresses and telephone number. This address list was used to contact trainees at various later stages in the project to gather information on their training experience and wheat management activities. The evaluation team has been told of examples of farmers who received elements of the training without a baseline questionnaire having been completed and thus who do not appear in the data set; this may have arisen because they missed the first farmer-to-farmer session, or because the consultant attending the session failed to issue and collect forms from all participants. The evaluation should bear in mind that the training provided may have been somewhat more widespread than the evidence of completed questionnaires indicates, though by a degree that is not readily quantifiable but unlikely to be large.

It appeared from replies to questions that there was little or no difficulty in recruiting the target 15 each, only one farmer reporting difficulty (Table 2.2). However, this was not always borne out by the evidence in the form of numbers of base-line questionnaires that were distributed by consultants at the first session, collected and forwarded to the evaluation team. While 1 farmer managed to start training 18 and another 16, two only managed 8 trainees. The average (and median) number in the group was 12.

Table 2.2 Perceptions by intensively trained farmers of difficulties in organising farmer-to-farmer training.

Intensively trained Group 1	Very Difficult	Quite Difficult	A little Difficult	Not Difficult
Choosing group *N = 14*	~ ~	7% 1	36% 5	57% 8
Arranging visits *N = 14*	7% 1	~ ~	29 4	64% 9
Maintaining attendance *N = 14*	21% 3	50% 7	21% 3	7% 1
Presenting subject matter *N = 14*	~ ~	7% 1	57% 8	36% 5
Intensively trained Group 2	Very Difficult	Quite Difficult	A little Difficult	Not Difficult
Choosing Group *N = 10*	~ ~	20% 2	30% 3	50% 5
Arranging Visits *N = 8*	13% 1	38% 3	~ ~	50% 4
Maintaining Attendance *N = 6*	67% 4	~ ~	17% 1	17% 1
Presenting Subject matter *N = 7*	14% 1	~ ~	71% 5	14% 1

Unfortunately, baseline questionnaires relating to two of the groups were not received by the evaluators, so it is not possible to present a complete picture, though there is no obvious reason to expect these were substantially different in size from the others. Table 2.3 shows the numbers trained by each farmer in IT1; names have been suppressed.

Maintaining attendance throughout the farmer-to-farmer training programme was more difficult, with 7 out of 14 farmers finding it quite difficult and another 3 finding it a little difficult. As registers were not kept of the numbers of trainees turning up for the on-farm sessions it is not possible to correlate this experience with attendance rates; in retrospect registers would have been an advantage, even if only informally kept. From the 169 that completed base-line questionnaires only 99 provided information on their response to the training on offer, though it should not be concluded that the other 70 had all dropped out. In the post-training questionnaire an open-ended response by trainees was invited on the organisation of the farmer-to-farmer sessions. Among their comments several indicated why they had not attended. This was usually pressure of work, but a few did not see the relevance of the training to them, or stated that they did not need the information.

The second year in which this part of the project was intended to run was to have been different from the first in that the planned role of ADAS consultants was reduced. ADAS consultants did not form part of the groups given intensive training (unlike the first tranche) and were not seemingly given explicit responsibility for organising groups, managing them or taking part in farmer-to-farmer training. Nevertheless, as things turned out, consultants did play important roles in these respects.

The planned programme of second tranche of farmer-to-farmer training should have taken place in 2001, but this was severely truncated by Foot & Mouth Disease restrictions. Consequently the numbers trained by the second group of intensively trained farmers (FFT2, trained by IT2) was far less than had been hoped and below those of the previous year (Table 2.4). The extent to which the initial recruitment was affected by F&M is not clear. Two farmers managed to recruit at or near the target 15, but these could only deliver the introductory session before the series had to be called off. However, 5 farmers only apparently assembled groups of less than 10 members. Questions were asked of trainees about the number of sessions that had been cancelled. While one might have assumed the smallest groups to be the ones that started later and thus lost the majority of their series, this is not apparently the case. These small group tended to have only lost "some" sessions cancelled.

The conclusion from looking at both years is that recruitment and retention of trainees for the farmer-to-farmer part of the programme is important for the success of project as a whole. Without adequate numbers and satisfactory attendance over the sessions, the opportunity for the intensively trained farmers (plus their consultants) is constrained. The choice of groups of 15 (rather than 10, or 20) was determined before the evaluation plan was drawn up and had to be accepted. We have no direct evidence that this is an optimum size. But there is sufficient here to suggest that this target may be difficult to achieve.

Table 2.3 Numbers of responses from first group of intensively trained farmers, and their trainees

Questionnaires to intensively trained farmers (IT1)					Questionnaires to their trainees (FFT1)		
Identity	**Baseline before training**	**After training**	**After 1-year growing and demonstrating**	**After 2-years growing**	**No.in Group (baseline)**	**Responses after training**	**After 1-year of growing**
Pilots					**Q1**	**Q2**	**Q3**
A	No	No	Yes	Yes	18	12	3
B	Yes	No	Yes	Yes	8	3	3
C	No	No	Yes	Yes	10	5	2
First main group (IT1)							
1	Yes	Yes	Yes	Yes	11	9	5
2	Yes	Yes	Yes	Out	13	6	4
3	Yes	Yes	No	No	11	8	4
4	Yes	Yes	Yes	Yes	Not received		
5	Yes	Yes	Yes	Yes	14	10	3
6	Yes	Yes	Yes	Yes	16	10	6
7	Yes	Yes	Yes	Yes	8	4	4
8	Yes	Yes	Yes	Yes	Not received		
9	Yes	Yes	Yes	Yes	10	5	4
10	Yes	No	No	Out	*	*	*
11	Yes	Yes	No	Yes	14	9	6
12	Yes	Yes	Yes	Yes	10	2	1
13	Yes	Yes	Yes	Yes	13	7	4
14	Yes	No	No	Out	**	**	**
15	Yes	Yes	Yes	Yes	13	9	5
16	Yes	Yes	Yes	Yes	~		
17	Yes	Yes	No	Out	*	*	*
	18	15	15	15	169	99	54

~ Attended sessions as observer only; * Left with ADAS consultant; ** Left due to ill heath in family

Table 2.4 Numbers of responses from second group of intensively trained farmers, and their trainees

	Questionnaires to intensively trained farmers (IT2)			Questionnaires to their trainees (FFT2)	
Identity	**Baseline before training**	**After training**	**After 1-year growing and demonstrating**	**No. in Group (baseline)**	**F & M impact**
Second main group (IT2)					*
18	Yes	Yes	Yes	5	Some lost
19	Yes	Yes	Yes	11	Some lost
20	Yes	Yes	Yes	Not received	Intro only
21	Yes	Yes	Yes	15	Intro only
22	Yes	Yes	Yes	10	
23	Yes	Yes	Yes	11	2 only
24	Yes	Yes	Yes	7	
25	Yes	Yes	Yes	No meetings	None
26	Yes	Yes	Yes	14	Intro only
27	Yes	No	No	7	Some lost
28	Yes	Out	Out	Out	Out
29	Yes	Yes	Yes	10	None?
30	Yes	Yes	Yes	No meetings	None
31	Yes	Yes	Yes	6	
32	Yes	Yes	No	9	2 only
	15	13	12	105	

2.2.3 The control group

The evaluation required a control group of farmers, recruited independently of the intensively trained farmers groups, who would be broadly representative of cereal growers as a whole in the UK. This group would serve to show how knowledgeable farmers as a whole are of the wheat technology being passed on by the project and how much of it is already being put into practice. It would also permit the representative nature of the intensively trained farmers and those undergoing farmer-to-farmer training to be tested.

The control group was recruited using the HGCA mailing list of farmers (and others) who had asked to receive the periodic HGCA Topic Sheets newsletter. It is worth noting how this list was assembled. In 1999 the HGCA had a mailing list of some 7,000, made up of organisations and individuals who had got to know about the information published by HGCA from the press, road shows etc.. In November 1999 MAFF (DEFRA) sent a letter to all cereal levy payers (70,000) whose identities were not known to HGCA inviting them to contact the HGCA. Between 27,000 and 28,000 responded. These were sent another letter, this time from HGCA, thanking them for responding, giving more information about HGCA and its publications, and including a questionnaire. Those who subsequently ordered Topic Sheets or asked for more information were added to the original mailing list, making up its current size to 8,600. Of this total, growers constituted 72%, agronomists 3%, and a further 23% were plant breeders, DEFRA staff, libraries etc.).

To set up a control group for this Sector Challenge Project, a baseline questionnaire, introductory letter and prepaid envelope were included in the mailings to all those on the list that requested single copies of the HGCA Topic Sheet, thereby reaching most of the growers. This resulted in the distribution of about 6,000 questionnaires. This mailing took place in March 2000 and coincided with a similar survey of farmer-to-farmer trainees.

Some 1,300 baseline questionnaires were returned to the evaluators of this project, of which 1274 were used in the analysis. Any known participants at either level of training were eliminated at this stage. The control group had a wide geographical spread, from Aberdeen to Plymouth and from Canterbury to Swansea but is most heavily represented in the main cereal growing areas. Compared with the distribution of cereal enterprises for the UK as a whole, the control group had a significantly higher representation of the larger enterprises and holdings. Despite this, the control group provided a very useful source of information on the sort cereal growers with an active interest in new developments who would be the most likely to try novel management techniques and thus who would ostensibly be the ones targeted by this Sector Challenge project.

Rather more than a year later, (July 2001) 400 from this control group were contacted again with a similar questionnaire to discover how their knowledge and practice of the new wheat technology had changed. The respondents to the baseline survey were divided into four size groups and equal numbers were selected from each. This was done to ensure an adequate coverage of the larger holdings. Reasons for selecting a subset, rather than resurveying all controls, was (a) it was not necessary to establish whether the background against which evaluation was to take place had changed and

(b) it preserved the possibility of going back to other subsets of undisturbed controls at later dates, should the life of this project be extended.

Of the 400 controls contacted, 265 replied, an unexpectedly high response rate. In terms of farm areas, distribution and wheat area they were a representative sample of the control group as a whole.

3 Characteristics of participants in training and of controls

The process of selection might be expected to lead to the farmers who were chosen for intensive training being rather different from growers in general. Selection might favour the larger-scale farmer, the younger and the better educated. They would also be expected to be already familiar with some of the terms and already using some of the new concepts and management techniques being disseminated by the training programme. This might also be anticipated, though to perhaps a lesser degree, among the growers that these intensively trained farmers (plus their consultants) approached for farmer-to-farmer training. While some characteristics accord with expectations, this is not the situation when looking at familiarity with technical terms associated with the new technology and the way that the crop is managed

3.1 Farm and enterprise size, ages of farmer and education

In some respects this is borne out by socio-economic data collected in the baseline surveys. Table 3.1 shows the size distribution of farm and cereal areas for each group. (In this table the two sets of intensively trained farmers have been combined as there was no reason to expect them to differ, but only one FFT group is included, because of the difficult situation in the second year in which the programme was run). Compared with the control group (where average farm size was 389 ha) among the IT group average farm size was much greater (some 78% larger at 696 ha), the farmer-to-farmer group taking an intermediate position (averaging 576 ha). Wheat areas followed a similar pattern, with the average area of the IT growers approaching double that of the control group. However, in terms of the share of the farms taken by wheat, the percentages were similar, at 40 – 44%. When distributions by farm and wheat areas are examined it is clear that the farmers selected for training tended to be larger ones. Almost two-thirds of the IT farmers had farms of more than 400 ha, compared with almost half for the FFT group and less than one third for the controls. Considering only the wheat enterprise, more than three-quarters of the controls had less than 100 ha of wheat, compared with less than a quarter among both the IT and FFT groups. Similarly, large wheat enterprises (400 ha and more) were least frequent among the controls and most frequent among farmers selected for intensive training, those undergoing FFT taking an intermediate position.

Farmers selected for training were noticeably younger than the control group. About 50% of IT and FFT farmers were aged under 40 years, compared with 29% for the controls. The FFT group contained particularly few aged over 50. IT and FFT farmers also had significantly more agricultural qualifications than the control group at degree/diploma level (over 60% in contrast with 52%). Among all three groups the large majority of persons given the training were business principals (that is, they bore some entrepreneurial responsibility). However, among the group selected for intensive training there were more managers than in either of the other groups, with more than a quarter (28%) describing themselves as salaried managers. In part this may be explained by the way in which recruitment took place. The first group selected for farmer-to-farmer training had significantly more business principals than even the controls.

Table 3.1 Characteristics of farms by group of farmers

Farm Area Distribution	Control Group	Intensively trained (IT1 and 2)	Farmer-to-farmer trained (FFT1)
Number	1274	32	167
Farm Size	%	%	%
1-49 ha	1.5	0*	0*
50-99 ha	10.5	3.1*	1.2*
100-199 ha	24.8	6.3*	15.2*
200-399 ha	32.7	25	35.2
400-599 ha	13.9	21.9	20.6
600 ha and over	16.7	43.8*	27.9*
	100	100	100
Average size	389 ha	696 ha	576 ha
Wheat Area Distribution			
Wheat Area	%	%	%
1-49 ha	24.8	6.3*	6*
50-99 ha	24.4	12.5*	15.1*
100-199 ha	28.1	34.4	33.1
200-399 ha	15.1	25	34.3*
400-599 ha	4.4	12.5*	3
600 ha and over	3.2	9.4*	8.4*
	100	100	100
Average size	155 ha	291 ha	253 ha

* significantly different from control group

Table 3.2 Characteristics of farmers by group

	Control Group	Intensively trained (IT1 and IT2))	Farmer-to-farmer trained (FFT1)
Number	1214	28	94
Age group (years)	%	%	%
<30	6.3	3.6	7.4
30-39	22.5	46.4*	42.6*
40-49	31.9	21.4	34.0
50-59	27.3	25.0	13.8*
60-69	9.3	0.0 *	2.1*
70 +	2.7	3.6	0.0
Qualifications	%	%	% (99 replies)
Agric. Certificate	26	32	27
Agric. Diploma/Degree	52	61	64*
Other	18	21	14
Number	1274	28	167
Farmer (business principal)	78.3	71.9	85.2*
Manager	16.2	28.1	13.0

* significantly different from control group

Responsibilities for decisions

The person who makes the decisions about management of the wheat crop is the point of entry for the introduction of new techniques. This is not always the farmer or manager who attended the training sessions. It might other principals in the business or consultants who are employed to give specialist advice. In the baseline questionnaires farmers were asked who was responsible for the management of their wheat crop, the farmer, someone else, or both farmer and someone else. Because of the different sorts of choices that have to be made, this question was subdivided into decisions about variety choice, seed rates and planting time, fertilizer applications, and agro-chemical applications.

A similar pattern emerged among all three groups (Table 3.3). Farmers themselves assume most of the responsibility for variety choice, seed rate and timing of planting, a little less for fertilizer application. Among participants in the training programme farmers claimed that between half to two thirds of them were solely responsible, though among the control group this was somewhat higher, at nearly three-quarters. Among the intensively trained group the main other person involved was the agronomist/consultant, perhaps to be expected among a group that consultants were responsible for recruiting. Among those given farmer-to-farmer training the balance between sharing decisions with a consultant and with other members of the business or family was approximately equal for variety choice but somewhat more dominated by the former when decision on seed rate and planting date were considered. The involvement of consultants was similar among the control group as in those given farmer-to-farmer training.

However, the situation concerning the responsibility for decisions regarding agro-chemicals was rather different. Less than a quarter of the intensively trained farmers decided independently on agro-chemical applications. Farmers reporting that the agronomist/consultant was involved accounted for more than half of cases, with little difference observable among the various groups.

It is clear that consultants play a significant role in decisions, especially in agro-chemicals. In Section 2 the role of the consultants in running the training programme itself was highlighted. A later chapter will bring together all these aspects.

Table 3.3 Responsibilities for decisions concerning various aspects of wheat management

	Control Group	Intensively trained	Farmer-to-farmer trained Group 1	Farmer-to-farmer trained Group 2
Number	1,274	32	167	105
Role of respondent	%	%	%	%
Respondent was Farmer	78	72	85*	77
Respondent was Manager	16	28	13	22
Other	6	0	2	1
Responsibilty for:	%	%	%	%
Variety Choice				
Farmer/Manager alone	71	63	58*	65
With Family member/Partner	8	6	15	6
With Agronomist/Consultant	14	31*	14	15
with Other	7	0	13	14
Seed Rate and Planting Date				
Farmer/Manager alone	72	56	63*	66
With Family member/Partner	8	6	14	4
With Agronomist/Consultant	15	34*	13	19
with Other	6	3	10	12
Fertilizer Applications				
Farmer /Manager alone	63	50	56	60
With Family member/Partner	7	6	12	4
With Agronomist/Consultant	23	38	22	22
with Other	7	6	10	14
Agro-chemical Applications				
Farmer /Manager alone	24	22	19	24
With Family member/Partner	4	3	7	9
With Agronomist/Consultant	58	62	58	53
with Other	14	13	16	19

* significantly different from control group

3.2 Recognition of terms

In Section 1.5 a number of "flag" terms were described and a set of "flag" procedures were listed that are relevant to the new management techniques for the wheat crop. Each group was asked in its baseline survey whether it recognised the "flag" terms and whether it already carried out the "flag" procedures.

An attempt was made to assess the degree of recognition and a score built up over the 10 terms that could reach 30. All three groups scored similarly overall (17 – 19) (Table 3.4). Despite the criteria by which farmers had been selected for intensive training, this group did not appear to be particularly more familiar with the terms. Rather surprisingly, the control group was a little ahead of the either of the trained groups. It is difficult to explain this in terms of positive choice by consultants of clients who were less than typically informed. Perhaps the pattern indicates that those selected for inclusion in the training programme (at both levels) may have been somewhat more circumspect in their answers, as they would be aware that that their understanding may have been tested in some way during the course of training. It is worth noting that the IT groups made no 'low' scores (Table 3.4).

Table 3.4 Recognition scores by group of farmer (baseline)

	Control group	Intensively trained	Farmer-to-farmer trained
Number	1274	32	167
Average Recognition Score/30	18.6	18.3	16.9
Recognition Level	%	%	%
High (21 – 30)	34	28	15
Medium (11 – 20)	61	72	80
Low (0 – 10)	5	0	5

Table 3.5 shows the pattern of recognition in more detail, including how they were ranked and where statistical difference (from the controls) was reached. For several of the terms the farmer-to-farmer trainees were significantly worse at recognition or familiarity than the controls. When recognition was ranked, with a few variations the three groups had the same 'top' five and the same 'bottom' five. 'Benchmark Value' and 'Valley of Optimum Control" were rarely recognised. More of the controls claimed recognition of the latter rarely encountered term, perhaps some indication of the validity of their other claims. It will be shown later that, when the recognition questions were posed to consultants *before* they took part in the training programme, their scores reached almost 100%.

3.3 Wheat management practice

Perhaps of greater relevance in the present context is what actually happened on the farms of growers. In the baseline survey scores were given for each of the 10 "flag" procedures undertaken by growers. On a practice score of 1 – 10 again, surprisingly, the control group came out marginally ahead of farmers selected for intensive training, with those that formed the groups chosen to receive the farmer-to-farmer training scoring least (Table 3.6).

Table 3.6 Practice scores by group of farmers (baseline)

	Control group	Intensively trained	Farmer-to-farmer trained
Number	1,274	32	167
Average Practice Score/10	4.0	3.5	3.1
Practice Level	%	%	%
High (7 – 10)	14	9	8
Medium (4 – 6)	41	41	31
Low (0 – 3)	45	50	61

Table 3.5 Recognition of individual "flag" terms by group of farmer (baselines)

	Controls		Intensively trained		Farmer-to-farmer trained	
Wheat Management Terms	% recog	Rank	% recog	Rank	% recog	Rank
Recognise						
Canopy Nitrogen Requirement	53	1	50	3=	55	4=
Canopy Management	51	2	69	2	70	1
Green Leaf Area Retention	48	3	50	3=	55	4=
Green Area Index	46	4=	50	3=	58	3
Root Anchorage	46	4=	72	1	65	2
Harvest Index	42	6	39	6	46	6=
Soluble Stem Reserves	41	7	38	7	46	6
Shoot Leverage	30	8	31	8	35	8
Benchmark Value	20	9	28	9	16	9
Valley of Optimal Control	10	10	3	10	7	10
Familiar With						
Canopy Nitrogen Requirement	31	5	19	6	12	7
Canopy Management	46	2	28	3	21	2
Green Leaf Area Retention	40	3	25	4	16	4
Green Area Index	34	4	38	1	15	5
Root Anchorage	47	1	22	5	27	1
Harvest Index	26	6	16	7	14	6
Soluble Stem Reserves	19	7	31	2	20	3
Shoot Leverage	20	8	9	9	11	8
Benchmark Value	7	9	13	8	4	9
Valley of Optimal Control	3	10	0	10	1	10
Recognise + Familiar With						
Canopy Nitrogen Requirement	84	4	69	5=	68*	5
Canopy management	97	1	97	1	91*	2
Green Leaf Area Retention	88	3	75	4	71*	4
Green Area Index	80	5	88	3	86	3
Root Anchorage	91	2	94	2	92	1
Harvest Index	68	6	55	7	60	7
Soluble Stem Reserves	60	7	69	5=	66	6
Shoot Leverage	50	8	40	8	45	8
Benchmark Value	27	9	41	9	19*	9
Valley of Optimal Control	13	10	3*	10	8	10
Not Recognise						
Canopy Nitrogen Requirement	16	7	31	5=	33	6
Canopy management	3	10	3	10	9	9
Green Leaf Area Retention	12	8	25	7	29	7
Green Area Index	20	6	13	8	14	8
Root Anchorage	7	9	6	9	8	10
Harvest Index	32	5	45	4	40	4
Soluble Stem Reserves	40	4	31	5=	34	5
Shoot Leverage	49	3	59	2=	54	3
Benchmark Value	73	2	59	2=	81	2
Valley of Optimal Control	81	1	97	1	92	1

* significantly different from control group; only tested for "Recognise + familiar with"

When declarations concerning the individual practices are examined (Table 3.7) the controls were shown to claim more activity in relation to most of them compared with the other groups. For 7 of the 10 practices the percentages of controls claiming to carry them out were significantly above the levels of farmer-to-farmer trainees, and for two (calculating soil nitrogen reserves, and adjusting fungicide rates in relation to measuring shoot numbers) the controls claimed significantly greater percentages than farmers selected for intensive training. However, a high degree of conformity of ranking is apparent between the groups. "Considering Tillering Characteristics" when choosing a variety and "Adjusting Fungicide Rates relative to canopy size" were the most frequently claimed practices. With the exception of these, the other practices were carried out by less than half the farmers.

The questions on practice were directed at the farmer (*Do you currently carry out any of these practices with the wheat crop*). This is not, however, a complete guide as to whether these practices took place on the farm, because some may have been carried out by consultants with or without awareness by the farmer of precisely what had gone on to form the basis of the advice he was given. Thus among the control group the higher degree of responsibility of the farmer for decisions may have been reflected in their higher claimed activity rates, and the higher involvement of consultants in the decisions of the programmes'trainees may be compatible with the lower activity rates that these farmers reported. When we come to study consultants later, it will be shown that they carried out considerably more of all the practices than growers claimed for themselves. But their ranking of practices was not very different from that of the farmer groups, with the exception of "Measuring canopy size before the main N applications". This was ranked first by consultants but last or last-but-one by farmers.

Table 3.7 Individual practices declared by group of farmer

Wheat Crop Practices	Controls		Intensively trained		Farmer-to-farmer trained	
	%	Rank	%	Rank	%	Rank
List order						
Consider earliness of flowering	27	8	25	7	29	4
Consider tillering characteristics	70	1	72	1	67	1
Calculate soil nitrogen reserves	55	3	34*	4	43*	3
Measure shoot nos before first N application	37	6	31	5=	20*	8
Measure canopy size before main N application	20	9	3*	10	13*	9=
Adjust N rate/timing re measuring shoot nos	39	5	22*	8=	25*	6
Measure plant nos before deciding on PGRs	42	4	47	3	28*	5
Estimate root anchorage re PGR use	34	7	31	5=	23*	7
Adjust fungicide rates relative to canopy size	60	2	59	2	45*	2
Consider stem reserves re ear sprays	13	10	22	8=	13	9=
Ranked (by controls)						
Consider tillering characteristics	70	1	72	1	66	1
Adjust fungicide rates relative to canopy size	60	2	59	2	45	2
Calculate soil N reserves	56	3	34	4	43	3
Measure plant nos before deciding on PGRs	42	4	47	3	28	5
Adjust N rate/timing re measuring shoot nos	39	5	22	8=	25	6
Measure shoot numbers before first N application	37	6	31	5=	20	8
Estimate root anchorage re PGR use	34	7	31	5=	23	7
Consider earliness of flowering	27	8	25	7	29	4
Measure canopy size before main N application	21	9	3	10	13	9=
Consider stem reserves re ear sprays	13	10	22	8=	13	9=
* Significantly different from the control group						

4 Management of the wheat crop, and changes associated with the Sector Challenge project

The central issue in the evaluation is whether the project caused a change in the management of the wheat crop. The main focus is on farmers who were either intensively trained or who were trainees in the farmer-to-farmer phase. The causal links between training and practice are not too difficult to establish, though the evaluation must bear in mind that information may well be reaching participants from other directions.

The greater spread to the wider population of growers from the project is not part of this evaluation (see the objectives stated earlier). It would be far less easy to establish. While some information about new management techniques may have reached the controls from direct contact with farmers that the project trained, it is more likely that it did not. A question was included in the repeat survey to the control group as to whether they knew a farmer who had participated; only 2% did so. Probably some of the publicity about the techniques, for example appearing in he farming press, was the indirect result of the project, but this publicity was not an integral part of the training. Consequently, it will be assumed that any changes seen in the control group emanate from outside the training programme.

4.1 Changes in practices of the control group

The purposes of the control group were to provide a background against which the farmers selected for training could be judged and to enable changes in that background to be assessed. Changes were of two sorts. First were those resulting from the general spread throughout the farming industry of information about cereal management techniques. Farmers selected for training would not be immune from the general systems of communication by which awareness is disseminated. Second (and much more significant in retrospect) was the short-term variation in growing conditions that might have an impact on the application of some if not all of the practices that formed part of the training programme. In reality the autumn/winter of 2000/1 were abnormally wet, so that season was likely to have disrupted normal management.

As noted in Section 1, the control group was surveyed for its baseline in March 2000 (coinciding with the baseline for the first group of trainees of the farmer-to-farmer part of the programme) and followed up in July 2001 (pre-harvest) to cover the practices that had taken place in the 2000/1 season. Table 4.1 contains only those replies from the constant cohort of growers who were both in the baseline and repeat surveys. It can be seen that the percentages reporting each of the 10 activities for the 2000/1 season fell below the baseline, most noticeably (and statistically significantly) in the adjustment of the N rate or timing in relation to shoot numbers, perhaps a reflection of the urgency to act when weather and soil conditions became suitable. The average activity score fell from 4.0 to 3.4, a drop of 15%. The behaviour of trained farmers must be viewed in the light of the conditions that caused this retraction in management activity for growers in general. However, the possibility should not be ruled out that the repeat survey to a selected subset of the controls may

Table 4.1 Practices of control group (constant sample of 265)

Wheat Crop Practices		
	March 2000	July 2001
	Yes %	**Yes %**
Consider earliness of flowering	29	23
Consider tillering characteristics	71	64
Calculate soil nitrogen reserves	56	49
Measure shoot nos before first N applic	40	27*
Measure canopy size before main N applic	18	15
Adjust N rate/timing re measuring shoot nos	44	26*
Measure plant nos before deciding on PGRs	40	37
Estimate root anchorage re PGR use	34	33
Adjust fungicide rates relative to canopy size	57	56
Consider stem reserves re ear sprays	14	11
Average activity score	*4.0*	*3.4*

* statistically significant difference between the periods

have elicited answers that were somewhat more realistic than they gave to the baseline.

4.2 Changes in practice of the intensively trained farmers

The first stage of this technology transfer programme involves the uptake of new techniques by the intensively trained farmers. If this does not happen it would be highly unlikely that the next stage – in which their experiences are passed on to others – would be effective. The upper part of Table 4.2 shows what the farmers in the first intensively trained group (IT1) did before training and what they did in each of the two years following training. Results relate to a cohort of 10 farmers who remained in the programme throughout the period.

There was a clear impact on behaviour in the first year after training. Where practices were never normally carried out, or by only a small minority of the group (20% or less), there was a dramatic increase. Only where the majority of growers were already doing something was the impact zero (consideration of tillering characteristics, adjusting fungicide rates relative to canopy size) or more modest (calculate soil nitrogen reserves). The average activity score more than doubled.(from 3.2 to 8.2)

The second year saw a mixed pattern. On the one hand, there may have been a growing confidence that encouraged greater use of new techniques, but on the other there were the adverse growing conditions that perhaps made their use less appropriate or enlarged risks. In the second season of this cohort some procedures were more used for at least part of the crop, but these were outnumbered by practices that were used less. The pattern was similar when looking at the application to all the crop; in the second year there was a rise in 7 of the procedures being applied to all the crop, and 3 cases where it fell.

Table 4.2 Practices of Intensively Trained farmers – Group 1 (IT1, constant 10 cases) and Group 2 (IT2, constant 12 cases)

Wheat Crop Practices	Before		Action Year 1 (1999/2000)					Action Year 2 (2000/01)				
* significantly different from the "before"	%	%	%	%	%	%	%	%	%	%	%	%
	No	Yes	No	Yes	some	most	all	No	Yes	some	most	all
IT1 (10 cases)												
Consider earliness of flowering	100	0	30	70*	30	20	20	20	80*	40	30	10
Consider tillering characteristics	40	60	40	60	20	40	0	30	70	30	20	20
Calculate soil nitrogen reserves	30	70	0	100*	30	50	20	0	100*	10	40	50
Measure shoot numbers pre first N applic	80	20	10	90*	0	40	50	20	80*	10	50	20
Measure canopy size pre main N applic	100	0	0	100*	10	40	50	10	90*	10	40	40
Adjust N rate /timing re measuring shoot no's	80	20	10	90*	0	40	50	20	80*	10	50	20
Measure plant no's pre deciding on PGRs	80	20	0	100*	10	70	20	22	78*	33	44	0
Estimate root anchorage re PGR use	70	30	30	70	20	40	10	11	89*	57	33	0
Adjust fungicide rates relative to canopy size	30	70	30	70	0	60	10	10	90	30	30	30
Consider stem reserves re ear sprays	70	30	50	50	30	10	10	40	60	30	30	0
Average activity score *Standard Deviation*		*3.2* *1.52*		*8.2* *1.14*					*8.0* *2.45*			
IT2 (12 cases)								Action Year 1 (2000/01)				
Consider earliness of flowering	67	33						33	67	25	25	17
Consider tillering characteristics	25	75						17	83	17	17	50
Calculate soil nitrogen reserves	75	25						8	92*	25	8	58
Measure shoot numbers pre first N applic	42	58						8	92	42	8	42
Measure canopy size pre main N applic	92	8						8	92*	33	25	33
Adjust N rate /timing re measuring shoot no's	67	33						8	92*	42	8	42
Measure plant no's pre deciding on PGRs	42	58						0	100*	33	25	42
Estimate root anchorage re PGR use	67	33						25	75	25	25	25
Adjust fungicide rates relative to canopy size	42	58						33	67	42	25	0
Consider stem reserves re ear sprays	83	17						33	67*	33	25	8
Average activity score *Standard Deviation*		*4.0* *2.34*							*8.26* *2.09*			

However, despite the difficult 2000/01 season, the proportion of growers using each technique had expanded substantially from the 1999 baseline situation, except in "considering tillering characteristics" when selecting a variety, where the activity was already used by more than half of the growers (60%). Most of the changes from the "before" situation achieved statistical significance. The average activity score was still more than double the base-line score.

The lower part of Table 4.2 shows the situation for the second intensively trained group (IT2), who were faced with difficult conditions in the first year of trying the new procedures. The baseline survey found some differences compared with the IT1 group in terms of what growers were currently doing when managing their wheat crop and a somewhat higher score in the flagged activities, though perhaps this is not surprising as quite small numbers of cases were involved. The more important feature is that, despite the difficult weather, after training there were increases in the percentages of growers using each technique, even among those which were found to be the most widely used in the baseline survey. "Measuring canopy size" and "Considering stem reserves when applying ear sprays" came from being used at a very low level to usage by a substantial majority of growers. Many of the changes reached statistical significance, despite the small number of cases. At least two-thirds of growers used each of the 10 procedures and five of them were used by more than nine growers out of ten. The average activity score again more than doubled.

The conclusion must be that training appeared to have a substantial impact on the practices of *Intensively trained farmers*, at least within the timeframe of this evaluation. While the controls saw a static or retreating position concerning practices and a falling activity score, the intensively trained farmers saw an increased use of almost all the practices and a large rise in the average activity score.

4.3 Changes in practice of farmers given Farmer-to-Farmer Training (FFT)

The critical test in the evaluation of the Sector Challenge Project's training programme is whether the new management techniques are taken up by farmers who receive the second stage Farmer-to-Farmer Training (FFT). The baseline of these trainees, reported above, found that they scored less in terms of "flag" practices carried than the control group or those selected for intensive training.

The evaluation timetable was such that only the first group of FTF trained farmers could be followed through to the first year in which they had the opportunity of applying the new procedures. Numbers of cases become an issue here. The target was to recruit 270 trainees. In reality, only about 190 were trained, of which usable baseline (before training) records exist for 167. After training the survey of intentions to apply the techniques contained only 99 records, despite follow-ups. The survey of trainees after their first year of application contained only 54 cases, again despite follow-up. Thus the conclusion on the effectiveness of the training system as a whole has to depend on quite a small number of observations, and conclusions must be viewed in this light.

Table 4.3 shows for the 54 cases that remained in the cohort throughout, the practices reported in their baseline survey and after their first year's experience of application. It should be recalled that this season (2000/01) suffered particularly adverse weather conditions. For 8 of the 10 "flag" practices, the numbers using them increased after training, especially among those involving adjusting the use and timing of N (in relation to shoot numbers and canopy size) where the changes reached statistical significance. For 2 they fell, though only marginally. Before training, 6 out of the 10 techniques were used by less than a third of the growers. After training all but one of the "flag" procedures were used by between one third and two thirds of farmers, the exception being "Consider stem reserves in relation to ear sprays", used by only a fifth. The average activity score increased by about a half (53%), a much more modest change than among the intensively trained farmers, though the fall of 15% among the control group over the same period must be borne in mind.

Table 4.3 Practices of farmers given Farmer-to-Farmer Training (FFT1) – first group (constant 54 cases)

Wheat Crop Practices	Before		Action Year 1 (2000/01)				
	%	%	%	%	%	%	%
	No	Yes	No	Yes	some	most	all
54 cases							
Consider earliness of flowering	76	24	65	35	19	12	4
Consider tillering characteristics	43	57	37	63	28	24	12
Calculate soil nitrogen reserves	56	44	35	65	28	20	18
Measure shoot numbers pre first N application	76	24	42	58*	29	12	17
Measure canopy size pre main N application	89	11	34	66*	32	17	17
Adjust N rate /timing re measuring shoot no's	72	28	42	58*	29	12	17
Measure plant no's pre deciding on PGRs	57	43	58	42	12	21	10
Estimate root anchorage re PGR use	72	28	65	35	18	10	8
Adjust fungicide rates relative to canopy size	50	50	56	44	23	12	10
Consider stem reserves re ear sprays	87	13	81	19	8	6	6
Average activity score *Standard Deviation*		*3.22* *2.13*		*4.94* *2.57*			

* significantly different from the "before" situation

4.4 Relative changes among intensively trained, farmer-to-farmer trained, and controls

One of the aims of the evaluation, cited above, was to explore any relationship between the level of inputs to training and the response observed. One way of looking at this is to see the intensive and farmer-to-farmer training programmes as two levels of input.

At this stage it is useful to bring together the before and after training situations for the three groups. To reduce the impact of inter-year differences in weather conditions, the practices in 2000/01 are compared, though this means taking a year that was not typical. This season is common to the *second* intensively trained group, the *first* farmer-to-farmer group and to the controls.

Table 4.4 shows the percentage of growers carrying out each practice before and after training, and the change in what happened in the control group. Average activity scores are also given. Table 4.5, derived from this, shows the absolute change in percentages using individual procedures, activity scores, and the changes compared with the initial levels.

It can be seen that the changes in the use of procedures (increases in absolute percentages) was, for all practices, greater among the intensively trained growers than those given the farmer-to-farmer training. In turn, the increases among this group were greater than among the control group; for most practices the proportion of farmer-to-farmer trained growers using them increased whereas among the control group they all declined. The changes in activity scores followed this pattern, the biggest occurring among the intensively trained farmers, less among those given farmer-to-farmer training but still positive, viewed against the negative movements witnessed among the controls. All this is suggestive that there was a positive relationship between intensity of training and uptake of these new management techniques.

Table 4.4 Percentage of the group conducting "flag" practices before and after training

Wheat Crop Practices	Intensively Trained IT2 (12 cases)			Farmer-to-Farmer Trained FFT1 (54 cases)			Controls (265 cases)	
	Before	Action Year 1 (2000/01)		Before	Action Year 1 (2000/01)		March 2000	July 2001
	%	%	%	%	%	%	%	%
	Yes	Yes	*Of which most/all*	Yes	Yes	*Of which most/all*	Yes	Yes
Consider earliness of flowering	33	67	*42*	24	35	*16*	29	23
Consider tillering characteristics	75	83	*67*	57	63	*36*	71	64
Calculate soil nitrogen reserves	25	92	*66*	44	65	*38*	56	49
Measure shoot numbers pre first N applic	58	92	*50*	24	58	*29*	40	27
Measure canopy size pre main N applic	8	92	*58*	11	66	*34*	18	15
Adjust N rate /timing re measuring shoot no's	33	92	*50*	28	58	*29*	44	26
Measure plant no's pre deciding on PGRs	58	100	*67*	43	42	*31*	40	37
Estimate root anchorage re PGR use	33	75	*50*	28	35	*18*	34	33
Adjust fungicide rates relative to canopy size	58	67	*25*	50	44	*22*	57	56
Consider stem reserves re ear sprays	17	67	*33*	13	19	*12*	14	11
Average of the above	*40*	*53*	*51*	*32*	*49*	*27*	*40*	*34*
SD of the above	*21*	*13*	*14*	*16*	*16*	*9*	*18*	*18*
Average activity score	*4.0*	*8.25*		*3.22*	*4.94*		*4.0*	*3.4*
Standard Deviation	*2.34*	*2.09*		*2.13*	*2.54*		*2.42*	*2.32*

Table 4.5 Change in percentage of the group conducting "flag" practices before and after training

Wheat Crop Practices	Intensively Trained Farmers IT2 (12 cases) Before % Yes	Action Year 1 (2000/01) % Abs. change	*% change*	Farmer-to Farmer Trained FFT 1 (54 cases) Before % Yes	Action Year 1 (2000/01) % Abs. change	*% change*	Control (265 cases) March 2000 % Yes	July 2001 % Abs. change	July 2001 % change
Consider earliness of flowering	33	34	103	24	11	46	29	-6	-21
Consider tillering characteristics	75	8	11	57	6	11	71	-7	-10
Calculate soil nitrogen reserves	25	67	268	44	21	48	56	-7	-13
Measure shoot numbers pre first N applic	58	34	59	24	34	142	40	-13	-33
Measure canopy size pre main N applic	8	84	1050	11	55	500	18	-3	-17
Adjust N rate /timing re measuring shoot no's	33	59	179	28	30	107	44	-18	-41
Measure plant no's pre deciding on PGRs	58	42	72	43	-1	-2	40	-3	-8
Estimate root anchorage re PGR use	33	42	127	28	7	25	34	-1	-3
Adjust fungicide rates relative to canopy size	58	9	16	50	-6	-12	57	-1	-2
Consider stem reserves re ear sprays	17	50	294	13	6	46	14	-3	-21
Average of the above	*39.8*	*42.9*	*217.8*	*32.2*	*16.3*	*91.0*	*40.3*	*-6.2*	*-16.7*
Standard Deviation of the above	*21.4*	*23.8*	*308.1*	*15.5*	*18.7*	*151.4*	*17.8*	*5.5*	*12.6*
Average activity score	*4.0*	*+5.26*	*+131%*	*3.22*	*+1.72*	*+53%*	*4.0*	*-0.6*	*-15%*

4.4 **Impressions of financial implications of adopting the new practices**

Innovation is a profit-seeking (or loss minimising) action, or one that increases profit stability. Hence it would be unlikely that new practices in wheat management would be implemented in the absence of some anticipated financial benefit, perhaps after some initial period of familiarisation. Changes that were likely to reduce profitability or increase risk would be avoided.

This evaluation was not set up to assess the impact on businesses of the new practices. However, the questionnaire distributed after growers had achieved one year's experience of trying them out attempted to collect data on the growers' impressions of the impact on the value of output per ha, the variable costs per ha and the gross margin per ha. This information, in addition to indicating the strength of the impetus behind adoption, was useful in throwing some light on one of the specific criteria for assessing the performance of this Sector Challenge Project – that 75% of the farmers who underwent Farmer-to-Farmer Training accepted that the new approaches had the potential to increase the profitability of the enterprise. While direct questions of expectations were not employed, the out-turn of the intensively trained farmers and the experiences of the first group of the Farmer-to-Farmer trained groups would have been instrumental in creating a climate of opinion.

Among the first group of intensively trained farmers, who grew their first crop in 1999/2000, the balance of opinion (two-thirds of the growers) was that output had not altered much or had increased modestly; more had the impression that output had been increased than that it had fallen (Table 4.6). There was a stronger impression that costs had fallen. The net effect was that for 11 out of the 13 who replied, the perception was that gross margin had been increased by adopting the practices (at least to the extent that farmers had done so). In their second year of experience, corresponding with difficult growing conditions, the balance was slightly more towards a positive affect on output, with again variable costs falling and most (10 out of 14) seeing a rise in gross margin. Experience had not dampened the impression of benefit. For the second tranche of intensively trained farmers, the overall impression in their first year of experience seemed very similar to that of the first tranche's second year.

Among farmers who had undergone Farmer-to-Farmer Training the pattern was again similar. Most reported that output had not altered much as the result of applying the techniques, but outside this category more suggested a positive change than a negative one. While two thirds thought that variable costs had not altered much, there were far more who perceived a fall than a rise. On balance, while almost half had the impression that gross margin had not changed (13 cases out of 29), an equal number thought it had risen and only 3 felt that it had fallen. This suggested a more muted impression of financial gain than came from the intensively trained farmers.

Overall, clearly most farmers perceived a positive financial outcome from using the new management procedures, or at least no deterioration. Thus a necessary condition for their uptake by the substantial sections of the industry appears to be in place.

Of course, the cost of acquiring the training has not been included in the farm-level costs (opportunity costs of time spent being trained, any impact on fees charged by consultants etc.). Also, numbers of cases are quite small and the experiences of all but IT1's first year corresponded to the difficult 2000/01 growing season, when impacts of new practices may not have been typical. However, there is sufficient indication of impact to suggest that a fuller and more detailed cost-benefit analysis might be worthwhile.

Table 4.6 Impressions of the financial impact of adopting new practices (some or all)

	Down £50 or more	Down £25 - £50	Down £10-£25	Not altered much	Up £10 -£25	Up £25-£50	Up more than £50
Intensively trained (IT1) – first year of growing							
Value of output per hectare	-	8% 1	15% 2	23% 3	46% 6	-	8% 1
Variable costs per hectare	-	23% 3	54% 7	15% 2	8% 1		
Gross margin per hectare	-	8% 1	8% 1	-	46% 6	23% 3	15% 2
Intensively trained (IT1) – second year of growing							
Value of output per hectare	7% 1	-	7% 1	14% 2	36% 5	29% 4	7% 1
Variable costs per hectare	7% 1	13% 2	53% 8	13% 2	13% 2	-	-
Gross margin per hectare	-	7% 1	-	21% 3	21% 3	43% 6	7% 1
Intensively trained (IT2) – first year of growing							
Value of output per hectare	-	-	-	25% 2	50% 4	25% 2	-
Variable costs per hectare	-	22% 2	44% 4	22% 2	11% 1	-	-
Gross margin per hectare	-	-	-	13% 1	25% 2	38% 3	25% 2
Farmer-to-farmer trained (FFT1) – first year of growing							
Value of output per hectare	-	3% 1	-	57% 17	33% 10	7% 2	-
Variable costs per hectare	-	-	32% 10	61% 19	7% 2	-	-
Gross margin per hectare	3% 1	-	7% 2	45% 13	41% 12	3% 1	-

5 The training programmes and their impact on the acceptance of the new management techniques

Mental acceptance of an innovation is a critical and necessary step in the process by adoption spreads though the industry. A specific task in the evaluation plan was to assess whether the target that 75% of the farmers who attended the second-tier training programme accepted that the practical adoption of the new approaches to wheat management would lead to crop management decisions that have the potential to increase the profitability of the enterprise.

Both the intensively trained growers and those given farmer-to-farmer training were asked about how the training had influenced their intentions to put into practice the techniques that had been explained and demonstrated to them. Thirteen questions were posed, covering intentions related to variety choice, seed rates, nitrogen application, the use of plant growth regulators, and disease control. The focus was on the changes that resulted from the training. It is clear that the training had a major impact on their intentions, as revealed in the replies.

5.1 Intensively trained farmers as trainees

Among the intensively trained farmers, the training was associated with a high level of declared intention to put the new techniques into action, as revealed in the responses to questionnaires that were completed after training. Of the 13 specific actions mentioned in the questionnaire (see the Appendix) that were envisaged as being affected, among the first group of farmers 12 (out of 15) replied that there had been a (positive) change resulting from the training for 8 or more of the questions. There were very few cases of the training event *not* having either a “yes” or “not sure” reply. At least some of the “no” response came from farmers who were already undertaking these actions before undergoing training, so their intentions could not be attributed to the training.

5.1.1 Quantitative data on intentions

Over 70% of IT1 farmers intended to adopt most of the new techniques to some degree. In most cases the changes from the baseline before training were statistically significant (Table 5.1). The actions where the training seemed to be less influential in achieving a high level of intentions were

[Specifically as a result of the training events]

- Will you consider targeting more fungicide on leaf 3 (64% “yes”)
- Will you consider earliness of flowering when choosing a wheat variety this autumn (47% “yes”, though this still represented a statistically significant increase on previous practice)
- Will you take stem reserves into account when considering the application of ear sprays (47% “yes”)

The answers to secondary questions (“If so, how much of the crop is likely to be involved”) were broadly spread between the “some”, “most” and “all” categories, with “most” being generally the most numerous.

Table 5.1 Intentions after intensive training

Wheat crop practice	Activity before		Intentions after training					
FIRST GROUP	%	%	%	%	%	%	%	%
Intensively Trained (IT1) n = 15	no	yes	no	not sure	yes	some	most	all
Variety choice re. rotation or soil type			0	0	100	20	47	33
Consider earliness of flowering	87	13	13	40	47*	27	7	13
Consider tillering characteristics	33	67	7	7	87	27	47	13
Amend seed rate and/or sowing date			0	0	100	13	47	40
Calculate soil nitrogen reserves	47	53	0	7	93*	27	53	13
Measure shoot numbers pre first N applic.	80	20	0	0	100*	27	47	27
Estimate canopy size pre first N application	100	0	7	0	93*	27	53	13
Adjust N rate/timing re measuring shoot no's	80	20	0	0	100*	27	47	27
Measure plant no's pre deciding on PGRs	67	33	7	13	80*	13	60	7
Examine root anchorage re PGR use	73	27	0	27	73*	7	53	13
Adjust fungicide rates relative to canopy size	33	67	0	20	80	33	33	13
Consider targeting more fungicide on leaf 3			29	7	64	14	29	21
Consider stem reserves re applic of ear sprays	73	27	7	47	47	13	27	7
Average of the above	*67.3*	*32.7*	*5.4*	*12.9*	*81.8*	*21.2*	*42.3*	*18.5*
Standard Deviation of the above	*22.6*	*22.6*	*8.3*	*16.0*	*19.2*	*8.2*	*14.5*	*10.3*
SECOND GROUP	%	%	%	%	%	%	%	%
Intensively Trained (IT2) n = 14	no	yes	no	not sure	Yes	some	most	all
Variety choice re. rotation or soil type			14	0	86	14	43	29
Consider earliness of flowering	67	33	14	14	72	36	21	14
Consider tillering characteristics	27	73	21	0	79	14	29	36
Amend seed rate and/or sowing date			14	0	86	7	14	64
Calculate soil nitrogen reserves	80	20	7	7	86*	29	14	43
Measure shoot numbers pre first N application	53	47	0	0	100*	7	29	64
Estimate canopy size pre first N applic	93	7	21	0	79*	36	0	43
Adjust N rate/timing re measuring shoot no's	73	27	0	0	100*	7	29	64
Measure plant no's pre deciding on PGRs	40	60	7	0	93*	14	29	50
Examine root anchorage re PGR use	60	40	21	0	79	7	21	50
Adjust fungicide rates relative to canopy size	33	67	7	21	64	7	21	43
Consider targeting more fungicide on leaf 3			29	21	50	7	0	43
Consider stem reserves re applic of ear sprays	80	20	0	43	57	0	14	36
Average of the above	*60.6*	*39.4*	*11.9*	*8.2*	*79.3*	*14.2*	*20.3*	*44.5*
Standard Deviation of the above	*22.0*	*22.0*	*9.4*	*13.3*	*15.3*	*11.8*	*12.1*	*14.5*

* statistically different from the actual "before" situation

Among the second intensively trained group (IT2) responses were even more positive in terms of a high level of intention (Table 5.1b). Over 70% intended to adopt ***all*** the techniques, other than the group of three related to fungicide use (adjusting fungicide rates relative to canopy size; consider targeting more fungicide on leaf 3; and relating ear sprays to stem reserves), but neither of these fell below 50%. Compared with the first group, the intentions of the second was less stimulated in some techniques, with somewhat fewer changes between the activity before training and intentions after training reaching statistical significance, but the small numbers of cases mean that nothing systematic can be detected. Also there may have been changes in how the material was presented to the each of the two tranches that may form part of the explanation.

Later analyses confined attention to the 10 questions that could be directly related to actions about which information was collected in the baseline surveys, so that the correspondence between intentions and actual practice could be followed up. The three questions on intentions that were not taken further were:

[Specifically as a result of the training events],

- will you consider choosing varieties according to the position in the rotation or to the soil type
- will you amend your seed rate and / or sowing date to a greater extent than you did previously
- will you consider targeting more fungicide protection on leaf 3 than in the past.

5.1.2 Qualitative reactions to training

Intensively trained farmers were invited by open-ended questions to give their impressions of the training they had received. These are listed in the Annex to this chapter. Generally these suggest a very positive response. Commonly mentioned factors were how the practical sessions served to bring together the theory, and the anticipated consolidation that experience of growing would provide, in preparation for explaining to others.

It became apparent when monitoring the training sessions that information was being passed in two directions, in line with modern perceptions of technology transfer. Not only were ADAS scientists passing their expertise to farmers and associated crop consultants, but that the scientist valued the contact with practical growers. Though not formally part of this evaluation, the benefit to the science community flowing from this particular form of technology transfer should not be overlooked.

5.2 Intensively trained farmers as trainers

An essential part of this Sector Challenge Project was the training provided to other farmers by those that had been intensively trained by ADAS (the Farmer-to-Farmer Training). Immediately after their course of intensive training farmers were asked about their confidence to explain the new approach to the various aspects of wheat management to their fellow farmers. A further questionnaire was sent to each intensively trained farmer after their first year's experience of applying the new management procedures, during which they were also providing training to the groups they had assembled.

5.2.1 Confidence about acting as trainers before carrying it out

When farmers who had been intensively trained were asked about their confidence to deliver the material in the subsequent farmer-to-farmer training, the levels reported were generally high, implying the perception of a firm grasp of the underlying principles (Table 5.2). Confidence was highest with seed rate and planting date issues, with more than a half in both groups (IT1 and IT2) declaring themselves "very confident". Only among the use of plant growth regulators and fungicides did there appear to be many farmers who considered themselves "not at all" confident, but these were still in the minority. How much of this confidence came from the training and how much from previous knowledge and experience is not possible to ascertain.

Table 5.2 Confidence of Intensively Trained farmers to act as trainers

IT1 *N = 15*	Very Confident	Quite Confident	Not at all Confident
Variety Choice	33% 5	60% 9	7% 1
Seed Rate and Planting Date	67% 10	33% 5	~ ~
Fertilizer Applications	13% 2	73% 11	13% 2
Plant Growth Regulators	13% 2	80% 12	7% 1
Fungicides	20% 3	47% 7	33% 5
IT2 *N = 14*	Very Confident	Quite Confident	Not at all Confident
Variety choice	21% 3	64% 9	14% 2
Seed rate and planting date	57% 8	36% 5	7 1
Fertilizer applications	29% 4	64% 9	7% 1
Plant Growth Regulators	14% 2	64% 9	21% 3
Fungicides	29% 4	50% 7	21% 3

5.2.2 Forming and maintaining groups to which to explain and demonstrate

As noted in chapter 2, when the first group of intensively-trained farmers acted as trainers to others, all but one of the 'trainers' said that they had little difficulty in choosing a group or arranging the visits, though almost all were smaller than the target 15. Maintaining attendance was obviously trickier with 9 'trainers', 70% of the group, finding it quite difficult or worse.

Training imparted by the second group (IT2), planned for the 2000/01 season, was seriously disrupted by weather conditions and Foot and Mouth disease outbreak. However, of those (10) who formed groups to train, half said it was not difficult to choose the group, 3 had a little difficulty and 2 found it difficult. Arranging visits posed problems for 4 of the 8 who got that far with the training. Among IT1 presenting the subject matter appeared to pose only slight problems if any, probably related to the fact that three quarters of the group had had at least some previous experience of making presentations. Among IT2 it was found not at all difficult by 1 farmer, a little difficult by most (5), and very difficult by 1 farmer. 5 had had some previous presentation experience. The majority of farmers (60% or more in IT2) were very confident or quite confident in putting over the different aspects of the information

5.2.3 Experiences of giving training

Among members of the first intensively trained group (IT1), the impression from the 13 returned questionnaires is that the exercise worked well with no serious problems. However the input of ADAS was rather more positive than had been foreseen at the outset of the evaluation, in particular through the active participation of its crop management experts. This is discussed more fully in the section on consultants

The level of (post-experience) confidence about having been able to put the new concepts across varied between activities (Table 5.3, where allowance was made for two degrees of low confidence). Most 'trainers' in IT1 were confident with variety choice and seed rates, rather fewer with fertilizer applications and less still with PGR's and fungicides, where 39% were not confident. (This reflects the willingness to apply the measures expressed in earlier questionnaires and may have some bearing on the success of putting over/understanding these topics in the intensive training sessions).

If the table from Question 14 in Questionnaire B (Table 5.2) is compared with that of Question 29 of Questionnaire C/D (Table 5.3) it is possible to see how the earlier level of confidence to impart the knowledge compared with the confidence they actually felt when they were training. Differences were not large but a slight movement is detectable away from "very confident", although only one farmer actually felt 'not at all confident' when training others. Fungicide use was still the one where there was some doubt.

Most 'trainers' in both groups felt they did not need more preparation. Those in the first group who felt they did require it (3 out of the 10 who replied) failed to suggest which particular aspects could have been improved. Most in the second group (7 out of 8) felt they did not need any more preparation.

Among the first group ADAS support was rated as very satisfactory in almost all cases and the visual materials that were provided 'satisfactory' or better by 90% (all but one) of the 'trainers'. Among the second group ADAS support was also rated satisfactory or very satisfactory by 90% and the visual materials provided satisfied 8 out of the ten.

Table 5.3 Post-experience confidence about having put across new concepts

IT1 *N = 13*	Very Confident	Quite Confident	Not very Confident	Not at all confident
Variety choice	23% 3	62% 8	15% 2	~ ~
Seed rate and planting date	46% 6	39% 5	15 2	~ ~
Fertilizer applications	15% 2	54% 7	31% 4	~ ~
Plant Growth Regulators	15% 2	46% 6	39% 5	~ ~
Fungicides	31% 4	31% 4	31% 4	8 1
IT2* *N = 7/8*	Very Confident	Quite Confident	Not Very Confident	Not at all Confident
Variety Choice	- -	63% 5	37% 3	~ ~
Seed rate and planting date	37% 3	37% 3	25 2	~ ~
Fertilizer applications	14% 1	57% 4	29% 2	~ ~
Plant Growth Regulators	- -	71% 5	29% 2	- -
Fungicides	14% 1	57% 4	29% 2	~ ~

* Some IT2 farmers did not carry out any farmer-to-farmer training

Five of the first group 'trainers' felt that they could not have managed without ADAS at the on-farm meetings, six felt that ADAS support was desirable to some degree. Only two felt that they could almost certainly have managed perfectly well without ADAS involvement. Notwithstanding the lesser role planned for consultants among the second group, ADAS staff helped with the presentation with 7 out of 8 groups. Most (6) of ten farmers felt they could not have managed without ADAS help while 4 felt less reliant on it. This role of the consultant is taken up later.

5.3 Farmer-to-Farmer trainees

As noted above, the numbers of farmers who underwent Farmer-to-Farmer training in the first year of the programme's operation was substantially smaller than had been anticipated. Intentions following training were collected from only 99 of the first group of trainee farmers (FFT1) (in contrast with an anticipated number about double this). Because of disruption to the second replicate arising mainly from Foot & Mouth Disease, numbers were even smaller, with intentions gathered from only 40 farmers.

On the whole, the response to farmer-to-farmer training carried out by the intensively trained farmers (together with their consultants) was positive. Following training the level of intentions varied between practices. For example 76% intended to consider tillering characteristics when choosing a wheat variety but only 31% were going to take stem reserves into account when considering the application of ear sprays (see

Table 5.4). However, the absolute level of intentions after training should be distinguished from whether the training appeared to have a statistically significant impact on those levels, as reflected in extent to which the declared intentions were above the actual practice recorded in the baseline survey.

Training made a statistically significant difference to intentions for the same group of actions for both groups of trainees who underwent farmer-to-farmer training.

- Measuring shoot numbers before the first N application
- Estimating canopy size before the first N application
- Adjusting N rate / timing in relation to measuring shoot numbers
- Measuring plane numbers before deciding on PGRs
- Examining root anchorage in relation to PGR use
- Considering stem reserves in relation to the application of ear sprays

The actions where training had least influence on intentions were as follows:

"[Specifically as a result of the training events]

- will you consider earliness of flowering when next choosing a wheat variety
- do you intend to calculate soil nitrogen reserves
- will you examine root anchorage when considering the use of PGRs
- and the set relating to disease control.(adjusting fungicide rates, targeting more fungicide protection on leaf, and taking stem reserves into account)".

In most of these cases however a substantial proportion of farmers were 'not sure' rather than wholly negative. In some cases the farmer was already carrying out the activity (so the attribution of actions to the training may have been invoked) but the apparent lack of positive intentions flowing from training cannot wholly be explained by this.

It is worth noting that the intensively trained farmers (IT1) were also less likely to declare that their training had affected their intentions in regard to some of the same actions (the first above and two of the three related to disease control). It is possible (though not tested here) that IT1 farmers transmitted their own doubts about certain of the actions to their own trainees. Or these particular actions may be contentious or difficult to carry out. On the question of how much of the crop would be involved 'some' and 'most' predominated among the farmer-to-farmer trainees, which is much the same as for the IT1 group at the same stage.

The qualitative comments of the FFT1 trainees, and a smaller number from FFT2 trainees, are listed in Annex 2 of Chapter 5. They were generally positive, though it is clear that some saw themselves already doing what was been demonstrated to them and, in some instances, were technically in advance of what the intensively trained farmer was doing.

Table 5.4 Intentions after training – Farmer-to-Farmer trainees

Wheat crop practice	Activity before		Intentions after training					
* difference from the "before" situation statistically significant	167 Farmers		99 Farmers					
	%	%	%	%	%	%	%	%
Farmer to Farmer (FTF1)	no	yes	no	not sure	Yes	some	most	all
Variety choice re. rotation or soil type			11	7	82	33	35	14
Consider earliness of flowering	71	29	43	22	34	21	4	9
Consider tillering characteristics	33	67	16	6	76	34	24	18
Amend seed rate and/or sowing date			17	8	74	19	39	14
Calculate soil nitrogen reserves	58	42	29	20	51	21	17	13
Measure shoot numbers pre first N application	80	20	13	17	70*	23	27	20
Estimate canopy size pre first N applic	87	13	7	18	75*	25	29	21
Adjust N rate/timing re measuring shoot no's	75	25	13	17	70*	23	27	20
Measure plant no's pre deciding on PGRs	72	28	23	16	61*	14	28	19
Examine root anchorage re PGR use	77	23	25	28	47*	15	21	11
Adjust fungicide rates relative to canopy size	55	45	17	25	58	22	20	15
Consider targeting more fungicide on leaf 3			24	32	44	17	14	13
Consider stem reserves re applic of ear sprays	87	13	27	42	31*	12	14	5
Average of the above	*69.5*	*30.5*	*20.4*	*19.8*	*59.5*	*21.5*	*23.0*	*14.8*
Standard Deviation of the above	*16.6*	*16.6*	*9.5*	*10.3*	*16.8*	*6.6*	*9.4*	*4.8*
Farmer to Farmer (FTF2)	105 Farmers		40 Farmers					
	no	yes	no	not sure	Yes	some	most	all
Variety choice re. rotation or soil type			5	10	85	28	28	28
Consider earliness of flowering	79	21	57	20	23	5	10	8
Consider tillering characteristics	32	68	32	13	55	18	30	8
Amend seed rate and/or sowing date			15	0	85	23	38	25
Calculate soil nitrogen reserves	62	38	24	33	43	10	18	15
Measure shoot numbers pre first N applic.	78	22	13	30	58*	15	21	21
Estimate canopy size pre first N application	92	8	12	18	70*	25	20	25
Adjust N rate/timing re measuring shoot no's	74	26	13	30	58*	15	21	21
Measure plant no's pre deciding on PGRs	65	35	26	15	59*	16	19	24
Examine root anchorage re PGR use	73	27	28	23	49*	16	8	22
Adjust fungicide rates relative to canopy size	49	51	18	31	51	13	18	21
Consider targeting more fungicide on leaf 3			31	40	29	3	11	16
Consider stem reserves re applic of ear sprays	96	4	26	47	26*	8	5	13
Average of the above	*70.0*	*30.0*	*23.1*	*23.8*	*53.2*	*15.0*	*19.0*	*19.0*
Standard Deviation of the above	*19.2*	*19.2*	*13.2*	*13.0*	*19.9*	*7.4*	*9.3*	*6.5*

5.4 Training levels and degrees of response

One of the objectives of the evaluation was to find out if there was a relationship between the level of training input and the level of response

Comparing the two sets of responses, IT1 and FFT1, to the Post Training Questionnaire (B) shows that overall the *Farmer to Farmer transfer did not have the same impact on the intentions of farmers as the original training sessions given to the IT1 farmers themselves.*

For example, in response to the question whether variety choice would be varied according to the position in the rotation or soil type as a result of the training (Question 1), 100% of IT1 farmers, but only 82% of FFT1 farmers, answered 'yes'. And while 80% of IT1 farmers were going to apply this aspect of training to most or all of their crop, only 60% of FFT1 farmers who said 'yes' were. This pattern was repeated throughout the 13 Questions; this can be seen in Table 5.5 which is assembled from the upper parts of Tables 5.1 and 5.4.. It cannot be explained by FFT1 farmers already carrying out the activity and hence not responding to the training, as IT1 farmers overall carried out more of the practices beforehand.

The precise explanation for the different levels of response is not self-evident but is consistent with a view that the impact of training lessen as it passes from one tier to another. However, differences in the nature of the individual being trained may enter into the picture.

5.5 Information coming from outside the training programme

Some of the information reaching trainees about new wheat crop management and which influenced their decisions to adopt them is likely to have come from sources other than the training delivered by this project. Hopefully this would have reinforced messages coming from the training or may have filled gaps, though there is a possibility of contradiction or confusion if the source was not of high quality.

The events attended by trainees, their sources of literature and discussion that were not part of the training programme are shown in Table 5.6. This also contains; for farmer-to-farmer trainees, the number of session within the training programme that were attended. It is apparent that relevant information was coming to them from a wide range of sources. Intensively trained farmers appeared to attend more events than those invited for farmer-to-farmer training, but both received literature from several sources, with only the HGCA seeming to be markedly more important for the IT1 and IT2 groups than for the farmers they trained. Discussion with an agronomist / consultant was common among intensively trained farmers, reinforcing the prominence of these professionals already noted, but rather less so among the other farmers. The intensively trained farmers also seemed to be ready discussers of the new approach with other farmers, especially those not using it (yet).

5.6 Response through the tiers of training

Wheat crop practice	Activity before		Intentions after training					
Intensively Trained (IT1)	%	%	%	%	%	%	%	%
n = 15	no	yes	no	not sure	yes	some	most	all
Variety choice re. rotation or soil type			0	0	100	20	47	33
Consider earliness of flowering	87	13	13	40	47	27	7	13
Consider tillering characteristics	33	67	7	7	87	27	47	13
Amend seed rate and/or sowing date			0	0	100	13	47	40
Calculate soil nitrogen reserves	47	53	0	7	93	27	53	13
Measure shoot numbers pre first N application.	80	20	0	0	100	27	47	27
Estimate canopy size pre first N application	100	0	7	0	93	27	53	13
Adjust N rate/timing re measuring shoot no's	80	20	0	0	100	27	47	27
Measure plant no's pre deciding on PGRs	67	33	7	13	80	13	60	7
Examine root anchorage re PGR use	73	27	0	27	73	7	53	13
Adjust fungicide rates relative to canopy size	33	67	0	20	80	33	33	13
Consider targeting more fungicide on leaf 3			29	7	64	14	29	21
Consider stem reserves re application of ear sprays	73	27	7	47	47	13	27	7
Average of the above	*67.3*	*32.7*	*5.4*	*12.9*	*81.8*	*21.2*	*42.3*	*18.5*
Standard Deviation of the above	*22.6*	*22.6*	*8.3*	*16.0*	*19.2*	*8.2*	*14.5*	*10.3*
Farmer to Farmer Trained (FTF1)	167 Farmers		99 Farmers					
Variety choice re. rotation or soil type			11	7	82	33	35	14
Consider earliness of flowering	71	29	43	22	34	21	4	9
Consider tillering characteristics	33	67	16	6	76	34	24	18
Amend seed rate and/or sowing date			17	8	74	19	39	14
Calculate soil nitrogen reserves	58	42	29	20	51	21	17	13
Measure shoot numbers pre first N application	80	20	13	17	70	23	27	20
Estimate canopy size pre first N application	87	13	7	18	75	25	29	21
Adjust N rate/timing re measuring shoot no's	75	25	13	17	70	23	27	20
Measure plant no's pre deciding on PGRs	72	28	23	16	61	14	28	19
Examine root anchorage re PGR use	77	23	25	28	47	15	21	11
Adjust fungicide rates relative to canopy size	55	45	17	25	58	22	20	15
Consider targeting more fungicide on leaf 3			24	32	44	17	14	13
Consider stem reserves re applic of ear sprays	87	13	27	42	31	12	14	5
Average of the above	*69.5*	*30.5*	*20.4*	*19.8*	*59.5*	*21.5*	*23.0*	*14.8*
Standard Deviation of the above	*16.6*	*16.6*	*9.5*	*10.3*	*16.8*	*6.6*	*9.4*	*4.8*

The main point is that this evaluation cannot ignore the possibility that these sources of information may have had a bearing on the acceptance and adoption of the new management practices. The effectiveness of the project's training must bear this in mind.

Table 5.7 shows the sources of information coming to the control group, gathered from 265 cases that were resurveyed rather more than a year after their baseline. Bearing in mind the problems encountered during the period covered, figures for the attendance at events are likely to be representative of normality. Although a surprisingly high proportion claimed to have attended farm demonstrations of some aspects of new wheat management (almost a third), this was a rather imprecise category. Where closer parallels existed between the control group and trainees (access to literature and discussions) the controls seemed to be relatively well informed. The proportion of controls reporting literature was higher for each category than that of the intensively trained farmers, and much higher than for those selected for farmer-to-farmer training. HGCA literature was particularly commonly reported among the controls, though this is not surprising in view of the way the control group was assembled (HGCA distribution lists). Nine out of ten controls claimed to have discussed wheat management with a consultant / agronomist, much higher than the farmer-to-farmer participants (a fifth for FFT1) and even more than the intensively trained farmers. Though over half had discussed wheat management with another farmer, only 2% were aware that they had had a discussion with a farmer who had been trained by this Sector Challenge project. While by no means conclusive, this suggests that the diffusion of new management practices beyond the project's participants has only been small as yet, a point relevant to the project's evaluation

It would seem unlikely that the farmers selected for farmer-to-farmer training were chosen because they were particularly poorly informed compared with farmers in general (or technologically behind the controls, as was found in the base-line surveys). Part of the possible explanation for the rather high absolute figures for the controls may be that, in the absence of any obvious opportunity for their replies to be verified within the system of training, they presented rather optimistic estimates.

Nevertheless, the general picture is one in which there is a stream of information reaching wheat growers from a range of sources by which messages about new techniques may be carried. One again there is an underlining of the significance of consultants / agronomists (high incidence of discussions, and receipt of associated literature) in the process of managing the wheat crop.

Table 5.6 Sources of trainees' information on managing the wheat crop – events attended, literature seen and discussions held

	IT1	IT1	FFT1	FFT1	IT2	IT2	FFT2	FFT2
	%	Number	%	Number	%	Number	%	Number
Events – in the project								
FFT Initial introduction			100	99			84	36
FFT One subsequent farm visit			75	74			65	28
FFT Second farm visit			53	53			23	10
Events – outside the project								
Any further farm visits			16	16			16	7
Visit ADAS research centre	50	7	8	8	8	1	7	3
ADAS Crop Centre meeting	43	6	20	20	33	4	2	1
HGCA Roadshow	36	5	12	12	42	5	12	5
HGCA Cambridge Conference	14	2	2	2	8	1	na	na
Other	93	13	52	51	42	5	2	1
Origins of Literature								
ADAS (for IT farmers, in addition to the guide issued to growers)	79	11	87	86	58	7	76	32
From agronomist or consultant	57	8	51	50	33	4	31	13
Information from trade or commerce	57	8	43	43	42	5	17	7
HGCA literature	79	11	16	16	75	9	7	3
Farming press	93	13	78	77	75	9	60	25
Other	7	1	11	11	17	2	7	3
Discussion (outside training sessions) with								
Agronomist/consultant	71	10	22	22	83	10	67	28
Commercial/trade representative	43	6	56	56	33	4	0	0
Another farmer using the new approach to wheat management	43	6	54	54	50	6	29	12
Any other farmer	93	13	45	45	75	9	38	16
Family member / business partner	43	6	79	78	67	8	21	9
Anyone else	21	3	10	10	8	1	5	2

Table 5.7 Control group* – sources of information on managing the wheat crop

Information source	%	Number	
Events attended			
Farm demonstration	32.5	86	
Visit to research centre	15.8	42	
HGCA Roadshow	10.9	29	
Other	23.8	63	
Average no. of events attended			0.83
Origins of literature			
ADAS	39.6	105	
Agronomist or consultant	75.1	199	
Trade or commerce	75.8	201	
HGCA literature	90.2	239	
Farming press	94.3	250	
Other	30.2	80	
Average information sources			4
Discussion with			
Agronomist or consultant	89.8	238	
Trade or commercial rep.	53.2	141	
Trained farmer	2.3	6	
Any other farmer	56.6	150	
Family member / business partner	42.3	112	
Anyone else	18.5	49	
Average no. of discussions			2.6

* Relates to 265 cases that were resurveyed.

Annex 1 to Chapter 5

Responses by Intensively Trained farmers to the question "Have you any other comments about …the training you received in wheat management?"

Intensively Trained Group 1 (IT1)

- Gained far greater understanding of wheat husbandry. Still not very confident to train others – need help from my agronomist.
- Intend to put some of it into practice in close liaison with my crop advisor. Most of what we were told related to what we are doing already. Confident of being able to transfer some of the knowledge I have acquired – particularly on the practical side. With help from my agronomist will be OK
- Notes are the key to bringing it all together – should have been available at the sessions. Some of training, eg. Nitrogen, was very complex and relied on great assumptions. Therefore some of approaches will be tried on a limited scale to assess commercial viability. Growing a crop and seeing results on own farm will give confidence/ experience to communicate it to others. Working with agronomist goves confidence. A structured set of training notes, slides etc which are uniform and consistent, from the course, combined with our own farmer input will ensure the message is effectively communicated and not diluted by disparate strands. E-mail and on-line regularly updated notes and pictures, given the adequate technology will assist greatly by being able to discuss with fellow farmers on the course.
- Not enough information on growing crops on a chalk soil. Feel fairly confident to pass it on. Although probably not suitable for chalk soils it has made us look at crop structure very closely and gives pointers.
- Notes needed as well as training.
- Notes needed while the training is fresh in the mind. Confident to communicate it assuming it will be in combination with ADAS advisor and the notes will be available.
- Concepts interesting but practical application more difficult. Complicated Nitrogen assessment will need some simplification if it is to be communicated successfully.
- Training good but would like to do it again to really grasp it all. Expect time and experience will accumulate knowledge. Not a confident speaker but could explain the basic principles and offer my personal experience with enthusiasm.
- N-rates could work out too low following some break crops eg. OSR, main crop potatoes. How old is the data? It should be put across to other farmers in such a way that they feel they will be falling behind if they do not use it. Then our task will be easy.
- Worthwhile but some was revision. Some presentations muddled and aimed at researchers rather than lay people. With help from agronomist communication should be possible. Communication less of a problem than the technology.
- Growth stages could have been shown more thoroughly. More confident having an ADAS consultant to help relay info. than having to do it on my own.
- Enjoyed the course. Some points need clarifying re Nitrogen (Canopy assessment at different GS, in relation to tiller survival and final crop canopy); Seed rates (early and late drilling dates defined for different areas); Varieties (info. on variety characteristics). Not particularly confident to train, waiting for notes to clarify and condense. Expect decisions will be clearer when we have put them into practice on our own farms for a year – looking forward to trying.
- Excellent training – some new some not but it put it all together. Altered the way I look at growing wheat. Might have benefited from some training in teaching/passing on that did not seem patronising.
- Need to be more aware of general farm picture- multiple enterprises, time constraints. Should have been some cost/benefit information.

Intensively Trained Group 2 (IT2)

- Good but too intense. Farmers sceptical- need help from advisor to put it over.
- Training needs more structure- group of 15 rather unruly. Looking forward to challenge of teaching –going to a visit on another Sector Challenge farm to pick up a few hints.
- This format is a good way of transferring technology. Practical exercises useful in emphasising the value of individual crop assessment. Logistics of organising and planning meetings is onerous – ADAS could help here.
- Over last three years have been edging my way into this system and the training has given me the confidence to pursue it on a farm scale. Communication is not my strong point.
- Have been doing a lot of it for years. I like the emphasis on canopy management. ADAS consultant will be doing most of the talking, we will be hosting the party.
- Good reinforcement, as I am using concepts such as low seed rates and early drilling. Not confident of showing others particularly on my own.
- It will take a lot of effort to persuade others. We will get lots of "it won't work on my farm".
- Concerned that the research was carried out under favourable conditions. Communication not discussed at training days. Feel that the group should have been formed and then the farmer to be intensively trained selected.
- Aware of most aspects but training reinforced my knowledge and put some science to it.
- Useful but some members of the group dominated and slowed down progress. Need trials data for further north (Scotland) and some detailed costings and demonstrable financial gains.
- Already affecting my wheat management and applying it is helping my understanding. All made sense only after final session and discussion. Canopy assessment needs more work or a different approach. Nervous of appearing to be telling experienced farmers their job. Will we be able to pass on the knowledge in the time other farmers can spare to be taught the system?
- More information needed for making decisions when soil or establishment conditions are poor. Our local group is being run by an ADAS fieldsman, although I am quite happy to participate.

Annex 2 to Chapter 5

Responses by farmers given Farmer-to-Farmer Training to the question "Have you any other comments about …the training you received in wheat management?"

Comments made after Training by FFT1:

- It was a good way of passing on information as the practical side could be looked at all through the growing season.
- While not adopting canopy management wholeheartedly I feel certain aspects of it will be taken on board and used in future.
- The project encouraged people to think a little more deeply into how they grow a crop and the reasons and implications of many of our inputs.
- For us it was 1-2 years late as we are already trying low seed rates, minimum N etc but it was still a good summary and revision.
- ' A Grower's Guide to Wheat' is a very good booklet
- It is a brave grower who changes his whole cropping/growing system at someone else's suggestion! I am happy to be a solvent imitator, but I do not wish to be a bankrupt innovator!
- The information received was mainly from the ADAS advisors present and very little from the farmer.
- We studied the crops involved but it was difficult to draw any specific conclusions other than slight visual differences
- Both farm meetings seemed rushed and drawing conclusions was difficult.
- In an effort to take advantage of some of this new work we have reduced our seed rates this autumn and will be reviewing our fungicide programme.
- Altering or lowering seed rates should take into account seedbed conditions.
- Total waste of time. Drill ½ rate and the slugs will have the rest. No thank you!
- None of this is new. We have been practising these principles for many years now; ADAS have given existing methods some fancy new names.
- New growing concepts can only tinker at the edges. (Given all the other problems)
- We still have weather and slugs to hamper our plans
- With ever-increasing slug population and the struggle to control it coupled with adverse weather conditions I am glad we did not drill at the low seed rates recommended.
- As most of our wheat is grown on 1:4 hills on chalk wold the crop is generally on a fine balance regarding seed rates and PGR's without trying to manipulate it.
- I think I was more experienced at low seed rates than the host farmer.
- Some of the techniques were already being practised because we use ADAS as crop consultants.
- It would not be wise to take on the whole concept in one year. With the weather being such a variable especially this autumn I feel that canopy control will not be our major concern in the Spring.

Comments after training made by FFT2

- It has been well worth the time and effort and the information has been put across very well
- I intend to adapt the plan to my wheat cropping.
- Would like to see concept of lower seed rates trialed on heavier slug-prone land.
- As a farmer I am interested in all developments in technology but rarely get the opportunity to see any information other than printed matter which is hard to apply or seemingly irrelevant. Farmer to farmer training should be encouraged.
- When someone comes up with an accurate March-August weather forecast then we can tailor fungicides and PGR's to suit!
- I do like these farmer groups as a way of learning as practical experience is always an aid to ones understanding and implementation.

6 The role of ADAS consultants in the process of farmer-to-farmer technology transfer

As was described above, although the project was initially portrayed as one of training farmers and of farmer-to-farmer dissemination of information about new management techniques in wheat growing, early in the process of evaluation it became apparent that ADAS consultants were to be heavily involved. The first group of intensively trained farmers (IT1) was chosen largely as a result of their existing links with individual ADAS consultants who in fact accompanied their clients to the intensive training sessions. It was envisaged that the second Intensively Trained group would not necessarily have ADAS consultants but other advisors who would not attend the intensive training sessions. The relationship between consultant and client can be a close one – when the consultant of two farmers in IT1 left ADAS both his clients abandoned the project. Also, it became clear as the project progressed that intensively trained farmers (in both groups) were relying on their consultants for at least some input in the training process by them of other farmers.

6.1 Consultants' awareness and practices before training

Answers to the 'Before Training' questionnaire completed by the intensively trained farmers, the farmer-to-farmer trained farmers and the large control group (see Table 3.3) provided an insight into the role of the consultant in farm decision making relating to the management of the wheat crop. Farmers, very largely, made decisions relating to Variety Choice and Seed Rate and Planting Date, independently of consultants. They took a little more advice on Fertilizer Use but 60% relied on consultants when deciding on Agro-chemical Applications.

Consultants associated with the first Intensively Trained group of farmers (IT1) also completed 'Before' and 'After Training' Questionnaires. Their replies showed, not surprisingly, that they all recognised, or were familiar with, all the 'flag' wheat management terms except Benchmark Value and Valley of Optimal Control, scoring more highly than IT1 famers (Table 6.1a). Consultants also more frequently carried out most of the 10 'flag' wheat crop practices than their clients, the greatest differences being in considering earliness of flowing when making variety choice and in measuring canopy size before making the main N application (Table 6.1b). So although the consultants were aware of the new technology, it was not reflected to an equal extent by their IT1 clients' knowledge or practice before these farmers received intensive training. Why this occurred is worth further investigation.

Referring back, however, to Table 3.3 on decision making, shows that in activities where consultants' advice is little used there is a wide gulf in the level of practice between farmers and consultants. For agro-chemical applications, where consultants' advice *is* used by the majority of farmers, the level of practice was very similar between farmers and consultants. It seems rather obvious to suggest that the influence of consultants in introducing new technology is limited to the areas where their advice is sought and valued.

Table 6.1 Consultants before intensive training

(a) Recognition of terms

	Consultants	**Consultants**	**IT1 Farmers**	**IT1 Farmers**
Wheat Management Terms	% recog	Rank	% recog	Rank
Recognise				
Canopy Nitrogen Requirement	54	1	41	6
Canopy Management	15	6=	77	2
Green Leaf Area Retention	39	2=	53	4=
Green Area Index	8	8=	59	3
Root Anchorage	15	6=	88	1
Harvest Index	8	8=	31	7
Soluble Stem Reserves	8	8=	53	4=
Shoot Leverage	39	2=	24	8
Benchmark Value	33	4	24	8=
Valley of Optimal Control	31	5	6	10
Familiar With				
Canopy Nitrogen Requirement	46	8	12	7
Canopy Management	85	4=	23	4
Green Leaf Area Retention	62	6=	24	2=
Green Area Index	92	1=	29	1
Root Anchorage	85	4=	6	8
Harvest Index	92	1=	13	6
Soluble Stem Reserves	92	1=	24	2=
Shoot Leverage	62	6=	0	9=
Benchmark Value	42	9	18	5
Valley of Optimal Control	0	10	0	9=
Recognise + Familiar With				
Canopy Nitrogen Requirement	100	1=	53*	6
Canopy management	100	1=	100	1
Green Leaf Area Retention	100	1=	77*	4=
Green Area Index	100	1=	88	3
Root Anchorage	100	1=	94	2
Harvest Index	100	1=	44*	7
Soluble Stem Reserves	100	1=	77*	4
Shoot Leverage	100	1=	24*	9
Benchmark Value	75	9	41	8
Valley of Optimal Control	31	10	6*	10

* significant difference between consultants and IT1 farmers groups

(b) Practices

Wheat Crop Practices	Consultants	Consultants	IT1 Farmers	IT1 Farmers
	%	Rank	%	Rank
List order				
Consider earliness of flowering	62	4	18*	7=
Consider tillering characteristics	77	3	71	1
Calculate soil nitrogen reserves	85	2	47	3
Measure shoot nos before first N application	31	9	18	7=
Measure canopy size before main N application	100	1	0*	10
Adjust N rate/timing re measuring shoot numbers	46	5=	18	7=
Measure plant numbers before deciding on PGRs	46	5=	35	4
Estimate root anchorage re PGR use	39	8	24	5=
Adjust fungicide rates relative to canopy size	46	5=	53	2
Consider stem reserves re ear sprays	23	10	24	5=

* significant difference between consultants and IT1 farmers groups

6.2 Participation by consultants in Farmer-to-Farmer Training

ADAS consultants were involved in the Group 1 Farmer-to-Farmer (FFT1) training sessions. Several consultants felt that they would be needed to give at least some 'moral support' to their client and some farmers were clearly banking on having the consultant present to help if necessary.

In practice the role of the consultant in the farmer-farmer training sessions was a very significant one. At the outset the consultants helped the farmer to choose his training group. Of the 15 IT1 training groups for which we had information, the consultant alone chose the group in 2 cases, did it jointly with the farmer in 9 cases and in the remaining 4 they chose some each. In no case was the farmer alone responsible for choosing his training group. Only one consultant suggested that there was any difficulty in recruiting members although in practice the average size of group was smaller than the 15 planned for. The most important criteria used in selection were the ability to understand the material and technical competence. In almost all cases the consultant issued the invitations to join the group and arranged for the first indoor meeting (if it was not on-farm). His contribution to maintaining attendance was important too. When farmers were asked how difficult it was to choose a group, arrange meetings and maintain attendance few found it particularly difficult (See Table 2.2 of Chapter 2). This is understandable since it appears that these tasks were in many cases carried out largely by the consultants.

Once the training programme was under way it was the consultants' view that farmers almost always dropped out of the group due to time pressure and other commitments although a few did not see the relevance or felt they knew the techniques already. At meetings printed handouts were considered very important if not vital.

The second set of intensively trained farmers encountered severe difficulties because of weather conditions and Foot & Mouth Disease in their first growing and demonstrating season (2000/01). Only three groups were unaffected by disease restrictions, several lost one or two meetings and at least two abandoned the training altogether. Though this second group (IT2) were not accompanied to the intensive training by consultants, all did have consultants to help with their farmer-to-farmer training. However, only 7 replies were received from these consultants, 2 of whom were associated with one training group. Our information is therefore rather limited but on the whole it is very similar to that given by the consultants to the Group 1 farmers.

Only one of the 7 consultants to the IT2 group was not from ADAS (but was probably ex-ADAS). Only one had been wholly responsible for choosing the IT farmer, 4 partially and 2 not at all. Technical competence, understanding the material, size of enterprise and ability to communicate were all cited as important factors in this choice. The majority of groups, 5, were chosen jointly, one by the consultant only and one by the farmer. Only one consultant suggested that recruiting the group was difficult, although the size of several groups was small. The most important criteria used for selection were ability to understand the material, and technical competence. In two thirds of cases the consultant did the inviting. If the first meting was off-farm the consultant was always involved with organisation, and was important in maintaining attendance at all the meetings. Reasons for farmers dropping out were mostly time pressure, but in one case the trainee did not see the relevance and, in another, no further information was needed. Printed handouts were important in all cases.

6.3 Consultants' views of their importance in farmer-to-farmer training

The role of consultants in the training process can be viewed from the perspective of the farmer and of the consultant. Table 6.2 shows how important the *consultants* felt they were in supporting their intensively trained clients in passing on the information on the different topics in the farmer-to-farmer stage of the programme. In no instance did the consultant feel he was unimportant. He rated his contribution as 'vital' or 'very important' in 80% of cases when Nitrogen Use, PGRs and Disease Control were being discussed. When asked which aspects of crop management stood out as requiring the presence of the consultant there were a variety of suggestions; Green Area Index, Nitrogen Use, Canopy Management, Plant Populations, PGR Use and Disease Control. Almost all agreed that the aspects of crop management best explained and demonstrated by the farmer were site characteristics, soil types, seed rates and establishment.

Among the consultants to the second tranche of intensively trained farmers, at least 5 of the 7 saw their supporting role as vital or very important in all of the topics. The presence of a consultant was most useful to explain Nitrogen Use and Disease Control while farmers best handled site characteristics, and seed rate and establishment and any essentially practical issues.

Table 6.2 Views of consultants of their role in presentation

Intensively trained Group 1	Vital	Very Important	Quite Important	Not Important
Variety Choice	7% 1	47% 7	47% 7	~ ~
Seed Rates	7% 1	67% 10	27% 4	~ ~
Nitrogen Use	40% 6	47% 7	13% 2	~ ~
PGRs	27% 4	60% 9	13% 2	~ ~
Disease Control	20% 3	60% 9	20% 3	~ ~
Intensively trained Group 2	Vital	Very Important	Quite Important	Not Important
Variety Choice	43% 3	29% 2	29% 2	~ ~
Seed Rates	43% 3	57% 4	~ ~	~ ~
Nitrogen Use	43% 3	57% 4	~ ~	~ ~
PGRs	43% 3	43% 3	14% 1	~ ~
Disease Control	43% 3	43% 3	14% 1	~ ~

6.3 Farmers' view on the role of consultants

The IT *farmers*, with only one exception, valued the consultants' input highly; 85% of IT1 and 60% of IT2 found the support very satisfactory (Table 6.3). The majority was also satisfied with the visual materials provided. When asked if they could have managed without an ADAS presence at meetings, again the majority said no, or probably not, although two or three felt that they could have managed without.

From their quoted remarks (see Annexes to this chapter), as well as their answers to the questionnaires, it is clear that the consultants thought that their presence and contribution was essential to the technology transfer process being tested by this project - from the choosing and organising of the groups to putting across much of the information. In some instances the consultant had taken over the presentation entirely. At least one farmer felt that this was his understanding of the project – he provided the location and the consultant did the talking! More than one consultant implied that his contribution had been time consuming and somewhat onerous. On the other hand several suggested that the combination of consultant and farmer was a very good one for putting over new technology.

However, if the technology transfer process being sponsored by the Sector Challenge project is meant to be essentially *farmer-to-farmer* then the apparently pivotal role of the consultant has to be questioned.

Tabe 6.3 Perceptions by intensively trained farmers of support provided by consultants and ADAS

Level of support	IT1		IT2	
	%	No.	%	No.
Very poor	-	-	10	1
Poor	-	-	-	-
Satisfactory	15	2	30	3
Very satisfactory	85	11	60	5
Visual material provided				
	%	No.	%	No.
Very poor	-	-	10	1
Poor	7	1	10	1
Satisfactory	57	8	40	4
Very satisfactory	36	5	40	4
ADAS contribution				
	%	No.	%	No
Absolutely No 1	36	5	60	6
2	14	2	-	-
3	7	1	-	-
4	14	2	-	-
5	14	2	20	2
6	-	-	10	1
7	-	-	-	-
8	-	-	10	1
9	14	2	-	-
Absolutely Yes 10	-	-	-	-

Annex 1 to Chapter 6

Consultants' comments after participating in (intensive) training sessions

"The extent to which the training would enable farmers to communicate the new approach to other wheat growers"

- The farmer with whom I am involved is keen to grow at least one crop in accordance with the new guidelines although questions have arisen which indicate the training needs to be backed up by further input from a consultant or more notes should be provided.
- They have the theory and are keen to try it. They will be more confident after trying what they have leant in putting it across to other farmers. Farmers are quite good communicators and their consultants are always there to help out. My farmer has fully taken the concepts on board together with most of the technical detail and should be in a apposition to pass on this knowledge well.
- Due to the fact that the techniques were relatively new there were no strong 'take home' messages or 'blueprints'. Some growers might find trying to communicate he ideas in the training difficult because of the time lag between training and implementation.
- Need a measurement system for Crop Area Index. Not just by eye.
- The course failed to provide a single clearly defined message on what it was all about and I feel the farmers would struggle. This might be rectified by the notes. Need an overview of the purpose of this form of crop management with each section starting with a summary of how it fits into the wider picture.
- There are clear messages that will be easily communicated by the farmer. Anything less easy will become clearer once it has been put into practice on the farm. A greater emphasis on how the new principles differ from the standard practice will allow the farmers to communicate the message more effectively.
- Main task will be remembering details but with the own field examples it should be easier.
- With the assistance of their local consultant and the training guide I think they will be able to do it well.

Annex 2 to Chapter 6

Consultants' Impressions after Farmer-to-Farmer Training Sessions

Group 1

- The concept is good as a means of training but due to the complex nature of the subject I think a lot was asked of the lead farmers in view of the poor quality of the training they received. Thus the consultant had to provide a lot more input than was originally planned.
- As a method of information transfer the project works very well. Having the combination of a local group (which must be technically competent to start with) and a trained lead farmer with consultant back up, transfers information well and allows group members to apply that information more effectively that any other format I have experienced.
- Both groups went well with good attendance at the first, indoor, meeting and the April outdoor meeting. The important June meetings, when it was possible to see the 'proof of the pudding' in the demonstration crops, were only 50% attended due to pressure of work, holidays and drop in interest, but possibly also due to a fear of it being a success and therefore necessary to implement. I have communicated the favourable harvest results to group members and I hope this will encourage them to try the techniques. I suspect the full uptake will be poor. Many will perhaps reduce seed rates a bit and hope that everything else will come right as a consequence.
- On the whole the project has been well received by farmers attending the meetings. It would perhaps have been useful for the consultant and client of each group to meet after each meeting to discuss feed back and areas of difficulty.
- I wish I had chosen all the farmers. I spent a lot of time organising the meetings preparing power points etc and then attendance was poor. The people I had invited came but those chosen by the farmer himself were unreliable.
- Rightly or wrongly I felt responsible for running the whole thing. I undertook most of the organisation- group selection, invitations, providing refreshments etc and conducted the meetings. I don't believe the lead farmer expected to take on responsibility for the training sessions. (I had inherited the project when the original consultant left ADAS).
- I believe that the most technically competent larger farmers are becoming less and less keen to help other farmers to improve their business. They will be competing directly with those they have trained. This may well affect this type of information transfer.

Group 2

- I was fortunate enough to have an enthusiastic host farmer and attendance was good throughout the 3 meetings. The group requested a 4th meeting just before harvest to see how the demonstration crop had developed I felt that this was a very effective way of getting a technical message across to farmers who were keen to learn. Most of the group are using the training in their crop management this season.
- Although generally well received the overall feeling of scepticism as to whether the project objectives would work for all attending seemed to be the overriding factor.

7 Conclusions of the evaluation

Here the major points emerging from the evaluation of various aspects of this Sector Challenge project, established in earlier chapter, are grouped together to produce an overall view. The Executive Summary that appears at the start of this report is essentially a condensed version of this chapter.

7.1 The nature of this project and its evaluation

The purpose of this evaluation was to study the *effectiveness* of the two stage training programme. The efficiency with which the resources were used, and the economy of delivering the outcome were beyond the terms of reference. Nevertheless, some issues were raised that pertain to these other facets, and these are mentioned below.

As a subject for evaluation, this project has some features that make it a particular challenge, including the following.

- It related to a raft of new techniques, not just one; many are complex and they could be adopted partially or entirely and applied to some or all of the wheat crop on each farm.
- There was a potential for techniques to develop or new ones to emerge during the course of the project, which itself was rather long, extending for three years (plus six months of pre-project design and a period afterwards for writing up).
- Some of these techniques were already in use by some farmers before training, and by the industry in general. Hence questions on whether the training had changed intensions or practices could receive a negative response if this "new" technique was already in use.
- The flow of information to farmers came not only from involvement in the programme but also from other sources, some of which (such as the farming press) may have been stimulated by this particular training programme.
- The uptake of new technology (including management practices) could be expected to take a number of years, yet the evaluation was restricted to a relatively short period with only a small number of cases followed for more than one growing season.
- The role of consultants as part of the management unit of the wheat crop on the farms participating in training did not seem to have been fully appreciated in the planning stage of the evaluation. Had this been so, perhaps the nature of the evaluation, and perhaps the design of the project, may have been different.
- The design of the system was modified during the period, resulting in smaller numbers of cases on which the evaluation could be based.
- The difficult weather conditions in the autumn/winter of 2000 and the disruption to the planned farmer-to-farmer training caused by Foot & Mouth Disease restrictions further severely reduced the number of cases.

7.2 Meeting the objectives set in the evaluation plan

The five objectives set in the evaluation plan (see para 1.3 above) appear to have been broadly met by the project. In direct response to each of them, it is the view of the evaluators that, within the limitations imposed by the relatively small number of cases,

(a) *the first-tier intensively trained farmers appear to have understood the new concepts and were in a position to transfer this knowledge to other groups of farmers through group activity.*

After training, 70% or more of both groups of intensively trained farmers intended to adopt most of the new techniques (Section 5.1). The levels of confidence about giving farmer-to-farmer training was high both before and after the experience of doing so, though for some practices there was greater reserve (Section 5.2).

(b) *the farmers who attended the second-tier training programme appeared to accept that the practical adoption of the new approaches to wheat management would lead to crop management decisions that have the potential to increase the profitability of the enterprise.*

On the whole, response to farmer-to-farm training was positive. After training the level of intension to carry out actions varied between practices, being lower with some (such as disease control) than with others (such as considering tillering characteristics when choosing a variety)(Section 5.3). However, the training increased the intensions compared with past practice in almost all situations, often significantly and even when the final level was not high.

(c) *a positive relationship existed between the levels of information made available to potential adopters of techniques (as reflected in intensive or farmer-to-farmer training) and the degree of response of these adopters.*

(d) *though an assessment of the effectiveness of the various forms of information/training was not carried out in detail, including the cumulative nature of these forms, it was evident that intensive training was more effective at influencing intentions and practice than farmer-to-farmer training, and that the availability of a hard-copy growers' guide was a powerful supplement to verbal instruction and practical demonstrations.*

Changes associated with intensive training were greater than with farmer-to-farmer training (Section 4.4).

(e) *there was evidence that this form of transfer process provided additionality to the awareness of potential adopters who were involved in the project. There was no evidence that there was any impact on wheat growers who were not directly involved as trainees and did not visit the farms of trainee.*

While the practices of the control group appeared to regress in the difficult conditions of 2000/01, there was an advance in their use among those that had been intensively trained and, to a lesser extent, those who received farmer-to-farmer training (Section 4.4). However, any spill-over effect to the industry at large was likely to only have been very small, if present at all. Within the time-span of the project only a very small percentage of control group farmers (some 2%) were aware of having had contact with any trainee of either stage.

7.3 The mechanics of group formation and maintenance

Though at the outset attention was focused on the effectiveness of the two forms of training, in reality the practicalities of assembling and, in particular, the maintenance of numbers in groups proved a challenge. Selecting farmers for intensive training used rather loose criteria, of which familiarity to an ADAS consultant was pivotal, at least for the first group. While the intensively trained farmers reported no great difficulty in choosing groups for farmer-to-farmer training (though in practice consultants were heavily involved), in reality numbers per group were smaller than intended. Keeping up attendance was not easy. Chapter 2 dealt with these issues.

This project was not designed to investigate the optimum size of group for intensive or (perhaps more pertinent) for farmer-to-farmer training, and the evaluation has not evidence to contribute. The choice of 15 participants per group was indicated at the outset, but the achievement of this did not constitute a central aim for the project. However, it is obvious if numbers of farmers per group are small, the opportunity for the intensive training to be diffused to the next level is reduced. The efforts and resources used in the first tranche of the programme resulted in about 20 farmers being intensively trained and about 200 being given farmer-to-farmer training (compared with the 270 projected). In the second tranche (where there were disrupting external factors), numbers were 14 and about 117 (out of a projected 225) respectively. In both tranches training may have been delivered to rather more farmers than the number of baseline questionnaires indicate. This could be because some farmers may have joined after the initial “indoor” session at which these questionnaires were distributed, or completed questionnaires may not have been collected from all present. However, these are unlikely to be numerous and to alter the general picture.

To improve this aspect of the project, a more systematic approach might be considered for any future application. For example, would it be possible to select farmers for intensive training according to characteristics that might predispose them to be effective trainers (such as educational qualifications, participation in training courses etc.)? Perhaps more significant, could an incentive system be involved that made payments to intensively trained farmers that were conditional on reaching targets of numbers attending farmer-to-farmer sessions?

7.2 Impressions about the training programmes from recipients

The training programmes appear to have been successful in the sense that farmers developed the intentions to use most of the new practices (Section 5.1). Among the intensively trained farmers a high level of acceptance (of the order of 70% and more) applied to all but a few techniques, such as those relating to disease control. Written guidance notes were widely valued. The level of confidence about giving the farmer-to-farmer training was high, few suggesting that more preparation was needed, though there was variation between topic areas (Section 5.2). The level of confidence was only moderated a little by the experience of carrying it out, though again there was variation between topics. However, the involvement of the consultant in delivering the training was, in many cases, major, with few farmers feeling that they could have done it by themselves.

There were also positive responses to farmer-to-farmer training from those who underwent it, though intentions were changed less than by intensive training. Again there were variations between practices, with disease control again being among the least influenced. Where intensive farmers were less accepting and less confident in their ability to pass on information, there was a tendency for the messages to be less effectively passed on. How much is due to the nature of the issues and how much to the confidence of those delivering the message is difficult to disentangle. Nevertheless, this part of the project is judged to have been successful, at least partially.

The pattern suggests that, while some topic areas and new practices can be relatively easily spread by the type of training programme under trial here, it may be less suitable for others.

An interesting spin-off from the intensive training sessions was the benefit that at least some of the scientist-trainers appeared to obtain from the close contact with groups of practical farmers, judged by comments they offered to the evaluation team. This falls outside the terms of the evaluation being reported here, which looks at only the effectiveness of the training programme. But it is consistent with the literature on technology transfer, which sees the process as a two-way flow of information. In any broader assessment of the Sector Challenge Project's costs and benefits this flow from farmer to scientist should be recognised and included.

7.3 Adoption of new practices

Tracing patterns of acceptance through to application was constrained by the project's time horizon and the disruption to the 2000/01 growing season. Adoption of a new management technique is not likely to be complete at the first opportunity to apply it. Only for the first group of intensively trained farmers did data relate to more than one application.

Within the limitations of the project, it appeared that the training resulted in an increase in the use of the "new" management techniques to which the training related (Section 4). The rise among the intensively trained farmers was more than among those given farmer-to-farmer training, but both were positive. In contrast, the use of these practices declined among the control group, a change probably associated with the season's difficult growing conditions. Thus there is evidence for additionality arising from the training programme.

But farmers are not, by themselves, responsible for all decisions about wheat crop management, even by their own admission. In particular, decisions on agro-chemicals appear to be taken predominantly in association with a consultant / agronomist, and a large minority of fertilizer application too (Section 3.1). Agro-chemical applications formed a management subject in which farmers seemed relatively unwilling to apply the results of the training, something perhaps explained by the predominant role in these decisions played by crop consultants.

The perceptions by farmers of the financial implications of adopting the new techniques was that, on balance, in the first year there was an improvement in gross margin per ha.. Thus conditions seem to be in place for continued use (Section 4.4).

7.5 The role of the consultant

Although this Sector Challenge Project started out as one to train farmers (though soon modified in the face of the reality of how decisions about wheat growing are made), the involvement of their crop consultants throughout had a major impact;

- Consultants were (and are) responsible to some degree for crop management, particularly certain aspects such as disease control.
- In the first round of intensive training consultants and farmers were trained alongside each other. In practice, training was being delivered to the grower's "management team"
- Consultants were heavily involved in assembling and managing groups for farmer-to-farmer training, and in many cases for delivering the training in part or, in some cases, in whole.

The presence of consultants thus seems integral to the training programme *as it was organised.* Though intensive training was possible without consultants being present (the IT2 group was trained in this way), few farmers could have carried out the farmer-to-farmer part of the programme unaided. The dominant view among consultants was also that they were vital or essential to most of the training activity, especially concerning the use of Nitrogen and agro-chemicals. Evaluation must involve them.

Heavy involvement by consultants raises some other interesting issues. The survey of consultants found that the terms used by the new techniques were familiar to them even before training. They also claimed to be widely using the techniques, often more than found in the replies from their client farmer, though this varied between practices. This leads on to a question about why such a disparity might exist; would a consultant knowingly not use new process of crop management that could enhance profitability?

Explanations for the situation might come in various forms. Perhaps the consultant was using the techniques without explicitly telling the client how the recommendations for management were reached. Or the consultant may have been less than completely familiar with the processes, so that they were not implemented. Or, less likely, the client might not be willing for the new management practices to be applied.

7.6 An over-view of the effectiveness of the training programmes

In part the benefit from the training programmes seems to come from providing farmers with a firmer understanding of the scientific basis of decisions they are already making. Changes in seed rates or variety choice according to soil type might be examples. However, many aspects of wheat crop management seem to involve a mix of farmer and consultant inputs.

The interaction between client and consultant, combined with the specialist knowledge apparently required by some aspects of management, suggest that a potential benefit from the training of farmers may come more from creating a general familiarity rather than by endowing expertise. The training programmes, even the intensive one, are unlikely to be able to equip the farmer with the necessary detailed knowledge that a professional agronomist / crop consultant would be expected to possess in, for example, a sophisticated subject such as disease control. A short training programme would almost certainly not provide the wealth of experience necessary to reach authoritative decisions.

However, by raising awareness of the issues, the background science and the possibilities opened up by new management techniques, the client may be in a better position to make use of the expertise of the consultant. Thus the Sector Challenge Project approach will be performing, in these aspects, less of a training function than an educational one.