INTEGRATED CROP MANAGEMENT SYSTEMS in the EU

Amended Final Report for

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Submitted by

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S1. Executive summary

S1.1. Background and definition of ICM

Integrated Crop Management can be thought of as a concept defining ideals and goals which then have to be 'translated' into definitions which can be implemented by producers. Simply put, the concept is to integrate the management of individual crops in order to benefit from the interactions between them. In many respects integrating crop production strategies to provide benefits such as pest control, maintain soil fertility, etc. is an ancient technique. However, ICM also takes advantage of modern technology to improve on the system.

The International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC) redefined and published a conceptual framework for Integrated Production, within which ICM fits. In addition to this, a common codex for integrated farming was developed in January 2001 by the members of the European Initiative for Sustainable Development in Agriculture (EISA). Practicable ICM schemes translate the concept of ICM into more specific, 'working definitions' which define a management protocol for crop production.

A wide range of fairly similar 'working definitions' are used by various institutions throughout the EU. Eight of these definitions were examined and 'environmental sensitivity' emerged as the key component of ICM systems. This is closely followed by 'economic viability', reflecting the fact that food production is a business and hence must be profitable to exist. 'Modern techniques' is an important component and this reflects a key point of difference in comparison to organic farming which can be thought of, at least in principle if not always in practice, as rejecting modern techniques such as artificial inputs.

Although the concept of 'whole farm approach' is fairly prominent, two of the definitions that include this component are actually IFS or Integrated Production definitions. It is considered that it is possible to have an ICM approach within a single crop, although clearly some definitions suggest that multiple crops are often grown together in an integrated manner. In terms of two of the three least prevalent concepts, 'long term strategy', may be considered inherent in the use of 'integrated', but its inclusion is felt to be important as a reflection of the importance of the use of rotations in minimising weed and pest problems. 'Efficiency of input use' is not implied in the same manner, although it could be argued that rational producers would seek efficient input use in any case.

Finally, comments on food quality and consumer requirements in the definitions are not widespread. Whilst it is probably taken for granted that food produced through ICM techniques is of high quality, its inclusion in definitions might be a useful marketing aid.

Based on the above, one might summarise the main aspects of current ICM definitions by saying that it is an environmentally sensitive and economically viable production system or process which uses the latest available techniques to produce high quality food in an efficient manner.

Placing ICM on the scale between conventional production (as defined by the Codes of Good Agricultural Practice) and organic production is not straightforward. Although initial impressions would suggest that ICM is fairly closely aligned to organic production, their origins are very different and this has implications for their relationships with conventional production. Organic production represents a system distinct from conventional production and marketing, whilst ICM is clearly placed within the conventional framework. In terms of philosophy at least, ICM should therefore be placed closer to conventional farming than to organic production, representing as it does, modification of the existing system rather than abandonment of it.

S1.2. EU review of ICM systems

There are two broad categories of ICM system: those established for research purposes and those set up and run commercially. The purpose of this project was not to provide a comprehensive listing of all current ICM systems, but rather to illustrate the range and diversity of current systems.

On the basis of this review there are at least 10 research-type systems and 32 commercial systems (although this latter figure is in reality expected to be significantly higher). Of these systems, 19 apply to arable crops, 17 to fruit, 20 to vegetables, 4 to grapes/wine and 3 to 'other crops', which include hops, medicinal plants, herbs, spice, ornamental plants and olives[1]. However, if the crop coverage is analysed according to whether the system is research or commercially driven, then a different picture emerges in that the majority of research protocols (10 from 13) relate to the arable sector whereas the majority of commercial protocols (34 from 50) relate to the fruit (16) and vegetable (18) sectors[2]. All the wine systems are commercial.

An examination of the protocols for these systems shows that fertilisation and plant protection restrictions/guidelines are virtually universal (appearing in 95% and 93% of schemes respectively), while protocol elements referring to soil husbandry and tillage practices and crop rotation and varietal choice appear in more than half the examples. More than a third of the system protocols refer to harvest and post-harvest and irrigation restrictions.

Although the proportion of ICM in the EU is small, under 3% of Utilisable Agricultural Area (UAA), there is considerable variation between Member States. The UK has by far the largest area under ICM at around 1.5 million hectares whilst this figure is only 268 hectares in Greece. ICM accounts for around 20% of UAA in Austria and Denmark, although accounts for less than 1% of UAA in Belgium, Finland, France, Greece, Ireland and Spain. However, these figures should be interpreted with a degree of caution because ICM systems differ from scheme to scheme.

[1] There is clearly double counting in that many of the schemes apply to more than one of these cropping sectors.

[2] Including double counting where research is involved in more than one cropping sector.

S1.3. Impact of ICM systems in the EU

S1.3.1. Methodology

The research undertaken has sought to quantify the environmental effects of ICM at the individual system level for 10 different systems with an emphasis on plant protection (including choice of plant varieties and effects on biodiversity) as a priority. Where applicable, the research has also sought to evaluate the effects on nitrogen; erosion/soil protection; irrigation; waste management; and, crop rotation.

The scope and timescale of this project precluded primary research on the environmental impact of ICM. This aspect of the project therefore had to be conducted using research and data on existing systems. It was thus primarily based on an extensive review of available research and field trials, although where feasible the review was supplemented by limited field research.

The ten case studies selected represent a balance between the desire to examine commercial systems and the need for the environmental impact to have been assessed. It was also important to examine systems concerned with a range of crops including arable systems, fruit and vegetable production and viticulture. In order to meet these criteria, ten systems were selected for examination in five Member States as follows:

- **France:** Boigneville project and Champagne production
- **Germany:** the Lautenbach project and the AKIL project
- **Italy:** the CAMAR project and Chianti production
- **Spain:** citrus production in Valencia and pome fruit production in Cataluña
- **UK:** Less Intensive Farming and the Environment (LIFE) and Focus on Farming Practice (FOFP)

The case studies therefore provide five research and five commercial systems and six arable, two fruit and two viticulture systems.

S1.3.2. How protocols address environmental impact

Water

- Pesticide leaching: pesticide minimisation strategies coupled with the selection of pesticide products with minimal non-target impacts and varieties selected for resistance provide the main protection against pesticide leaching. Crop rotations are used in some cases to reduce the need for herbicide application. Rational fertilisation strategies will also help by reducing competition from non-crop plants and therefore reducing the requirement for pesticide application. Irrigation management strategies are also sometimes used.
- Nitrate leaching: fertiliser management strategies rely on either mandated reductions in use or on observation/soil sampling to determine requirements under the assumption that this will lead to reduced application. Crop rotations are also used to build up natural fertility and irrigation

control programmes provide a better matching of water to crop needs which reduces leaching. Cover crops are also sometimes used to 'lock in' nutrients over winter.

Soil

- Pesticide residues: the main strategies for reducing pesticide residues are the pesticide minimisation strategies (including use of lowest effective rate and band or partial application) used in conjunction with the selection of resistant varieties to reduce pesticide requirement and rotational control. Rational fertilisation strategies will also help in that they will reduce the demand for pesticide.
- Soil nutrient balances/soil nitrogen: the main tactic for achieving a better soil nutrient balance is fertiliser reduction strategies. These more frequently refer to nitrogen, but in many cases are extended to cover other nutrients (P_2O_2, K_2O). This approach is augmented in some cases by row application and the use of slow release nitrogen. Rotational management to reduce demand for artificial nitrogen is also used, as are cover crops to 'lock in' nutrients.
- Soil erosion: where this is considered an issue, soil erosion is addressed through the replacement of ploughing with non-inversion tillage. Cover crops and/or green cover are used to anchor the soil. There are also restrictions on the times of year when soil tillage activities can take place and contour planting of trees is mentioned in the Spanish pome fruit production case study.
- Soil quality: soil fauna are protected through pesticide minimisation strategies and the use of low toxicity compounds. Non-inversion tillage also helps maintain good soil quality, as does the use of organic manure. The use of fertiliser containing heavy metals is sometimes banned in order to reduce soil contamination.

Air

- Air quality: this is usually not addressed in protocols, but where it is, the banning of volatile fertilisers such as ammonia is the main approach to addressing the issue.
- Spray drift: only addressed in half of the case studies and none of the non-case study systems, the risk of drift is reduced through more stringent machinery maintenance and calibration. The use of low pressure nozzles also helps.
- CO_2 emissions: this is addressed only in the Lautenbach case study where the use of non-inversion tillage is thought to reduce CO_2 emissions.

Biodiversity

- Soil fauna: the two main approaches that enhance soil fauna are the use of low toxicity pesticide compounds with minimal side effects on non-target organisms and reductions in the total application of pesticide. Non-inversion tillage also promotes soil fauna.
- Plant species: again, the use of low toxicity pesticide compounds with minimal side effects on non-target organisms and reductions in the total application of pesticide are the main protocol elements with a positive impact in this area. These are augmented by rational fertilisation strategies which both reduce the need to apply pesticides and reduce the risk of nutrient-rich soil which is not conducive to many endangered plant species. Finally, the promotion of ecological infrastructure provides a habitat reservoir in which plant species can thrive.

- Macro fauna: this was only investigated in one of the case studies (FOFP) and improvements in bird populations result from the use of low toxicity pesticide compounds with minimal non-target species impact which maintains a source of food for bird life. Ecological infrastructure provide habitat for larger fauna and the protection of smaller fauna through pesticide reduction strategies will also have a positive knock on effect.

Landscape

- Ecological infrastructure: there are no particular production protocols which will have an influence on landscape, and in many ways, ICM is concerned with micro rather than macro impacts. However, the monotony of monocropped landscapes is broken up in half of the case studies by mandated areas of hedgerows, shrubs and woodland, field margins, flowering strips and headlands.

S1.3.3. Environmental impact of ICM systems

Water

- Pesticide leaching:
- *case study evidence:* two of the 5 research systems showed quantitative reductions in pesticide leaching. The other 3 all showed reductions in application which is likely to have reduced the risk of leaching. The commercial case studies all have protocols which will lead to reductions in pesticide use.
- *non-case study evidence:* Six of the 8 non-case study systems showed a quantitative reduction in pesticide use, whilst the remaining 2 suggested qualitative reductions in application.
- Nitrate leaching:
- *case study evidence:* two research systems showed quantitative reductions in leaching; the other 2 showed reductions in application which is likely to have reduced the risk of leaching. One research system showed higher leaching from the integrated system. Three of the commercial systems showed quantitative reductions in N application and 1 suggested a qualitative reduction in N leaching.
- *non-case study evidence:* two of the non-case study systems had quantified reductions in N application and 2 reported a qualitative reduction. One system showed a quantitative reduction in N in run-off water and 2 others suggested qualitative reductions in N leaching
- Soluble phosphate:
- *Case study evidence:* one research system showed a reduction in soluble phosphate in drain water.
- Summary: on balance it seems highly likely that ICM systems reduce the incidence of pesticide leaching, although more direct quantitative evidence linking reductions in application to reductions in leaching needs to be collected. The above evidence also suggests that ICM systems generally result in a reduction in the risk of nitrate leaching. Again, as with pesticide leaching, more quantitative evidence should be sought to investigate the link between reduced N application and reductions in N leaching. Although there is not enough evidence on soluble phosphate to make a firm statement, it is likely that ICM does generally contribute to reductions in application through fertiliser rationalisation/reduction strategies.

Soil

- Pesticide residues:
- *case study evidence:* one research system showed quantitative reductions in residues compared to conventional systems and the implication from all another research systems is that pesticide use reduced as a result of protocol restrictions and this should reduce the risk of soil residues. Two commercial systems suggested a reduction in soil pesticide residues, 1 through reduced application and the other through the use of pesticides with reduced residual activity and low toxicity.
- *non-case study evidence:* six of the non-case study systems reported quantified reductions in pesticide application. The other 2 reported qualitative reductions.
- Soil nutrient balances:
- *case study evidence:* although there is no quantitative evidence that soil N has been reduced, N application was reduced in 1 research system and another found that N uptake was better under integrated management. One research system showed a decrease in soil P. One commercial system reported quantitative reductions in the level of nutrients in the soil.
- *non-case study evidence:* one of the non-case study systems reported a reduction in N reserves, although this was coupled with an inferior N use balance. Other non-case study systems showed quantitative and qualitative reductions in fertiliser use.
- Soil erosion:
- *case study evidence:* 1 research system showed a quantitative reduction in soil erosion resulting from the use of non-inversion tillage, another system showed a greater degree of soil cover which should help reduce the risk of erosion. One commercial system provided quantitative evidence of a reduction in soil erosion and another suggested qualitatively that soil erosion had reduced. Two other commercial systems suggested that the risk of soil erosion was reduced through the use of green covers; this was also the case in one non-case study system.
- Summary: it seems clear that ICM systems, through a reduction in the application of pesticide, lead to a reduction in the risk of pesticide residues building up in the soil, although it is not possible to ascertain for definite on the weight of this evidence that they result in actual reductions in residues; more research is needed to establish the nature of any link. Where systems have restrictions on fertiliser use within the protocols (i.e. in the vast majority of cases), it is likely that nutrient application is better matched to crop demand. ICM systems generally appear to reduce the risk of excessive nutrients in the soil through lower or more rational fertiliser application strategies, although, as with pesticide residues, more research into the link between reduction in application and more appropriate soil nutrient balances should be conducted. Soil erosion is not considered an important issue in most systems, although where it is a consideration (in some cases a central one), the evidence suggests that the risk can be reduced.

Air

- Air quality:
- *case study evidence:* two research systems suggested improvements in air quality as a result of protocol restrictions. One quantified the environmental exposure to pesticides. Another

research system assumed improvements to CO_2 emissions through the use of non-inversion tillage. One commercial system suggested a qualitative improvement in air quality.

- Spray drift:
- *case study evidence:* none of the research or non-case study systems commented on this issue. However, 4 of the commercial systems suggested a qualitative reduction in spray drift through better machinery maintenance and sprayer calibration.
- Summary: there is little evidence of the impact of ICM on air quality, although this does not mean that there is no impact in practice. However, ICM systems are likely to have a positive impact on spray drift.

Biodiversity

- Flora:
- *case study evidence:* the density of native non-cropped plants was found to be higher under integrated management in 1 research system. Another found greater species richness in integrated systems. Two commercial systems concluded that there is qualitative evidence that ICM systems provide a benefit to flora.
- Micro-fauna:
- *case study evidence:* 1 research system found that population density was higher, although this was not quantified. Three research systems demonstrated quantitative improvements in populations in terms of number of individuals and biomass. One commercial system also provided quantitative evidence of increased population density and 3 suggested qualitative improvements based on pesticide reduction strategies and the use of less toxic chemicals.
- *non-case study evidence:* 1 study provided quantitative evidence of increased population density.
- Macro-fauna:
- *case study evidence:* 1 research system quantified increases in bird populations.
- Summary: all systems that reduce the use of pesticide and fertiliser are likely to have a positive impact on non-cropped species. Although only 1 system examined this area, it is likely that there will be an increase in macro-fauna populations which depend on the habitats and food sources of both flora and soil fauna which are enhanced under ICM.

Landscape

- Ecological infrastructure:
- *case study evidence:* 3 research systems showed a positive impact on landscape through the addition and/or maintenance of landscape features. Two commercial systems cited improvements in landscape through management of ecological infrastructures.
- Summary: landscape is not an element that is directly addressed in ICM protocols and the closest proxy for it refers to ecological infrastructure. In many cases landscape elements such as boundary features are encouraged under ICM.

S1.3.4. Economic impact of ICM systems

Production costs

- *Case study and non-case study evidence:* production costs refer to variable production costs and there may be other costs such as increased management time, education and changes in fixed costs which should be taken into account in a more detailed investigation of the economic impact of ICM. In only 1 commercial system (Chianti) were production costs higher under ICM, and then this is the result of further processing rather than ICM *per se*. In all other examples where data were available, variable production costs were lower. In some systems it was explicitly stated that the reduction in variable production costs was mitigated to some extent by increased costs elsewhere, namely management costs (for instance, the two Spanish case studies where these lower variable costs were outweighed by increases in management and analysis costs).

Summary: on balance, the evidence suggests that ICM results in lower variable production costs, mainly through savings relating to pesticide and fertiliser application.

Premium

- *Case study and non-case study evidence:* there were no premiums available for research systems (including non-case study systems which were also exclusively research driven), which is not unexpected given that these systems have been established to develop and investigate protocols and environmental impact rather than to produce commercial returns. Premiums are also the exception rather than the norm in commercial systems (only Chianti has a premium, although this results from bottling rather than ICM production). In 1 case (AKIL) the initial premium has now disappeared as supply of ICM produce has increased, in another (Champagne) labelling as ICM is not currently legal so it is impossible to attract a premium, and in both Spanish case studies (pome and citrus fruit production), ICM has provided a marketing advantage by become more of a right to supply multiple retailers rather than an identity preserved marketing niche.

Summary: premiums are generally not available for ICM production, although a marketing advantage is often conferred in that multiple retail outlets are more willing to source ICM rather than conventional production.

Yield

- *Case study and non-case study evidence:* the impact of ICM systems on yields appears mixed. Of the 9 case study systems that compared yields to conventional systems, 2 showed lower yields and the LIFE project showed lower yields for the feed quality system, but higher yields for the milling quality system. Six case study systems showed yields approximately equal to conventional systems. Of the 8 non-case studies, 5 recorded lower yields and 1 suggested that yields were comparable (2 did not compare yields). This is quite a mixed signal, although the non-case study research was primarily designed to examine environmental impact and therefore did not generally pay close attention to yield.

Summary: the yield in ICM systems tends to be lower at this point in time, however, further research could reduce this difference. Greater commercial interest may also result in greater investigation of the yield impact of ICM techniques.

Revenue

- *Case study and non-case study evidence:* revenue is a function of premium availability and yield. Of the 9 case studies for which there is revenue data, 3 had a lower revenue as a result of lower yields and no premium and 5 had revenues equating to conventional systems. One system (Chianti) had higher revenues reflecting the availability of premium. Because none of the non-case study systems attracted a premium, the impact on revenue follows the same pattern as for yield, i.e. of the 6 systems where there are data, 5 systems returned a lower revenue and 1 had a comparable revenue.

Summary: although revenue is generally lower for ICM systems (reflecting reduced yields and lack of premium, it certainly seems to be the case that the marketing advantage mentionhed above reduces revenue risk because it facilitates the sale of produce to multiple retailers. As with yield, further research and the possibility of attracting premiums in the future might result in increased revenues from ICM systems.

Profitability

- *Case study and non-case study evidence:* this is crudely defined as the difference between revenue and variable production cost, although it is recognised that this will not take into account other cost items (see under production costs, above). Four of the case study systems showed a profitability equivalent to that obtained under conventional management, 2 systems provided higher profitability and 3 systems lower profitability (including the 2 Spanish case studies where technically profitability, defined as revenue less variable costs, was higher, but the inclusion of increased management and analysis costs made whole farm profitability lower). The LIFE system showed a slightly higher profitability for the milling quality system and slightly lower profitability for the feed quality system. The evidence from the non-case study systems suggested that ICM resulted in lower profitability.

Summary: it is difficult to draw firm conclusions on profitability from the balance of the evidence, but the case study evidence at least suggests that it is possible to achieve similar levels of profitability using ICM techniques as a result of lower yields and hence revenue being balanced out by reductions in production costs.

1. Introduction

Agra CEAS Consulting has been commissioned by DG Environment of the EC Commission to carry out research into the current status of application of Integrated Crop Management systems throughout the EU. This report presents our findings.

1.1. Report structure

This report comprises eight Chapters (including this introduction):

- Chapter Two provides a brief background to ICM systems and clarifies the relationship between sustainable agriculture, Integrated Farm Management, Integrated Crop Management and Integrated Pest Management;
- Chapter Three examines concept and working definitions of ICM. A range of definitions are presented and the common components drawn out. This Chapter also positions ICM on the scale between conventional production practice and organic production techniques;
- Chapter Four considers the organisations promoting ICM in Europe and the retailer driven EUREP scheme. It then reviews ICM systems currently in place in the EU by Member State.
- Chapter Five presents the environmental impact of ICM systems in the EU through a case study approach augmented by environmental impact information from non-case study research schemes and systems;
- Chapter Six presents the economic impact of ICM systems in the same manner.
- Chapter Seven offers conclusions to the report.
- Chapter Eight contains references.

2. Background to ICM systems

Integrated Crop Management (ICM) can be thought of as a means of production which falls somewhere between conventional production[3] and organic production. The concept of ICM can therefore be considered ultimately as a compromise between two different consumer demands:

i. the demand for more environmentally friendly farming, especially the reduced use of plant protection products; and,
ii. the demand for food to be safe, affordable to all, widely available, fresh, blemish and insect-free and perfect in shape and size.

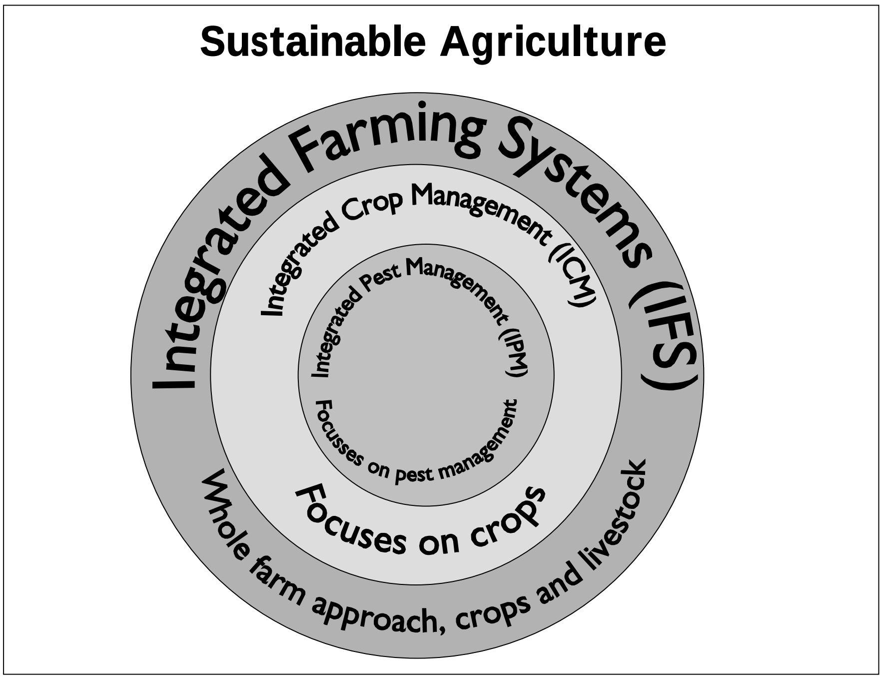
Whilst conventional agriculture clearly meets the latter demand and organic the former, neither fully meets both[4].

Although it is easy to state that ICM falls somewhere between conventional and organic production, it is considerably more difficult to define it precisely. Adding to the confusion are the use of the terms Integrated Production (IP) and Integrated Farming Systems (IFS), which can be used interchangeably, and Integrated Pest Management (IPM); compounding this is the concept of sustainable agriculture. The relationship between these terms and ICM is illustrated in Figure 2.1.

[3] For the purposes of this study, conventional production should be interpreted as production utilising all legal means and generally complying with relevant Codes of Good Agricultural Practice.

[4] Whilst organic production is safe and can be fresh, blemish and insect-free and perfect in shape and size this does involve large grading losses and consequently higher prices.

Figure 2.1: Relationship between ICM and related terms



The most widely quoted concept of sustainable development is the World Commission on Environment and Development definition of 1987 which states that, 'Sustainable development is development that meets the needs of the present without compromising the needs of future generations to meet their own needs'. Harwood (1990) developed the following definition of sustainable agriculture,

> '*sustainable agriculture is a system that can evolve indefinitely toward greater human utility, greater efficiency of resource use and a balance with the environment which is favourable to humans and most other species'.*

IFS/IP fit within this definition of sustainable agriculture and represent a whole farm approach to agricultural production where each individual enterprise is integrated with the others to produce benefits through their mutual interactions. Of particular note is the complementarity between livestock and crop enterprises[5]. IPM can be thought of as a component of ICM focusing specifically on the pest management aspect of crop production. ICM therefore encapsulates IPM and is in turn encapsulated by IFS/IP. Having said this, IFS is often used interchangeably with ICM. Technically, if

[5] Although complementarity between crop and livestock enterprises is considered desirable, it should be pointed out that the trend throughout the world is for increased specialisation of enterprises.

livestock are present, IFS or IP should be used, if not, ICM is the appropriate term[6]. To avoid confusion, this is the understanding applied throughout this report.

[6] Integrated Arable Farming Systems (IAFS) has also occasionally been used.

3. Definitions of ICM systems

There are two levels of detail at which to view the definition of ICM. At the wider level there is the concept of ICM which can be considered to encapsulate the scientific and theoretical ideals and goals of the approach, as developed by the scientific community. At a more specific level of detail are the actual working definitions used to translate these ideals and goals into practicable systems.

Section 3.1 considers these 'concept' definitions and Section 3.2 'working' definitions.

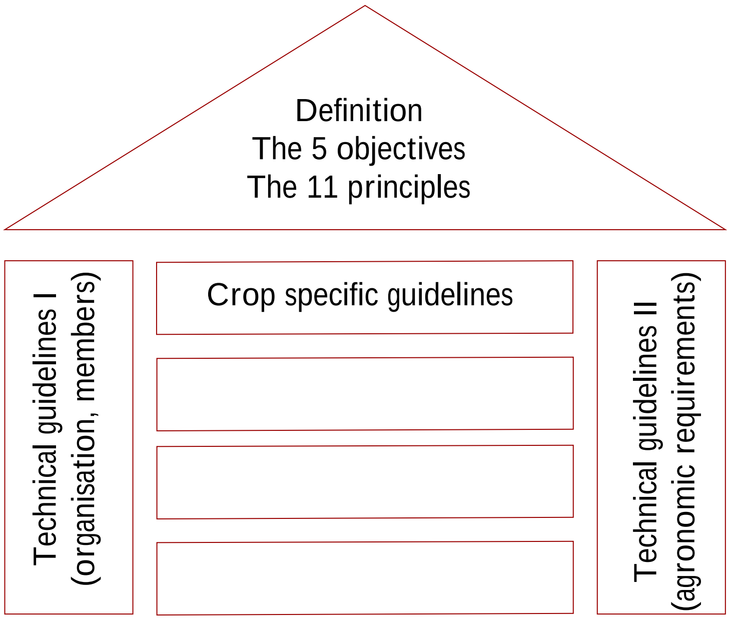
3.1. The ICM 'concept'

Integrated Crop Management can be thought of as a concept defining ideals and goals which then have to be 'translated' into definitions which can be implemented by producers. At a basic level, the concept is simply to integrate the management of individual crops in order to benefit from the interactions between them. In many respects, integrating crop production strategies to provide benefits such as pest control, maintain soil fertility, etc. is an ancient technique. However, ICM also takes advantage of modern technology to improve on the system.

In 1993 the International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC)[7] redefined and published a conceptual framework for Integrated Production, of which, as explained in Chapter2, ICM can be thought of as an integral component. Their framework serves equally well for ICM, although there are elements (most notably those relating to animal production) that are not relevant to ICM *per se*, although mixed farmers following ICM protocols are also likely to integrate their livestock with their cropping enterprises. The IOBC conceptual framework (as amended in 1999) is illustrated in Figure 3.1.

[7] IOBC is a politically independent scientific organisation devoted to the development of biological and integrated production and production systems with the General Secretariat at the INRA Station, Dijon, France. The IOBC Commission on IP Guidelines and Endorsement has its headquarters at the Swiss Federal Research Station at Wädenswil, Switzerland and publishes relevant documents on the Internet. It has the mandate to define and update the conceptual framework of IP; to develop, update and publish crop specific IP guidelines; and to operate an endorsement procedure for regional IP organisations.

Figure 3.1: IOBC Integrated Production conceptual framework



Source: IOBC/WPRS Guidelines (1999)

A ‘conceptual roof’ consisting of objectives and principles is supported by two ‘pillars’ which define the general standards for the organisation and its members and the general agronomic requirements valid for all crops respectively. Inside this construction are the crop specific guidelines defining in greater detail Integrated Production techniques for individual classes of crop.

The IOBC states that there are five objectives contributing to the ‘conceptual roof’ behind Integrated Production (see Box 3.1). The reader should note that the results of research into Integrated Production are equivocal and that some of the statements made on behalf of Integrated Production may not always apply.

Box 3.1: The IOBC Integrated Production conceptual objectives

Integrated Production is a farming system which:

- Integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs
  These objectives address the basic intentions of a sustainable agriculture. An intelligent management and careful utilisation of natural resources can help to substitute for farm inputs such as fertilisers, pesticides and fuel. Total or partial replacement of these materials not only reduces pollution, but also production costs and improves farm economics.
- Secures sustainable production of high quality food and other products through ecologically preferred and safe technologies
  IP aims at high quality production, but mainly through ecologically sound techniques that are safe for human health. Quality evaluation of the product considers not only its specific internal and external characteristics, but above all the means of production as significant criteria.
- Sustains farm income
- Eliminates or reduces sources of present environmental pollution generated by agriculture
  Existing pollutants of agricultural origin have to be eliminated whenever and wherever this is feasible.
- Sustains the multiple functions of agriculture
  Agriculture has to meet the needs of the entire society including those requirements that are not directly connected with the production of food and fibre. Diversified landscapes, wildlife conservation, decentralised colonisation and cultivation of remote areas as well as maintenance of local cultural traditions are some of the non-agricultural environmental and recreational values provided by operational farms.

The 'conceptual roof' is further defined by the IOBC's eleven principles of Integrated Production which elaborate on the objectives and are presented in Appendix 11 - The IOBC Principles of Integrated Production[8].

More recently, a common codex for integrated farming was developed in January 2001 by the members of the European Initiative for Sustainable Development in Agriculture (EISA)[9]. Given the relationship between IFS and ICM, the five principles behind this codex (Box 3.2) apply equally to ICM where they relate to crops.

[8] The IOBC perception and implementation of quality aspects in Integrated Production was updated and clarified in April 2001 to explicitly address the extrinsic, intrinsic, ecological, ethical and social dimensions of product and/or process quality. Social quality of production is linked to the International Labour Organisation 'Declaration on Fundamental Principles and Rights at Work'.

[9] EISA was founded by various national research bodies promoting integrated farming to allow them to intensify their efforts on a pan-European basis.

Box 3.2: EISA common codex for integrated farming

1. Producing sufficient high quality food, fibre and industrial raw materials

Food production is a fundamental need for society. The primary aim for Integrated Farming is to provide continuously a wide range of food as well as fibre and renewable materials, of the highest quality at affordable prices to the consumer. This requires skill, attention to detail and compliance with regulations.

2. Meeting the demands of society

Consumers are increasingly discriminating about the food they eat and the conditions under which it is produced. Safety to human health, animal welfare, environmental protection and conservation are the principal concerns. Integrated Farming demands an awareness of these concerns and the adoption of economically and socially acceptable production practices on a local, national and international basis.

3. Maintaining a viable farming business

Farmers must remain in business to produce food and take care of the countryside. Integrated Farming is efficient and profitable whilst ensuring that a balance is achieved between running an economically sound business and meeting the constraints imposed by responsible social and environmental practices.

4. Caring for the environment

The countryside is a rich and diverse variety of fields, meadows and forests, largely created by centuries of agricultural activity. Every farm operation affects the local environment, sometimes adversely. Integrated Farming enhances the positive aspects and minimises the negative effects so that the biological diversity of the agricultural landscape is maintained and preserved.

5. Sustaining natural resources

Taking care of natural resources is essential for future generations. Integrated Farming optimises their use. This is in such a way as to ensure soil fertility, protect water and air quality and encourage biodiversity.

For its part, the FAO has concentrated on IPM rather than ICM and has focused its attention exclusively on improving ecological sustainability through the reduction of pesticide use and promoting better pesticide application and pest management. The FAO's efforts have also been focused in Asia and developing countries. The FAO does not therefore have an ICM concept.

The IOBC and EISA objectives largely cover the same ground. However, if the order in which they are presented is indicative of the importance of the individual components, then a slightly different emphasis is suggested.

In both cases it is clear that IP/IF systems are essentially food production techniques. Although both organisations place emphasis on the need for high quality food, the EISA objectives explicitly cite the fundamental societal need for food and the importance of affordability. The IOBC places more emphasis on the need to produce food that is safe for human health and extends the concept of food quality to encompass the external impacts of production on the wider environment.

EISA continues its emphasis on the demands of society by stressing that IFS meets society's demand for safety to human health, animal welfare and environmental protection and conservation. Although the IOBC objectives are also concerned with societal demands, these are given less prominence, preferring instead to focus on the 'multiple functions of agriculture'. The result of this slight difference in emphasis is to make the EISA objectives sound more inclusive and IFS a food production system based within a society which also addresses other, non-food orientated societal needs. In contrast the IOBC objectives sound more like an environmentally based, but multi-functional, food production system.

Although both sets of objectives are concerned with the viability of farming as an activity, this is more explicitly stated in the EISA set. Despite this difference in emphasis, it is clear that both organisations believe it is possible to profitably produce food in an environmentally sensitive manner[10]. In neither set of objectives is it suggested that the non-market benefits of IP/IFS need to be subsidised. Both sets of objectives stress that IP/IFS techniques can improve farm profitability.

A final point of difference in emphasis relates to the sustainability of IP/IFS. Again, sustainability is more explicitly stressed in the EISA rather than the IOBC objectives.

The apparent difference in emphasis between the two sets of objectives can be summarised as follows:

- the EISA objectives describe a food production system which provides for both the demands of society and the economic needs of food producers whilst caring for the environment and sustaining natural resources;
- the IOBC objectives describe a way in which to minimise off-farm agricultural inputs to produce food in an environmentally sensitive manner which eliminates agricultural pollution and sustains the multiple functions of agriculture.

Despite the differences in emphasis highlighted above, the IOBC and the EISA objectives are in fact fairly similar. The differences in emphasis could be considered little more than a presentational device which is designed to appeal to different sections of society. The EISA objectives appear more market orientated in that their objectives could be summarised as: IFS is a food production system which also benefits the environment. The IOBC objectives are more prescriptive in that: IP offers environmental protection through a system which also produces food.

The ideas encapsulated by these principles are also equally applicable to ICM as can be seen in Section 3.2 which considers more concise working definitions.

3.2. Working definitions

This Section considers the practical implementation to date of the concepts discussed in Section 3.1. The definitions presented are not exhaustive. Although there is an incredible range of definitions of ICM in use, in many cases they are sufficiently similar not to merit separate treatment. We have focused on definitions drawn from significant organisations promoting ICM, whether in the European Union or further afield, and these are presented in Table 3.1. Unless otherwise stated the definitions relate to ICM. In some cases they relate to Integrated Production and IFS and are marked as such.

[10] The level of sensitivity is likely to gradually increase as new techniques become available over the next few decades.

Table 3.1: Working definitions of ICM

	Source	Definition
	Research (concerted action) *International level*	
1	**International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC)**	[Integrated Production] is a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming. Emphasis is placed on a holistic systems approach involving the entire farm as a basic unit, on the central role of agro-ecosystems, on balanced nutrient cycles and on the welfare of all species in animal husbandry. The preservation and improvement of soil fertility and of a diversified environment are essential components. Biological, technical and chemical methods are balanced carefully taking into account the protection of the environment, profitability and social requirements.
	European level	
2	**European Initiative for Sustainable Development of Agriculture (EISA)**	[IFS] is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food.
	National level	
3	**The Integrated Arable Crop Protection Alliance (IACPA) (UK)**	A whole farm policy aiming to provide the basis for efficient and profitable production which is economically viable and environmentally responsible. It integrates beneficial natural processes into modern farming practices using advanced technology and aims to minimise the environmental risks while conserving, enhancing and recreating that which is of environmental importance.
4	**FARRE (France)**	Based on the EISA definition above, the following definition was developed in October 2000 to respond more specifically to the French situation: [IFS][11] is characterised by the use of technological methods in a whole-farm approach. The method of production corresponds to a global farm management that aims, beyond the simple compliance to regulation, to encourage the positive impact of agricultural practices on the environment and to reduce the negative effects, while respecting economic profitability. [IFS] can facilitate the management of health risks and contribute to the improvement of animal welfare. It can also contribute a response to the needs of society.
	Industry *European level*	
5	**The European Crop Protection Association (ECPA)**	To manage crop production on the whole farm in a way that maintains and enhances the environment for wildlife and people, while at the same time producing economic yields of high-quality crops.
	National level	
6	**British Agrochemicals Association (BAA) (UK)**	A management system which employs controlled inputs to achieve sustained profitability with minimum environmental impact, but with sufficient flexibility to meet natural and market challenges economically.

[11] French terms ‘Production Integrée’ and ‘Agriculture Integrée’ correspond to the Anglo-Saxon concept of ‘Integrated Farming’.

	Source	Definition
	Retailer *National level*	
7	**BAA in conjunction with the ATB, LEAF and Sainsbury's (UK)**	A method of farming that balances the requirements of running a profitable business with responsibility and sensitivity to the environment. It includes practices that avoid waste, enhance energy efficiency and minimise pollution. ICM combines the best of modern technology with some basic principles of good farming practice and is a whole farm, long term strategy.
8	**Focus on Farming Practice (FOFP) (UK)**	[Integrated Farming] has the cultural, biological and mechanical control techniques characteristic of the organic system in the first instance, but instead of rejecting, on principle, the use of modern crop protection and crop nutrition products, practitioners seek to select the best of these and apply judiciously.

The above definitions are all fairly similar, with the exception of number 6 from the British Agrochemical Association (BAA) which, perhaps unsurprisingly, focuses on the controlled use of inputs much more specifically than the other definitions and therefore could be thought of as more of a definition of IPM than ICM, although it is cited as the latter.

Because there is no agreed 'official' definition of ICM at either the EU or the national level it is not possible to state categorically that a particular Member State uses a particular definition; different schemes within Member States may well be based upon definitions originating from different sources. However, there are organisations promoting ICM in some Member States (for example, EISA and its member organisations in France, the UK, Germany, Italy, Sweden and Luxembourg) and the definition used by these organisations (or the most prominent organisation in other Member States) are the ones cited in Box 3.3.

As can be seen in the case of certain countries (e.g. France, Germany, Portugal and Finland) ICM-type schemes receive support under specific (voluntarily proposed) agri-environment measures in national Rural Development Plans (RDP) for the period 2000-06 under EC Regulation 1257/99. In certain cases the agri-environmental schemes explicitly cover ICM or Integrated Farming (e.g. Saxony, Germany). It should be noted that our review of the Member State RDP's indicated that, even if not explicitly including ICM/IFS measures as such, in almost all cases they include components of the definition with specific objectives such as pest management, fertiliser use, nitrogen reduction and limiting the use of pesticides[12].

[12] Rural Development Plans (RDPs) were submitted by 68 EU regions (at regional or Member State level), on the basis of Council Regulation (EC) No 1257/99 of 17 May 1999, on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) (amending and repealing Council Regulation (EC) No 2078/92). The commitments taken under 'agri-environmental measures' (Chapter VI of Regulation 1257/99) in principle go beyond the application of Good Agricultural Practices (GAPs). The services covered are not provided by any other measures such as market support or compensatory payments. The approach can be targeted at different levels, whether at crop, farm or regional level. Support is granted annually to farmers who undertake the agri-environmental commitments for at least five years. The level of the support is calculated on the basis of: income foregone; additional costs resulting from the commitment; and the need to provide an incentive. The maximum level of EU support is set at €450-900 annually depending on the crop, but state aid may be provided in addition to Community support.

Box 3.3: ICM definitions by Member State

	ICM definition used
Austria	Austria bases its Integrated Production on the IOBC guidelines and defines Integrated Production as a method which uses all measures to minimise the use of pesticides and promote natural preventive measures instead.
Belgium	Under the government support scheme for the Integrated Production of fruit, the IOBC definition is used (Decree No 97/791 of the Ministry of Agriculture). The Flandria brand is an ICM-type scheme within the vegetables, apple and pear sectors and producers are committed to 'Integrated Production' methods. However, there is no definition as such and the scheme is designed by protocol (see Section 4.3.2).
Denmark	No national definition of ICM, although the guidelines of the Danish Good Farming Practices ('Godt landmandskab år 2000') provide a close approximation to the concept of ICM.
Finland	No national definition of ICM, although a close approximation to the ICM/IFS concept is provided by the guidelines of the General Agricultural Environment Protection Scheme (GAEPS), either fully (e.g. production of fruit and berries) or partially (e.g. IPM definition for potato, sugar, vegetables and small grains).
France [EISA definition]	[IFS] is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food. See also FARRE definition in Table 3.1. There is also a 'lutte raisonnée' definition (measure 8.1) under the RDP for 2000-06 (on the basis of EC Regulation 1257/99), which covers phytosanitary protection of crops with the eventual objective of water protection.
Germany [EISA definition]	[IFS] is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food.
Greece	No national definition of ICM. Most ICM/IFS projects are currently at the experimental stage.
Ireland	No national definition of ICM. Most ICM/IFS projects are currently at the experimental stage. ICM-type guidelines are contained within REPS 2000 (Rural Environment Protection Scheme) under EC Regulation 1257/99.
Italy [EISA definition]	[IFS] is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food.
Luxembourg [EISA definition]	[IFS] is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food.
Netherlands	Various definitions are used with varying degrees of rigour and depending on the sector. The use of the term in some government schemes (e.g. under the Valuable Man-made Landscapes (VML) project) is based on the concepts of sustainable agriculture and a whole-farm approach.
Portugal	No national definition of ICM. Integrated Protection schemes exist for citrus fruit, apple trees, viniculture, olive groves, commercial and horticultural crops in the open air and under glasshouses, under agri-environment schemes (RDP for 2000-2006 on the basis of EC Regulation 1257/99).
Spain [IOBC definition]	[Integrated Production] is a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming. Emphasis is placed on a holistic systems approach involving the entire farm as a basic unit, on the central role of agro-ecosystems, on balanced nutrient cycles and on the welfare of all species in animal husbandry. The preservation and improvement of soil fertility and of a diversified environment are essential components. Biological, technical and chemical methods are balanced carefully taking into account the protection of the environment, profitability and social requirements.
Sweden [EISA	[IFS] is a common sense whole farm management approach that combines the ecological care of a

definition]	diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food.
UK [IACPA definition]	A whole farm policy aiming to provide the basis for efficient and profitable production which is economically viable and environmentally responsible. It integrates beneficial natural processes into modern farming practices using advanced technology and aims to minimise the environmental risks while conserving, enhancing and recreating that which is of environmental importance.

Table 3.2 highlights the main elements explicitly drawn out in the ICM definitions in Table 3.1 and shows which definitions include which concepts. The elements are presented in order according to prevalence.

Table 3.2: Common components in ICM definitions

Component	Definition number							
	1	2	3	4	5	6	7	8
Environmental sensitivity	✓	✓	✓	✓	✓	✓	✓	
Economic viability	✓	✓	✓	✓	✓	✓	✓	
Whole farm approach	✓	✓	✓	✓	✓		✓	
Modern techniques			✓	✓			✓	✓
Efficiency of input use			✓	✓				
Food quality/consumer requirements		✓		✓	✓			
Long term strategy						✓	✓	

From the above it can be seen that ‘environmental sensitivity’ is the key component of ICM system definitions. This is closely followed by ‘economic viability’, reflecting the fact that food production is a business and hence must be profitable to exist. ‘Modern techniques’ are an important component and this reflects a key point of difference in comparison to organic farming which can be thought of, at least in principle if not always in practice, as rejecting specific modern techniques such as artificial inputs.

Although the concept of ‘whole farm approach’ is fairly prominent, two of the definitions that include this component are actually IFS or Integrated Production definitions. It is considered that it is possible to have an ICM approach within a single crop, although clearly some definitions suggest that multiple crops are often grown together in an integrated manner. In terms of two of the three least prevalent concepts, ‘long term strategy’, may be considered inherent in the use of ‘integrated’, but its inclusion is felt to be important as a reflection of the importance of the use of rotations in minimising weed and pest problems. ‘Efficiency of input use’ is not implied in the same manner, although it could be argued that rational producers would seek efficient input use in any case.

Finally, it is noticeable that comments on food quality and consumer requirements in the definitions are not widespread. Whilst it is probably taken for granted that food produced through ICM techniques is of high quality, its inclusion in definitions might be a useful marketing aid.

Based on the above, one might summarise the main aspects of current ICM definitions by saying that it is an environmentally sensitive and economically viable production system or process which uses the latest available techniques to produce high quality food in an efficient manner.

3.3. Positioning relative to conventional and organic production

Chapter 2 explained that ICM fits somewhere between conventional and organic production. Organic production in the context of this report is taken to mean production complying with the EU Regulations (Regulation (EEC) 2092/91 and amendments) defining organic production[13]. Morris and Winter (1999) in their paper entitled Integrated farming systems: the third way for European agriculture provide a useful discussion on the positioning of IFS (the debate applies equally to ICM, the term we use here) within the agriculture and the environmental debate. This discussion casts light on the positioning of ICM vis-à-vis organic and conventional agriculture and is drawn on in the discussion below.

ICM systems, conceptually at least, are closer to organic production systems than they are to conventional production in that both are food production methods which are designed to mitigate consequential negative environmental impacts. The environment is therefore internalised in the food production process rather than requiring a separate mechanism which is often applied to field margins and marginal land in general within conventional production. This means of addressing negative environmental impacts within conventional production does not therefore generally provide a challenge to the nature of food production in the same way as organic and ICM production do. This presents producers to organic and ICM standards with a marketing opportunity to differentiate their produce from that produced conventionally.

However, despite this similarity between organic and ICM production, both have very different origins and ideologies leading to differences in their relationships to conventional production. The roots of organic agriculture are considered by many to be in a radical social movement which originated from the ideas of a small number of ecologically minded people such as Friend Sykes, Sir Albert Howard and Lady Eve Balfour who founded the UK's Soil Association. Rudolph Steiner in Germany founded the biodynamic movement.

Although the movement was initially based on a critique of conventional farming, particularly the use of artificial chemical inputs, organic agriculture is now a widely recognised means of production which is defined by EU Regulation. As such, many organic farmers now consider it a marketing opportunity rather than an ideology *per se*. So, dedicated, ideologically motivated organic producers would also challenge conventional food processing, marketing arrangements and the distance these have placed between producer and consumer and would prefer a decentralised marketing system and the closer relationship between producer and consumer that this would imply. Producers

[13] Organic is equivalent to the terms 'ecological' and 'biological' which are sometimes used in some Member States. These terms should not be confused with the UK term Biodynamic agriculture, the Steiner school, where other factors such as the phase of the moon are considered important in activities such as planting.

seeking a marketing opportunity rather than an ideology would not necessarily share this view. In either case, organic agriculture represents a distinct alternative to conventional production, i.e. either produce conventionally **or** organically.

Despite the fact that ICM also emerged in response to perceived problems inherent in conventional agriculture the original underlying ideology is considerably less radical than organic production. Rather than being initially conceived as an alternative system to be operated instead of conventional farming, ICM has evolved to address perceived problems with conventional production from within the system by extending (sometimes significantly) and building on the concept of Good Agricultural Practice. The fact that ICM is considered 'mainstream' is witnessed by the significant involvement of agro-chemical companies and retailers. In keeping with this placement, ICM production techniques are not as radical as organic prescriptions, although they may still involve considerable departures from conventional production practice for many farmers.

Whilst in organic production chemical inputs are frowned upon and synthetic formulations prohibited, ICM views them as harmful only in excess and the response is to reduce their use rather than to ban them completely. Further, part of the rationale for reduced use is related to cost savings and/or maximising input efficiency rather than solely environmental criteria. Whilst ICM does not seek to operate outside the current conventional food production and distribution system (both upstream and downstream), it does advocate modification to these systems. ICM may also necessitate the creation of new downstream agencies to monitor and verify quality assurance schemes.

Box 3.4 summarises the differences between conventional, integrated and organic production systems in the UK, although these differences apply equally well throughout the EU.

Box 3.4: Summary of differences between conventional, integrated and organic systems

	Organic agriculture	ICM systems	Conventional agriculture
Practice Production techniques	Non-use of inorganic inputs. Emphasis on the sustainable use of resources and farm animal welfare.	Technologically intensive set of production techniques which emphasise equally environment, farm incomes and food quality.	Emphasis on the application of technology to increase yields, productivity and profits.
Knowledge requirement	Radical break with conventional farming knowledge networks. Requires the development of a new R&D and advisory system. Local/tacit knowledge base.	Demands new developments within the existing advisory system and more targeted R&D. Possible re-training needed if enterprise mix alters. Mix of local and external knowledge.	Traditional R&D and advice (public and private sectors). Standardised knowledge base.
Promotion Policy structures	Can benefit from the CAP	In addition to support under	Supported under the CAP

	Organic agriculture	ICM systems	Conventional agriculture
	commodity regimes. 88% of organically farmed land receives support through EC Regulation 1257/99.	the CAP commodity regimes there is support under 1257/99 in some Member States. Also modest support for R&D and technology transfer through organisations represented on IACPA.	commodity regimes.
Market structures	Niche markets[14].	Principally mass food market structures (e.g. farm assurance schemes based on IFS), but potential for niche marketing opportunities (e.g. regional labelling schemes).	Mass markets for conventional food products.
Conceptual issues			
Ideas underpinning practice	Initially a deliberate and radical critique of conventional methods of food production, marketing and consumption. Now defined by EU Regulation. Sustainable resource use for food production is key aim.	Environmental considerations given greater emphasis within food production. A relatively more sustainable use of resources for producing food than conventional agriculture.	Productivism through intensification, specialisation and concentration.
Relationships within the food chain.	Aims to draw consumers closer to producers. Potential for producers to exert more control within the food supply chain through alternative methods of marketing, price premiums.	IFS is in part a response to consumer concerns about production methods. Potential for consumers to be brought slightly closer to producers through labelling schemes based on IFS. Producers position in food supply chain slightly improved e.g. through quality assurance schemes.	Consumers distant from producers. Producers occupy a potentially more marginal position within the food supply chain.

Source: adapted from Morris and Winter (1999).

To conclude, although initial impressions would suggest that ICM is fairly closely aligned to organic production, their origins are very different (although it is recognised that organic production has shifted somewhat from its ideological origins with the introduction of EU level regulation) and this has implications for their relationships with conventional production. Organic production represents a system distinct from conventional production and marketing, whilst ICM is clearly placed within the conventional framework. In terms of philosophy at least, ICM should therefore be placed closer to conventional farming than to organic production, representing as it does, modification of the existing system rather than abandonment of it. However, it is also possible to consider the placement of ICM

[14] Certification by national bodies within the framework of the EU Organic Regulation. Conventional marketing structures may be bypassed.

in terms of its impact on the environment and farm profitability. This is explored further in Chapter 5 and Chapter 6.

4. EU review of ICM systems

There are two broad categories of ICM system considered in this report: those established for research purposes and those set up and run commercially. This Chapter provides an overview of both these types of system by Member State. The intention is to demonstrate the range of systems that are currently in existence. The information was compiled through a literature review drawing on available information from throughout the EU and was supplemented by telephone interviews with relevant organisations and individuals in a range of Member States. This Chapter is thus limited by the project budget, availability of information and the degree of assistance provided by contacts.

This document is therefore in no way an attempt to provide an exhaustive reference document to all ICM systems and schemes in place in the EU, nor does it provide a historical reference to previously carried out research. The inclusion of certain systems and the exclusion of others does not suggest approval/disapproval and should not be interpreted in this way. The primary purpose of this report is to consider the environmental impact of ICM through the use of limited case studies rather than to focus on the plethora of schemes in existence. These case studies are profiled in this Chapter, but full details and an analysis of their environmental impact can be found in Chapter 5. Economic impact is considered in Chapter 6.

Section 4.1 and Section 4.2 provide a brief background to the two broad types of ICM system and Section 4.3 reviews ICM systems in each Member State where appropriate, i.e. where no systems have been identified under either the research or commercial heading, these sub-sections do not appear.

4.1. Background to research systems

Prior to the late 1970s the majority of research into integrated farming was conducted on a small scale and was reductionist in nature, i.e. focused on system components rather than the systems themselves. The need to consider farming systems in their entirety rather than simply their components was established by the IOBC in 1976 and this realisation ultimately led to the founding of a working group for integrated farming systems and a network of European research. This research was usually established to improve environmental performance and it is not therefore surprising that ICM systems are widely considered to have a more benign impact on the environment than conventional production.

A brief overview of the most significant research carried out on Integrated Production systems in the EU, whether IFS, ICM or IPM is provided under the appropriate Member State sub-sections. References for each research programme are included and the reader should consult these for more complete details.

4.2. Background to commercial systems

Although there are often significant differences in the operation of commercial ICM schemes across the EU, the scale of adoption of commercial ICM-type systems can be seen in Box 4.1[15]. Although the proportion of ICM in the EU-15 is small, there is a great deal of variation between Member States. The UK has by far the largest area under ICM according to Box 4.1 (but see comments below the table), although this is less than a tenth of total Utilisable Agricultural Area (UAA). ICM accounts for around 20% of UAA in Austria and Denmark. At the other extreme, official ICM systems are virtually non-existent in Greece and represent less than 1% of UAA in Belgium, Finland, France, Ireland and Spain.

Box 4.1: Area under ICM in the European Union

	Area of ICM (hectares)	Total UAA (hectares)	ICM as proportion of total UAA
Austria	608,097	3,423,000	17.8%
Belgium	7,140	1,382,000	0.5%
Denmark	637,100	2,764,000	23.0%
Finland	14,390	2,150,000	0.7%
France	133,000	30,169,000	0.4%
Germany	225,070	17,327,000	1.3%
Greece	268	3,465,000	0.0%
Ireland	19,187	4,434,000	0.4%
Italy	159,381	15,256,000	1.0%
Luxembourg	n/a	127,000	n/a
Netherlands	29,970	1,848,000	1.6%
Portugal	57,969	3,942,000	1.5%
Spain	38,507	29,377,000	0.1%
Sweden	157,138	3,109,000	5.1%
UK	1,554,203	15,858,000	9.8%
EU-15	**3,641,420**	**134,631,000**	**2.7%**

Sources: the area of ICM is sourced from ECPA and total UAA is sourced from The Agricultural Situation in the Community and refers to 1997, the last year for which data are available.

Note: the year for each Member State is unknown, although is believed to be between 1995 and 1998. The true area of ICM is therefore likely to have increased (see Box 4.24). The true area will also be underestimated because there will be farmers using ICM techniques who are not registered in official schemes.

Box 4.1 requires a word of warning. As outlined earlier in this report, there is no common standard for ICM or integrated farming in the EU and therefore schemes that are labelled as being ICM may in fact not be equivalent (some ICM schemes may also be excluded for a variety of reasons). The greatest divergence in standards is between trade related schemes that represent the right to supply retailers and those established with the specific objective of reducing any negative environmental impacts, such as those that are primarily research-based or fall under the scope of Regulation 1257/99. However, schemes which involve retailers may often exclude some of the parameters of ICM production; on the other hand, they may incorporate aspects of production outside the remit of

[15] Box 4.1 does not consider the area of ICM for which full compliance has been achieved.

ICM (such as the UK's Assured Produce Scheme which includes worker welfare). The respective areas of ICM cropping should therefore be considered indicative only.

Part of the reason for the variability in uptake of the schemes is the fact that the degree of uptake in different countries is a result of different pressures and motivations. The uptake of ICM protocols across the EU is dependent on a number of factors, not least the sophistication of the agricultural and food distribution structures as shown in Figure 4.1.

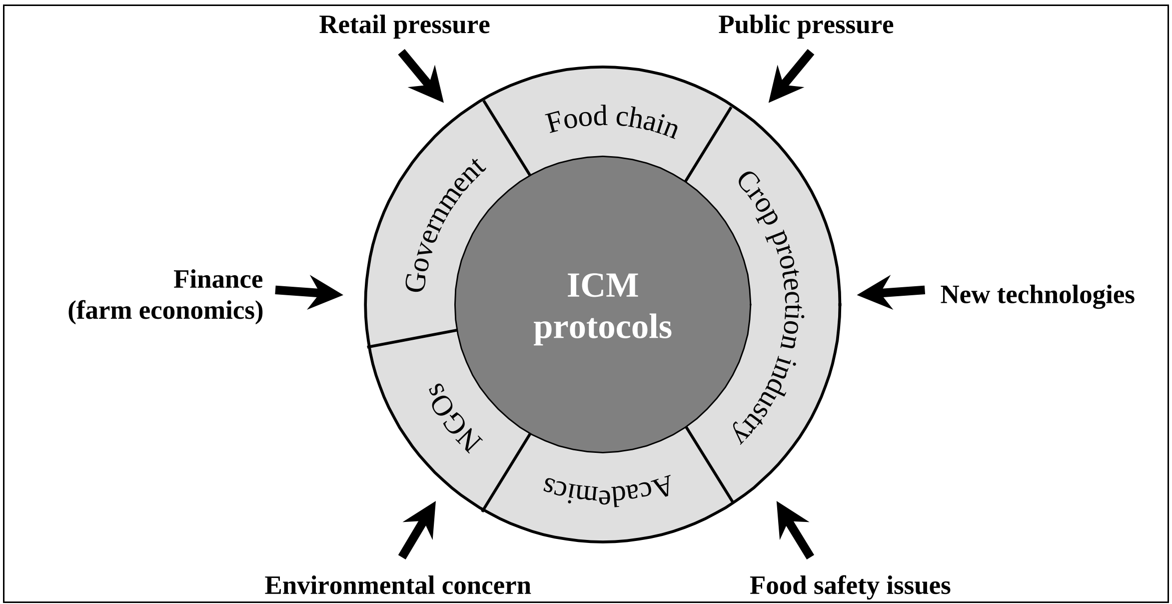


Figure 4.1: Key drivers for ICM uptake

The pressures behind the development of ICM systems vary according to Member State and help explain the type of systems in place. For example, in Member States with a particularly strong retail sector, ICM schemes are likely to be more trade related (e.g. the UK). In Member States where there is a high degree of environmental awareness and concern ICM is more likely to be a goal for the whole agricultural sector rather than for particular schemes (e.g. Denmark, Austria). In a number of member states (e.g. Italy, France, regions of Germany, Spain, Portugal and Finland) government support for ICM has reached a peak in the framework of Regulation 1257/99.

We would include amongst the most organised and coherent approaches to the application of ICM/IFS across the EU those pursued by a number of organisations specifically set up for this purpose as well as those schemes which take place under the auspices of the Euro-Retailer Produce Working Group (EUREP). These are explored further below, and highlighted where applicable under the country sections that follow.

4.2.1. Organisations promoting ICM in Europe

Integrated Production started at the local/regional level, although it is now sufficiently widespread to merit national level involvement. There are now six national organisations promoting the up-take of

ICM in their respective nations. These organisations (profiled in Appendix 12 National organisations promoting Integrated Farming) are:

- FNL (*Fôrdergemeinschaft Nachhaltige Landwirtschaft e.V.*) in Germany;
- FARRE (*Forum de L'Agriculture Raisonnée Respectueuse de L'Environnement*) in France;
- LEAF (*Linking Environment and Farming*) in the UK;
- Odling i Balans in Sweden;
- L'Agricoltura che vogliamo in Italy; and,
- FILL (*Fôrdergemeinschaft Integrierte Landbewirtschaftung*) in Luxemburg.

The intention of these organisations is to serve as a national forum bringing together all the different parties concerned (farmers, professional organisations, research initiatives, input suppliers and the distribution chain), to encourage the adoption of Integrated Farming on farms and also to provide information to consumers concerning the principles and advantages of the technique in terms of both the quality of food and its less adverse environmental impact.

In order to promote ICM across the EU these national organisations founded EISA (European Initiative for Sustainable Development in Agriculture) in January 2001. It is important to note that these organisations promote ICM generically and do not have their own ICM schemes. However, EISA does provide guidance to those wishing to develop ICM through its 'Common Codex' for Integrated Farming (see Chapter 3, Section 3.1). IOBC/WPRS[16] also serves to promote ICM in Europe (although its remit extends beyond the EU-15) by providing scientific support to grower organisations that practice production according to its principles.

There is also a network of demonstration farms run under the Concerted Action AIR 3-CT920755 project. The basic objective of this research is to establish a common frame of reference for prototyping integrated and ecological arable farming systems by elaborating and standardising the methods used. This research is not considered further because this report is concerned primarily with existing systems and schemes in the market place rather than generic Integrated Production practices.

4.2.2. Retailer driven schemes (EUREP)

One of the most widespread applications of an ICM-type scheme is controlled by the Euro-Retailer Produce Working Group (EUREP), which is made up of several European food retailers with suppliers and associate members drawn from four continents. Whilst the schemes run under the auspices of this organisation are not necessarily pure ICM systems (usually these schemes are considered to be less comprehensive, although some schemes may in fact be more comprehensive

[16] International Organisation for Biological and Integrated Control of Noxious Animals and Plants: West Palaearctic Regional Section.

than ICM in some ways by including such elements as worker welfare), their development and application is relatively widespread, and as such are important.

The EUREP objective has primarily been to raise standards for the production of fresh fruit and vegetables. A first draft protocol for Good Agricultural Practice (named EUREPGAP) was agreed in November 1997, and this was followed in September 1998 by pilot trial projects to verify implementation in practice. A first draft of the EUREP-GAP Protocol was discussed with growers, producer marketing organisations, verification bodies, agrochemical companies, farmer organisations and scientific institutes in 1999 and the official GAP Version 2000 subsequently released.

4.3. ICM schemes by Member State

The following sub-sections present some of the ICM schemes in use or under research in each Member State where appropriate.

4.3.1. Austria

4.3.1.1. Commercial systems

There is a long tradition of Integrated Production of apples in the South Tirol region and in 1995 many Integrated Production[17] schemes in Austria were incorporated within ÖPUL, Austria's agri-environment scheme and therefore became subsidised. Under this scheme the environmental performance of farmers is monitored and rewarded to some extent.

National guidelines are operated in conjunction with a point system, so producers have to attain a minimum standard, although there is flexibility. Points of –1, 0, +1 are awarded for a range of activities under several category headings and producers must attain a score of –2 or above in order to use a quality marketing seal (AMA-Gütesiegel[18]). Scores of –3 to –5 result in a warning to improve whilst scores of –6 or below lead to disqualification from the scheme. Where scheme members are receiving funding under ÖPUL, support will be withdrawn in the event of disqualification.

[17] Integrated Production is the term used in Austria. It equates to ICM.

[18] This scheme is under the EUREP-GAP umbrella.

Box 4.2: AMA-Gütesiegel

Start date:
- 1994

Area covered:
- No data on area covered, but 20,000 farmers participate

Crop coverage:
- Fruit: apple, pear, sweet cherry, sour cherry, morello cherry, peach, nectarine, plum, German prune, bush berry, elderberry
- Field vegetables: beans, broccoli, cauliflower, chicory, pak-choi, peas, cucumber, cucurbit, carrots, garlic, Florence fennel, cabbage, kohlrabi, horse radish, pumpkin, sweet pepper, chilli peppers, tomatoes, parsley, leek, radicchio, radishes, winter radish, rhubarb, jack bean, beetroot, lettuce, chives, salsify, celery, asparagus, spinach, brussels sprouts, sweet corn, onions, potatoes
- Protected crops: cucumber, cucurbit, kohlrabi, aubergines, sweet pepper, tomatoes, radishes, winter radish, lettuce

Organisation behind the scheme:
- Governmental organisation regulated by Austrian law

Objective:
- To ensure traceability of quality food produced to special programmes with specific guidelines

Scheme requirements:

Adherence to IP guidelines covering:
- soil husbandry
- crop rotation
- soil analysis and fertilisation
- irrigation
- harvest and storage
- farm equipment and hygiene
- plant protection
- management
- record keeping

In addition produce must be:
- of Austrian origin
- fully traceable
- of Class E or I, i.e. top class

Certification/control:
- Annual independent inspection

4.3.2. Belgium

4.3.2.1. Commercial systems

Although ICM is a relatively new concept in Belgium, it is considered by many within the Belgian industry to be preferable to organic production as a way forward for farming. ICM in Belgium is essentially limited to fruit and glasshouse production and could probably be more accurately described as IPM as a result, not least because pesticide minimisation is one of the main objectives.

The ‘Flandria Family’, part of EUREP-GAP is a quality concept for vegetables with consumer labelling and is the result of co-operation between producers, auctioneers, retailers and exporters, scientists and research stations and the Agricultural Marketing Board in Flanders. Although this scheme originated in Belgium, French and Dutch producers are now also using the label.

Box 4.3: Flandria

Start date:
- 1995

Area covered:
- N/A

Crop coverage:
- There are 29 crops with the most important being tomatoes, peppers, cucumbers, leek, cauliflower, aubergines, courgettes, fruit, lettuce, Belgian Endive

Organisation behind the scheme:
- Producer organisations co-ordinate the scheme through LAVA, a group of 7 auction houses

Objective:
- To produce crops to ICM standards as far as possible

Scheme requirements:
- Restrictions on use of plant protection products
- Strict record keeping requirements

Certification/control:
- LAVA is responsible for certification and control and is independent of the producers. In order to increase credibility, accreditation independent of LAVA was introduced in mid-2001

4.3.3. Denmark

4.3.3.1. Commercial systems

Integrated Production in Denmark is well advanced in horticulture and guidelines were laid down for arable farmers in 1996, although practice is thought to be restricted to larger farms. There are no official statistics on the issue as there is no official definition. However, estimates of the area of Danish agriculture cropped according to ICM guidelines currently varies from one third to two thirds (the upper estimate from the Dansk Planteværn and the lower from the Danish Crop Protection Association). The Danish use of ICM is incorporated within general production practices, based on the guidelines, rather than being set out in particular schemes.

4.3.4. Finland

4.3.4.1. Commercial systems

'Balanced Crop Protection', the Finnish equivalent of ICM is funded by the government under the Finnish Environment Programme 2000-2006. Some commercial companies also insist on Integrated Production as part of their contracts with growers. The guidelines used in Finland have been produced in association with research institutes and are ultimately based on the IOBC objectives and principles.

4.3.5. France

4.3.5.1. Research Systems

Integrated systems in France are seen as effective instruments for extensification and an alternative way to reduce overproduction and reverse the decline in farm incomes[19]. Experimental projects have been run notably in the arable and fruit sectors (Boigneville, Box 4.4 and Lanxade, Box 4.5 respectively).

In the Boigneville project, the objective has been to compare 4 micro-farms within the site (T+, Us, H+ and I), by applying different production techniques. Of the 4 micro-farms, 3 can broadly be characterised as 'conventional' (T+, Us and H+) in that their primary driver has been profit-maximisation. However, in 2 of these micro-farms this strategy has been pursued through a more controlled application of inputs (T+ and H+) based on a greater input of management time and crop observation. The fourth micro-farm (I), which has been characterised as an integrated production system, aims mainly to maximise the protection of the environment by only permitting input application after observation.

Box 4.4: Boigneville

Start date:
- 1993

Area covered:
- 75 hectares

Crop coverage:
- Winter wheat, durum wheat, oilseed rape, spring barley and peas

Organisation behind the scheme:
- French Cereals Technical Institute (ITCF)

Objective:
- Reducing chemical inputs to maintain the integrity of the environment and to reduce costs
- Maintaining soil fertility through the higher input of organic matter
- Maintaining satisfactory profitability for each crop in the rotation, although accepting a possible reduction in yield in the integrated system

Scheme requirements:
- This is a research scheme so the protocol is under development. The main element of the integrated scheme is crop observation/management time. The intention is that only the required quantities of fertiliser and plant protection products will be applied and that, as a result, the use of both inputs will be lessened. There are no prescriptions to actually limit input use if they are needed

Certification/control:
- There is no certification or control because the output is sold through normal marketing channels

In the fruit sector, the Ctifl (Interprofessional Technical Centre for fruit and vegetables) has run two main projects on integrated fruit production, one on apples (Lanxade) and one on peaches (Balandran). The latter is much smaller scale than the former and considerably more complicated

[19] Holland, Frampton, Cilgi and Wratten, 1994; Viaux, *et al*, 1989.

due to weather and crop conditions and results are still at an early stage of progress. In both cases, the primary objective has been to determine the feasibility of these crop systems in terms of whether the application of higher environmental requirements under Integrated Production methods compromises yield performance (both in terms of quality and quantity).

Box 4.5: Lanxade

Start date:

- 1996

Area covered:

- 70 hectares, of which 1 hectare dedicated to apples

Crop coverage:

- Apples (2 varieties)

Organisation behind the scheme:

- Ctifl (Interprofessional Technical Centre for fruit and vegetables)

Objective:

- Technical and economic follow-up of the orchard management and of its production
- Integrated phytosanitary protection (reduce chemical inputs)
- Controlled irrigation, soil maintenance and fertilisation
- Qualitative evaluations of the impact of these crop techniques on nitrates and pesticides in water (since 1998)

Scheme requirements:

The management strategy essentially follows the requirements laid down in the National Charter for Apple Production, introduced in February 1997 as a guideline document, and detailed protocols developed by Ctifl. It incorporates principles of integrated production (rather than IFS or ICM) regarding the entire farm management. These cover:

- orchard establishment (choice of production site, plant varieties and orchard system)
- management of the orchard (including plant protection, irrigation and fertilisation)
- control procedures

Certification/control:

- In accordance with the National Charter, products undergo a control procedure at three levels; the experimental site itself is under the control of Ctifl

4.3.5.2. Commercial systems

Integrated Production in France was first established in the 1970s, and despite a rather slow development, it has evolved rapidly in recent years to become a well known concept. Recent efforts, both by the government and by the industry, have concentrated on developing a common formal definition, and guidelines with a view to the development of a nation-wide concerted farm certification and product marketing scheme. This is largely a response to increasing concern over the multitude of schemes that have developed over the years in the different sectors, whether research or commercially driven, and the extent to which these are properly defined.

A major development for the wider acceptance of integrated production methods in France has been the adoption by the French Parliament of a Law on 'New Economic Regulations' on 2 May 2001. Article 58 of this Law inserts a new article (L.640-3) into the French Rural Code, which envisages the adoption of a Decree on integrated production (referred to as '*Agriculture Raisonnée*').

A framework for the adoption of the Decree was developed and formally proposed on 8 January 2002 by the Conseil Supérieur d'Orientation, which brings together within the Ministry for Agriculture all stakeholders of the French agricultural sector. It is a guideline or 'reference' document that specifies the acceptable methods of control, farm accreditation and qualification procedures and determines the conditions for the use of the term '*Agriculture Raisonnée'* and all other equivalent definitions. This will now allow the Ministry of Agriculture to provide a legal framework for '*l'Agriculture Raisonnée'*. Until the adoption of detailed formal rules, the use of the term for marketing purposes on consumer packs and labels has been prohibited.

However, the government's efforts so far have provided a definition for '*Agriculture Raisonnée*', which does not appear to correspond exactly to Integrated Farming as such. Although the reference document of 8 January 2002 lays down detailed requirements in terms of soil and crop management (including on fertilisation, crop protection, and irrigation), and although it refers to a whole-farm approach, the various provisions appear to be closer to the definition of Good Agricultural Practices (GAP) than to the more formal definitions of Integrated Farming such as that of the IOBC.

Prior to these latest developments, the wider drive towards ICM has been led through a network of demonstration farms co-ordinated by FARRE, the forum for environment-friendly integrated farming, which was established in 1993. To date, the network comprises some 350 farms in 64 regional departments of France, reflecting the diversity of French farming.

Several regional and product-specific, independent guidelines were developed from the mid-1990s onwards, under the initiative of professional organisations and with support from regional authorities. Some of these have since been amalgamated under the FARRE '*National Charter'*, prepared by the Scientific Council[20] of the organisation, the objective of which is to provide a common reference on Integrated Farming across France. The current version of this charter, dating from 27 December 1999 will be updated in the light of new information and advances in the field. This document amalgamates the principles of Integrated Framing with the tools that can be used to achieve them. The 'national charter' complements the FARRE Environmental Self-Diagnosis handbook which currently relates to the cereal and oilseed and fruit and vegetable sectors and vines. An Environmental Self-Diagnosis handbook is currently in preparation for livestock and mixed livestock farms.

The *Charter* is not a protocol as such (*'cahier des charges'*), in that it applies horizontally across a farm or a farmer's agricultural practices rather than being linked to a particular product sector. Also, in contrast to a protocol, the *Charter* does not have a quality mark certifying that the product has been produced in compliance with detailed specifications; instead the FARRE logo is displayed at the farm level. The *Charter* is supplemented by detailed *Guidelines* which have been put together by the various sectoral professional organisations for most major crops (e.g. major fruit and vegetable

[20] Composed of 14 members representing various sectoral organisations as follows: SNIA-SYNCOPAC, INA PG/INRA, Institut de l'Elevage, RPAF, INRA, ONC, CTIFL (fruit and vegetables), INA PG, CNEVA, Chambre d'Agriculture, PROFERTIL, ACTA, ITCF/COMIFER, CEMAGREF.

products, wine, durum wheat, soft wheat, malting barley and potatoes). The objective is that in future, the *Guidelines,* in conjunction with the *Charter,* will become the main reference to Integrated Farming substituting all other types of protocols in this field. Box 4.6 provides further information on the *Charter*.

Box 4.6: 'Socle Commun de l'Agriculture Raisonnée Respectueuse de l'Environnement'

Start date:

- 1993

Area covered:

- No data on area covered, but 320 farms participate in 56 geographical departments

Crop coverage:

- Not crop specific, applies to both arable and livestock farming

Organisation behind the scheme:

- *Forum de l'Agriculture Raisonnée Respectueuse de l'Environnement* (FARRE)

Objective:

- To provide a common reference on Integrated Farming across France

Scheme requirements:

There are 11 guidelines, 9 of which are applicable to crops:

- fertiliser management
- crop protection
- plant protection product treatment
- water leaching
- water management
- waste management
- soil erosion
- technical information on the socio-economic environment
- annual evaluation of the practices followed (on the basis of the FARRE Environment Self-Diagnosis, which currently exists for 3 crops: vegetables, cereals and vines)

Certification/control:

- Members of the FARRE network are selected and approved by local committees and a National Executive Committee. The FARRE Charter ('*Socle*'), signed by the member farmers, constitutes the basis of their commitment to the initiative. Farmers also agree to implement the Environmental Self-diagnosis process drawn up by the Scientific Advisory Board of FARRE. On April 2001, some 234 farms throughout France displayed the FARRE logo, which was accredited this way

Although, a survey conducted on behalf of FARRE in December 2000 stated that roughly half of French farmers claimed to practice Integrated Farming, there is no concrete up to date data available on the total land area or production volumes in France under IFS/ICM. However, some 58,000 hectares of vegetables, 25,000 hectares of apples and 50,000 hectares of arable crops were grown under commercial ICM/IPM systems in 1999. Glasshouse vegetable production following IPM techniques in France is quite advanced and is estimated to be practised on about 800 hectares or half the total glasshouse crop (of which 50% is tomato production). The total area is larger if various other fruit and vegetables, wine and potato schemes, as well as impact-specific schemes that follow a much narrower definition, such as Ferti-Mieux, Irri-Mieux and Phyto-Mieux are also included.

Some of the most developed commercial initiatives can be found in the fruit and vegetables and wine sectors. For wine these include: *Terra Vitis*, an umbrella scheme encompassing various regional initiatives of Beaujolais wine under the same logo (Box 4.7); *Vinealis*, which has a larger geographical spread across the country (Box 4.8); and the interprofessional scheme set up by *CICV* in the Champagne region.

Box 4.7: Terra Vitis

Start date:
- 1998

Area covered:
- No data on area covered, but 56 farmers participate with a total production of 45,000 hecto-litres

Crop coverage:
- Wine

Organisation behind the scheme:
- TERRA VITIS (association of Beaujolais wine farmers)

Objective:
- To promote integrated wine production practices, notably by promoting awareness both amongst commercial partners and consumers, and offering a product guarantee through the application of technical protocols

Scheme requirements:
In addition to maintaining records on all operations carried out on the farm, producers must adhere to a specific protocol covering:
- fertilisation
- soil maintenance
- phytosanitary protection
- harvest monitoring and control

Certification/control:
- Independent verification by Bureau Veritas

Box 4.8: Vinealis

Start date:
- 1998

Area covered:
- 2000/01: 3,000 hectares (7 co-operatives participate from different regions of France)

Crop coverage:
- Wine

Organisation behind the scheme:
- Economic Interest Group VRC (Integrated Controlled Viticulture)

Objective:
- To practice integrated farming

Scheme requirements:
Adherence to a specific protocol, in accordance with the FARRE Charter and the IOBC definitions, covering:
- planting
- fertilisation
- phytosanitary protection

Certification/control:
- Independent verification by Bureau Veritas

In the fruit and vegetables sector the initiatives tend to be more product specific and based on a narrower definition more akin to IPM than to ICM. The situation is somewhat more complicated than wine due to the large number of organisations involved at national, regional and product level. In the case of some products the situation is more advanced because the Ctifl (Technical Centre for Fruit and Vegetables) has been working together with national and regional product committees and has been instrumental in putting together so-called 'national production charters', an element of which is the use of integrated farming practices. Such charters have been developed for apples (currently in the fourth year of operation and covering about half of the total 2 million tonnes annual French production); for peaches (currently in the second year and concentrated in the south); and a charter has just been completed for pears. There are also some charters in the vegetables sector: for example for glasshouse tomatoes and cucumbers (Box 4.9), to which a number of commercial schemes adhere.

Box 4.9: Tomate De France/Concombre de France

Start date:
- 1997

Area covered:
- No data on area is available, but a total production of 300,000 tonnes of tomatoes and 50,000 tonnes of cucumbers are covered. 40 producer organisations participate, including SAVEOL, AMS, Prince de Bretagne, OCEANE, etc., although they can also participate in parallel in their own commercial schemes (see below)

Crop coverage:
- Tomatoes (glasshouse)
- Cucumbers (glasshouse)

Organisation behind the scheme:
- Economic Committee of the Val de Loire region (a loose regional organisation similar to the Belgian VLAM, which is informally appointed to represent the interests of the French tomato and cucumber industry)

Objective:
- To promote product quality, particularly on the basis of Integrated Production

Scheme requirements:

Adherence to an annually up-dated 'national charter', produced with the technical support of Ctifl, which covers for tomatoes:
- product quality (including product specifications, conditioning, storage and transport)
- traceability
- selection of varieties
- integrated production methods related to irrigation, fertiliser and plant protection product use
- harvesting conditions

Certification/control:
- Independently certified by an external organisation (ULACE)

Other specific commercial examples include the *GRCETA* scheme in Basse Durance covering 120 producers of apples, pears, peaches, cherries and apricots (Box 4.10); the vegetables scheme by *CEAFL* of Val de Saire in Basse Normandie; the scheme by *Cerafel* in Britanny covering over a million tonnes of vegetables marketed under the *Prince de Bretagne* brand; and a co-operative scheme in Brittany (Saveol) mainly for tomatoes (70,000 tonnes), although this is more accurately defined as an IPM scheme. In the potato sector (for direct consumption), some 25% of area is cropped according to an ICM guideline developed by the national interprofessional association *CNIPT* in 1998 and approved as a national (AFNOR) standard in October 2000.

Box 4.10: GRCETA

Start date:
- 1997

Area covered:
- No data on area, but some 250 producers in the region Basse Durance are members with a potential production of 100,000 tonnes

Crop coverage:
- Apples, pears, peaches, apricots, cherries

Organisation behind the scheme:
- Regional Group of Basse Durance

Objective:
- To promote Integrated Production (defined in accordance with the FARRE principles, comprising respect for the environment and quality protection, taking into account farm revenues and economic performance)

Scheme requirements:

Adherence to specific protocols, developed on the basis of the IOBC guidelines and FARRE Charter, which cover:
- development of the tree
- production practices such as fertilisation, irrigation and plant protection (there is a suggested order of priority in terms of use of chemicals: observe; intervene using natural methods (biological, bio-technical); intervene using the best adapted products with the least toxicological effect, etc.)
- control of fruit charge (limit fruit charge on the tree)
- harvest

Certification/control:
- Independently audited by an external organisation (ULACE) at the farm and product level

In addition, there are several other private, regional or product-specific initiatives, which are primarily based on quality considerations, but may also cover certain IFS/ICM specifications (e.g. controlled application of plant protection products) or ISO 14001 type of standards. For instance, Quali'Terre was launched by the Agriculture Chamber of the Picardie Region as an agri-environmental programme that also acts as a quality assurance scheme based on the ISO 14001 standard. It corresponds to the British 'Assured Combinable Crops' (ACC) scheme (see Section 4.3.15). A similar programme, 'Agriconfiance Volet Vert', has just been launched by the CFCA (French Confederation of Agricultural Cooperation - CFCA), which proposes certification for both product quality (ISO 9002) and respect for the environment in production methods (ISO 14001), following a systems approach (i.e. the certification will apply at the level of the farm holding rather that at the level of a specific product). This scheme is seen in France as the closest equivalent to EUREP-GAP. There are also various retailer schemes (e.g. by Auchan, Carrefour, Casino) which are marketed under retailer own brands. So far these have tended to concentrate on the fruit, vegetable and wine sectors. However, the extent of their impact has been widely contested by the industry.

Finally, there are a number of voluntary schemes set up with specific objectives that partially fall within the definition of Integrated Farming. Ferti-Mieux, which covers a surface of over 1.5 million hectares, aims to reduce the risk of water pollution from nitrates of agricultural origin by targeting farmers' nitrogen management methods. Irri-Mieux and Phyto-Mieux are similar schemes, run largely at the moment on a pilot scale, targeting irrigation and plant protection practices respectively.

4.3.6. Germany

4.3.6.1. Research systems

The research into the productivity and ecological impact of integrated and conventional farming systems at Lautenbach[21] was the first of its kind to be undertaken in Europe and dates back to 1978 (Box 4.11). Although this project has now finished, it is included here both because it forms a case study and because the experimental work continues on a commercial farm (Boxberg project).

Box 4.11: Lautenbach (1978-1994)

Start date:
- 1977

Area covered:
- 72 hectares, half farmed conventionally and half according to integrated management practices

Crop coverage:
- Winter wheat, spring wheat, spring barley, oats, sugar beet, peas, beans, faba beans

Organisation behind the scheme:
- The farming community with support from the official extension services

Objective:

To investigate whether:
- farming practices can be integrated to maintain pest populations below economically damaging levels
- energy inputs can be reduced and made more efficient in order to improve financial returns
- the farming system can be made sustainable;
- environmental pollution can be reduced and a reservoir for beneficial wild species established
- the effects of landscape components on crop productivity can be evaluated in the long term

An additional aim of the Lautenbach project was to demonstrate integrated farming. Although this limited the range of husbandry practices that could be investigated, it ensured that the project remained practical and economic.

Scheme requirements:

This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions were developed relating to:
- soil tillage
- drilling
- fertilisation
- soil cover
- plant protection methods and products
- ecological infrastructure
- farm machinery

Certification/control:
- Output is not marketed separately and is therefore not controlled

[21] El Titi, 1999; Holland, Frampton, Cilgi and Wratten, 1994; El Titi, 1992; El Titi, 1990; El Titi and Landes, 1990; El Titi, 1989; Wahl and Hurle, 1988; Zeddies et al, 1986.

INTEX[22] was initiated in 1989 and is presented in Box 4.12. Again, this project has now ceased in experimental terms, but is included as a current project because it remains part of an extensification programme.

Box 4.12: INTEX (1989-1997)

Start date:
- 1989

Area covered:
- 94 hectares

Crop coverage:
- Arable (winter wheat, oilseed rape, winter barley and field beans)

Organisation behind the scheme:
- University of Göttingen, co-ordinated by the Research Centre for Agriculture and the Environment

Objective:
- To develop further an integrated farming system
- To examine the economic and ecological effects of extensification in arable production

Scheme requirements:
This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions were developed relating to:
- soil tillage
- crop establishment
- crop varieties
- fertilisation
- plant protection
- ecological infrastructure

Certification/control:
- Output is not marketed separately and is therefore not controlled

4.3.6.2. Commercial systems

Integrated Production in Germany began when growers were required to take the principles of IPM into account in their production systems under German plant protection laws. Most farmers will therefore be following basic ICM guidelines. The ‘Guidelines for Integrated Fruit Production in Baden-Württemberg’ were established in the mid-1970s, and on the Lower Elbe matching the spread of Integrated Production techniques in Switzerland. Early promotion work ensured a fast expansion of Integrated Fruit Production in the region and area covered increased from around 10% in 1989 to 87% in 1999 in Baden-Württemberg and 33% in 1989 to 84% in 1992 in the Lower Elbe region. Since then the area has stagnated and is now at around 82%. This is blamed on the fact that producers do not receive the full benefits that their production system brings to the community.

There are currently ten regional schedules for fruit and vine growing based on IOBC guidelines. However, only Brandenburg, Hamburg, Rheinland-Pfalz, Sachen and Thüringen support IP through Regulation 2078/92 and 1257/99 since 2000. Also, as IP systems increased in number, retailers re-

[22] Gerowitt and Wildenhayn, 1997; Holland, Frampton, Cilgi and Wratten, 1994.

categorised the production as ‘normal’, which removed the possibility of attaching a premium to the product; schemes therefore became a ‘right to supply’.

Box 4.13 provides information on the HQZ label in Baden-Württemberg, Box 4.14 details the Brandenburg scheme for fruit and vegetables and Box 4.15 considers a wider scheme in Sachsen-Anhalt. Box 4.16 profiles the AKIL project in south west Germany which forms one of the case studies in Chapter 5 and Chapter6.

Box 4.13: HQZ- Baden-Württemberg

Start date

- 1990

Area covered

- No data on area covered, but 23,674 participants

Crop coverage

- Apple, pear, sweet cherry, sour cherry, morello cherry, plum, German prune, field vegetables, cereals, oilseed rape, sunflower, potato, onions, asparagus, protected crops

Organisation behind the scheme

- Government authorised marketing association entitled to sub-license local organisations

Objective

- To make clear the origin of the product, define an environmentally based, integrated and controlled production system to produce higher quality produce

Scheme requirements

Adherence to IP guidelines covering:

- soil husbandry
- crop rotation
- soil analysis and fertilisation
- irrigation
- harvest and storage
- farm equipment and hygiene
- pesticide use and application
- management (orchards: traffic ways and trees: rows/pruning/storage)
- record keeping

In addition produce must be:

- of Baden-Württemberg origin
- fully traceable
- of Class E or I, i.e. top class

Certification/control

- Annual independent inspection

Box 4.14: Brandenburg programme to support Integrated Production in the fruit and vegetable sector

Start date
- 1996

Area covered
- 7112 hectares in 2000; 156 enterprises

Crop coverage
- Fruit and vegetables

Organisation behind the scheme
- Brandenburg Ministry of Food, Agriculture and Forestry on the basis of EC Reg. 2078/92

Objective
- Reduction of fertiliser/pesticide use and improved product quality compared to conventional production

Scheme requirements

There are general requirements and more specific ones for different crops:
- general requirements (including restrictions on the use of pesticides, irrigation and fertiliser application)
- specific requirements for fruit include restrictions relating to the use of growth regulators and fertiliser, the planting of new trees and the installation of irrigation equipment
- specific requirements for vegetables, medicinal and other herbs and ornamentals include restrictions on fertiliser use and the requirement to use resistant plant and seed material (as long as this does not compromise yield and quality targets) and biological control where possible. Producers must also follow Federal Guidelines on environmentally sound production of ornamentals
- specific requirements for tree production include restrictions on fertiliser and pesticide use

Certification/control
- IP recognition and controls are conducted by a single control ring and 5% of applicants are controlled by the government. Further controls are built into the computerised application processing procedure

Box 4.15: Environmentally friendly production of vegetables, medicinal plants and herbs, pomaceous and stone fruit, wine and hops in Sachsen-Anhalt

Start date
- 2001

Area covered
- Offered in entire state, data not yet available

Crop coverage
- Vegetables, medicinal plants and herbs, pomaceous and stone fruit, wine and hops

Organisation behind the scheme
- Regional authority (75% co-financed by EU)

Objective
- The reduction/limitation of fertilisers and pesticides and the promotion of the use of products which are friendly to beneficial organisms, the protection of natural resources and the production of quality produce

Scheme requirements
- Participation must sign up to the prescriptions for at least 5 years. There are restrictions on the use of fertilisers and pesticides and monitoring of harmful and beneficial organisms should be undertaken

Certification/control
- This is via the Integrated Administration and Control System, since it is a governmental scheme within the framework of EU regulation

Box 4.16: AKIL- Kraichgau in south west Germany

Start date:

- 1988

Area covered:

- 5,000 hectares between 50 farms

Crop coverage:

- Winter wheat, spring wheat, winter barley, spring barley, rye, oats, oilseed rape, sugar beet, sunflower, potato, dried peas, silage maize, sweetcorn, grass clover, set-aside

Organisation behind the scheme:

- Farmers concerned about severe erosion problems

Objective:

The central objective is to maintain or improve farm income whilst reducing external inputs and erosion. There are also the following sub-objectives:

- disseminate IFS as a package to interested farmers on a no-subsidy basis
- identify potential constraints of implementation and impacts on farm income
- assess the impact on the farm environment and ecosystem components
- maintain and attract beneficial species as a tool to reduce the potential need for pesticides

Scheme requirements:

There are two categories of requirement: farm level and crop level. The former covers issues such as education and broad aspirations such as the enhancement of beneficial organisms. Crop level requirements relate to:

- soil tillage
- crop rotation
- varieties
- fertilisation
- growth regulators
- plant protection
- ecological infrastructure

Certification/control:

- A 'Control Board', consisting of representatives from an official body, a farmer association and a consumer association is responsible for checking documentation. There are no checks on final produce

There are a plethora of more market driven schemes which are often primarily certificates of geographical origin and general quality, although some ICM-type elements do apply. The CMA Quality Seal (Box 4.17) is run nation-wide by the Central Marketing Agency of German Agriculture. Box 4.18 presents guidelines for the promotion of integrated production of fruit and vegetables in Mecklenburg-Vorpommern. Box 4.19 details the programme for the promotion of environmentally friendly agriculture, the preservation of cultural landscape, environmental protection and landscape conservation (KULAP) in Thüringen. Integrated fruit production in Schleswig-Holstein is profiled in Box 4.20.

Box 4.17: CMA Quality Seal (Gütesiegel)

Start date
- 1990

Area covered
- Approximately 70% of German fruit and vegetable production

Crop coverage
- Fruit and vegetables

Organisation behind the scheme
- Central Marketing Agency of German Agriculture

Objective
- To achieve holistic, science based, dynamic and environmentally friendly high quality production using as few inputs as possible and the highest possible environmental protection

Scheme requirements (for fruit and vegetables)

There are regulations regarding:
- general production techniques and methods including pesticide and fertiliser use and soil cultivation
- post-harvest operations including restrictions relating to storage, grading and processing
- documentation

Certification/control
- Control methods are defined at the regional level and therefore differ. Neutral certified control bodies are envisaged in the near future

Box 4.18: Integrated production of fruit and vegetables in Mecklenburg-Vorpommern

Start date
- 19 March 2001

Area covered
- Available to all producers in Mecklenburg-Vorpommern, currently 36 farms, total area unknown

Crop coverage
- Fruit and vegetables

Organisation behind the scheme
- Local government for Mecklenburg-Vorpommern

Objectives
- To decrease the use of pesticides and fertilisers, especially Nitrogen
- To create transparency in the production process
- To adhere to the standards of the 'CMA-Guetesiegel' (see Box 4.17)

Scheme requirements

Producers must follow a production process which:
- promotes the sustainable improvement of natural and economic production factors
- considers the environmentally protection and the maintenance of natural habitats
- contributes to the market equilibrium

The guidelines to do this are those for the 'CMA-Guetesiegel'

Certification/control

Control is carried out via 2 mechanisms:
1. independent private control organisation carries out on farm control of 25% of the participating farms, control is carried out in conjunction with the Regional office for plant protection and the Regional research institute
2. administrative checks for a random 5–10% of farms

There are two elements to the KULAP ICM scheme. The first relates to fruit production, vine production, vegetable production, medicinal herbs, spices and other ornamentals hops, and the second to arable production. In Box 4.19 these are dealt with as Element I and Element II respectively where information differs.

Box 4.19: KULAP ICM in Thueringen

Start date

- Element I: 1993/94
- Element II: 1995/96

Area covered

- Element I: 4,982 hectares (1999/2000)
- Element II: 32,354 hectares (1999/2000)

Crop coverage

- Element I: fruit, vegetables, medicinal herbs, spices and other ornamentals, hops
- Element II: all other arable crops

Organisation behind the scheme

- Local government for Thueringen

Objective

General

- To adhere to the standards of the 'CMA-Guetesiegel' (see Box 4.17)

Element I:

- use of environmentally friendly production processes to protect the environment and natural resources
- sustainable maintenance of soil fertility
- efficient, environmentally friendly and consumer orientated production of horticultural products
- specific reduction of the use of inputs which have a negative environmental impact

Element II:

- use of environmentally friendly and reduced nutrient input production processes
- efficient and environmentally friendly production of arable crops with the maintenance of a minimum diversity of species
- market balance through the limitation of input use as well as reduction of eligible area to 83%

Scheme requirements

There are the following scheme requirements:

- participation for a minimum of 5 years
- no conversion of grassland to arable land
- maximum livestock density of 2.0 LU/hectare
- keeping of adequate records
- adherence to procedures as set out in detailed guidelines (the same as for CMA-Guetesiegel, see Box 4.17)
- membership of registered co-operative
- conduct of soil test and quality test for final products
- use of pesticides on the basis of monitoring and the use bio-technical agents

Certification/control

- There are administrative checks for at least 5% of farms and additional controls for individual parts of the programme

Box 4.20: Integrated Fruit production (Schleswig-Holstein)

Start date
- 1990

Area covered
- 40 farms, 330 hectares

Crop coverage
- Sour and sweet cherries, plums, apples, pears

Organisation behind the scheme
- Schleswig-Holstein Chamber of Agriculture

Objective
- Production of certified produce

Scheme requirements
- Producers must follow the guideline for integrated fruit production of the Schleswig-Holstein Chamber of Agriculture

Certification/control
- A private control organisation (Landwirtschafts-Consulting GmbH) is responsible for certifying the scheme

Box 4.21 details a scheme which again is primarily a certificate of geographical origin and general quality covering a wide range of products. However, principles for Integrated Production have been set out within this scheme to apply to potato production. Box 4.22 presents another, similar scheme for potatoes.

Box 4.21: 'Produced and tested in Schleswig-Holstein'

Start date
- 1985

Area covered
- 1,500 hectares, 110 farms

Crop coverage
- Potatoes

Organisation behind the scheme
- Schleswig-Holstein Chamber of Agriculture

Objective
- To provide quality assured produce for consumers

Scheme requirements

Participants must follow quality and control regulations and must:
- decrease pesticide and fertiliser usage by 50%
- not use slurry and sewage sludge
- conduct soil and residue tests

Certification/control
- Independent control by Chamber of Agriculture

Box 4.22: Pfaelzer Grumbeere

Start date
- 1992

Area covered
- 7,000 hectares

Crop coverage
- Potatoes

Organisation behind the scheme
- Co-operative 'Pfaelzische Frueh-, Speise- und Veredelungskartoffel – Erzeugergemeinschaft w.V.'

Objective
- To adhere to the standards of the 'CMA-Guetesiegel' (see Box 4.17)
- Achieve regional marketing

Scheme requirements

There are production requirements relating to:
- rotational requirements
- varietal selection
- fertiliser usage
- pesticide usage
- harvest and processing
- quality standards for product

Certification/control
- This scheme is self-controlled through the co-operative

4.3.7. Greece

4.3.7.1. Commercial systems

ICM is not well established in Greece, although IPM, mainly using beneficial insects, is used in glasshouse growing in western Greece and on Crete.

4.3.8. Ireland

4.3.8.1. Commercial systems

Although ICM is not yet widespread, some farmers have begun to use the technique. The prevalence of livestock enterprises in Ireland has meant that where ICM is used it is often actually IFS.

4.3.9. Italy

4.3.9.1. Research systems

The CAMAR experimental project forms a case study in Chapter 5 and Chapter 6 and is summarised in Box 4.23.

Box 4.23: The CAMAR experimental project

Start date:
- 1992

Area covered:
- 15 hectares, plus an additional 6 hectares for demonstration purposes

Crop coverage:
- Sunflower, spring wheat, spring barley, field beans, sorghum, maize

Organisation behind the scheme:
- European Network for Integrated and Ecological Arable Farming Systems

Objective:
- The definition and development of an integrated and an organic farming system to be applied in the Tuscan hills

Scheme requirements:
This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions are being developed relating to:
- soil tillage
- crops
- fertilisation
- soil cover;
- plant protection methods and products
- ecological infrastructure

Certification/control:
- Output is marketed through normal distribution channels and is therefore not certified or controlled

4.3.9.2. Commercial systems

Integrated Production in Italy largely comprises regional projects in Emilia-Romagna, Trentino and Alto Adige resulting from fruit production using IPM techniques in the mid-1970s. Retailers capitalised on a perceived demand for environmentally friendly production by launching own-label Integrated Production for fruit and vegetables which have been followed by meats and fruit juices. The range of schemes across the regions of Italy is detailed in Box 4.24. The total area is slightly higher than that shown in Box 4.1 because the data is thought to be more recent (unfortunately no date could be provided), although definitional differences could also be a factor.

Box 4.24: Integrated Production in Italy (hectares)

	Fruit crops	Citrus	Vegetables	Grapes	Olives	Cereals	Total area
Val d'Aosta	15						15
Piemonte	5,910		924	9,153		26,720	42,707
Lombardia	1,000		200	8,000		6,500	8,200
Trentino	13,000		50				21,050
Alto Adige	12,916			3,230			12,916
Veneto	3,149		1,305	8,000			7,684
Fruili V G	340			6,503			8,340
Emilia Romagna	15,348		700	7,020			
Toscana	290			2,500	8,330		
Marche				2,018			2,500
Molise	112		412	5,050	1,015		
Puglia	105		204	506	10,026		15,358
Basilicata	506	305	52		210		1,579
Sicilia		500					500
Sardegna			124				124
Total	**52,961**	**805**	**3,971**	**53,566**	**19,581**	**33,220**	**162,748**

Source: EUREP

Two of the major supermarket chains in Italy operate ICM schemes at the national level: the Co-op Italia (Box 4.25) and Conad (Box 4.26). Both schemes also extend to overseas produce which meets the production criteria.

Box 4.25: Co-op Italia- Prodotti con Amore

Start date:
- 1986

Area covered:
- 179,389 tonnes were sold under this label in 2000, although there is no information on area

Crop coverage:
- Citrus, potatoes, apples, mixed vegetables, carrots, onions, salad leaves, tomatoes, pears, strawberries, grapes, kiwi, peaches, nectarines, melon, kaki, apricots, plums, mushrooms, cherries, bananas

Organisation behind the scheme:
- Co-op Italia (multiple retailer)

Objective:
- To supply products which are guaranteed to be healthy and produced using as few chemicals as possible during production and none post-harvest

Scheme requirements:
- Not disclosed

Certification/control:
- Certification is carried out by the Co-op

Box 4.26: Conad- Percorso Qualita'

Start date:
- 1997

Area covered:
- Around 38,800 tonnes of produce are sold annually, although there is no information on cropped area

Crop coverage:
- Kiwi fruit, apricots, green beans, oranges, asparagus, bananas, artichokes, carrots, cabbage, cucumber, cherries, onions, mushrooms, clemantines, watermelons, fennel, strawberries, lettuce, kaki, lemons, aubergine, apples, melons, potatoes, peppers, pears, peaches, nectarines, tomatoes, radish, chicory, celery, plums, grapes, courgettes

Organisation behind the scheme:
- Conad Scarl (multiple retailer)

Objective:
- To supply producers with a production protocol to ensure integrated and environmentally friendly production and to supply consumers with high value produce grown with respect for the environment and low use of pesticides

Scheme requirements:

There is a range or requirements relating to:
- production requirements
- packaging
- working practices
- traceability

Certification/control:
- Conad co-ordinate the activity of several inspection organisations

Most ICM schemes in Italy are operated at the regional level, in many cases under Regulation 1257/99. Some regions have a regional brand which, *inter alia*, requires producers to use Integrated Production techniques. Producer Organisations typically market produce under these regional labels, although in many cases Producer Organisations have their own brands within the regional label (some of which may have additional requirements). Box 4.27 provides information on the regional brand for the Emilia Romagna region which is called Qualita' Controllata. Cogli e Gusta is a separate brand in Emilia Romagna, produce from which also uses the Qualita' Controllata label (Box 4.28).

Box 4.27: Emilia Romagna Qualita' Controllata

Start date:
- 1999

Area covered:
- 257,089 tonnes of produce were produced under this label in 2000. No information on area covered was made available

Crop coverage:
- Garlic, asparagus, carrots, cauliflower, brocolli, cucumber, chicory, onion, watermelon, endives, runner beans, beans, fennel, lettuce, aubergine, melon, potatoes, peppers, peas, tomatoes, radish, spinach, pumpkin, courgette

Organisation behind the scheme:
- Emilia Romagna regional government with involvement from single producers, producer organisations and processors

Objective:
- To add value to agricultural products produced through using environmentally friendly techniques
- To provide consumers with healthy products certified to respect the environment

Scheme requirements:

There are two types of standards:
- general standards which include compulsory and voluntary measures which are common for all crops
- technical rules for individual crops relating to agronomic practices (such as selection of varieties, use of machinery, fertilisation and irrigation practice) and crop protection

Certification/control:
- Independent certification is carried out by a range of verification bodies accredited under EN45000

Box 4.28: Cogli e Gusta

Start date:
- 1990

Area covered:
- 21,173 hectares

Crop coverage:
- Apples, pears, peach, plums, apricots, cherries, kaki, chestnuts, tomatoes, onions, green beans, other beans, spinach, peas, carrots, courgettes, peppers, watermelon, melon, asparagus, pumpkins, chicory

Organisation behind the scheme:
- Producer Organisation

Objective:
- To reduce environmental impact, provide guaranteed high quality and healthy food to consumers and to improve the marketing of products

Scheme requirements:
- The same as for Qualita' Controllata (see Box 4.27). Producers also use the Qualita' Controllata label

Certification/control:
- Independent verification is conducted periodically

The integrated production of wine in Chianti forms a case study in Chapter 5 and Chapter 6 and is profiled in Box 4.29.

Box 4.29: Integrated wine production in Chianti

Start date:
- 2000

Area covered:
- The Chianti Classico region covers 70,000 hectares, but it is not known exactly how many of these hectares are farmed according to integrated methods

Crop coverage:
- Grapes

Organisation behind the scheme:
- Farmer associations promoting EU Regulation 2078/92

Objective:
- To facilitate greater environmental sensitivity among farmers

Scheme requirements:

There are production prescriptions relating to:
- fertilisation
- cover crops
- irrigation
- soil tillage
- weed control
- the use of plant protection products

Certification/control:
- Wine is sold through the normal marketing channels, so there is no additional certification or control

4.3.10. Luxembourg

4.3.10.1. Commercial systems

Although, there are no ICM schemes in Luxembourg *per se*, ICM is promoted under the auspices of EISA. The objective of this promotion is to achieve complete use of ICM in conventional farming by 2010. Some of the criteria for ICM (relating to rotational and fertiliser requirements) are met under a scheme introduced in 1996/97 whereby subsidies are available for the proper upkeep of open spaces and the countryside. However, this is a landscape protection agri-environmental scheme rather than an ICM scheme and any ICM criteria that are met are done so incidentally.

4.3.11. Netherlands

4.3.11.1. Research systems

Research into integrated techniques in the Netherlands began in 1979 at Nagele[23] (Box 4.30).

Box 4.30: Nagele (1979-)

Start date:
- 1979

Area covered:
- 72 hectares

Crop coverage:
- Winter wheat, sugar beet, pasture, potatoes and carrots

Organisation behind the scheme:
- Research scheme- funding body not known

Objective:
- Develop organic and integrated farms in theory and test them in practice
- Evaluate the results of the system
- Compare the experimental systems with the conventional control system

Scheme requirements:

This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions are being developed relating to:
- soil tillage
- crop establishment
- crop variety selection
- plant protection products and practices
- fertilisation
- cover crops

Certification/control:
- Output is sold through normal marketing channels and there is therefore no certification or control

The research at Nagele was subsequently extended to additional sites in order to test the systems on the major soil types for arable farming in the Netherlands[24] (Box 4.31).

[23] Wijnands, 1997; Holland, Frampton, Cilgi and Wratten, 1994; Vereijken, 1989.

[24] Holland, Frampton, Cilgi and Wratten, 1994.

Box 4.31: Nagele, Vredepeel and Borgerswold (1986-)

Start date:
- 1986

Area covered:
- Two additional experimental farms were added to the Nagele site- area unknown

Crop coverage:
- Winter wheat, spring wheat, maize, sugar beet, field beans, dwarf beans, pasture, grass seed, peas, potatoes and carrots

Organisation behind the scheme:
- Research scheme- funding body not known

Objective:
- To extend the Dutch integrated systems research
- To develop an integrated strategy according to the soil types
- To reduce disease and soil fertility problems which had developed at Nagele

Scheme requirements:

This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions are being developed relating to:
- soil tillage
- crop establishment
- crop variety selection
- plant protection products and practices
- fertilisation
- cover crops

Certification/control:
- Output is sold through normal marketing channels and there is therefore no certification or control

4.3.11.2. Commercial systems

The use of crop protection products in the Netherlands was limited in 2000 to 50% of the average level used between 1985 and 1988. ICM techniques are particularly advanced in glasshouse growing and have been for some time.

The Environmentally Conscious Production (UBA) programme was initiated in the Netherlands in 1990. This coincided with a new generation of horticultural producers who saw the protection of the environment and production of, as far as possible, pesticide residue-free fruits and vegetables as important goals. It became clear that organic, or biological production as it is known in the Netherlands, could not meet the demand (both domestic and international) for more environmentally friendly products.

The UBA programme therefore has as its basic formula the desire to use biological methods of pest control in glasshouses wherever possible. Where there is severe pest infiltration, selective use of pesticides (as benign as possible) is permitted, but detailed records must be kept.

Environmentally friendly production has been most widespread in the Netherlands among glasshouse products destined for export (although there are also initiatives in the fruit, arable and field vegetable sectors). It is believed that all tomatoes, peppers and cucumbers are produced to UBA standards. Strict verification is required to ensure credibility. The authority co-ordinating UBA, now an independent foundation, sets out and updates production guidelines in consultation with producers, scientists, agricultural consultants and marketing organisations. This independent verification was further enhanced in 1996 through additional verification by SGS AgroControl, based in Switzerland.

4.3.12. Portugal

4.3.12.1. Commercial systems

Although the use of IPM techniques dates back to 1994 and are now subsidised under Regulation 1078/92, ICM schemes only currently exist in orchards. This suggests that ICM in Portugal would require financial support for widespread adoption.

4.3.13. Spain

4.3.13.1. Commercial systems

Although Integrated Farming is considered to be relatively new in Spain it is developing rapidly, supported to some extent by the EU agri-environmental measures (Regulation 1257/99 in continuation of past actions under Regulation 2078/92). A further reason for the rapid development is the fact that these techniques are now a condition of supply for many of Spain's important northern European markets (e.g. the UK, France and the Netherlands (the latter for re-export)).

Legislative responsibilities lie with the regional Governments and as a result rules differ and development has been variable. Box 4.32 provides an overall picture of the current situation by region and product.

Box 4.32: Development of IP schemes in Spain, by region

Andalucia	Strawberry, olive, rice, tomato, marrow, melon, water melon, citrus
Cataluña	Apple, pear, citrus, tomato citrus, olives, dry fruit, horticulture, potatoes, peaches, nectarines
Murcia	Citrus, fruit trees, lettuce, pimento, grape
Navarra	Asparagus, crucifers
Valencia	Citrus, tomato, grape, apricot, plum, peach, other vegetables

Source: EUREP

In some of the regions, for instance Cataluña, Integrated Production has expanded considerably since the introduction of Regulation 1257/99. A total of 39,000 hectares were managed according to Integrated Production techniques in 2001, compared to only 3,000 hectares in 2000. The goal of Integrated Production is the verifiable reduction of chemical use through the increased use of natural production methods, with the IOBC definition and guidelines forming the basis for protocols. Details are presented in Box 4.33.

Box 4.33: 'Cataluña' (Spain)

Start date:
- 1995

Area covered:
- 39,000 hectares

Crop coverage:
- Various crops as follows: 14,000 hectares are apples and pears, 7,000 hectares peaches/nectarines, citrus 1,000 hectares, olives 8,000 hectares, dry fruit 7,900 hectares and horticulture 650 hectares

Organisation behind the scheme:
- DARP Cataluña (Ministry of Agriculture) and Council of Generic Denomination of Integrated Production (DGPI)

Objective:
- To introduce practices that aim to reduce the contaminating effects of agricultural practices in soil and water through the verifiable reduction of chemical products, promoting the adoption of crop production methods that use natural resources and mechanisms as far as possible, and to assure a sustainable agriculture and the protection of natural resources

Scheme requirements:

Production has to comply with the requirements of detailed technical standards that have been laid down and approved for each product. All standards (22 in total) include the following elements:
- phytosanitary product application (including a positive list of products that can be used)
- irrigation
- fertilisation
- soil treatment

Certification/control:
- Unlike all other schemes in Spain, this one has a specific system of control set up and carried out by an independent body from the Ministry of Agriculture, the Conseil de la DGPI (established under Order 22/12/1992, with scope of competence set out in Order 24/2/1993). Farms that participate in the scheme have to register with this authority and are subject to regular controls to this effect. Complying products receive a specific logo ('Integrated production – Generic Denomination'). The whole control and logo system is run similarly to the denomination of specific origin schemes in the agricultural sector

The Integrated Production of citrus fruit is quite advanced in Spain, citrus being one of the key crops and one of the first sectors to adopt IFS/ICM approaches. Valencia, the key Spanish citrus region, has pioneered work in this field. Current Integrated Production of citrus in Valencia is in its fourth marketing year with almost 10,000 hectares under production. In addition, there is some Integrated Production of wine (currently in its second marketing year with 3,000 hectares) and also of table grapes (pilot project with 800 hectares). Two protocols have been developed for this production, one for citrus (in 1997 and modified in 2001) and one for wine (in 1999).

Amongst private initiatives, it is worth mentioning that set up by Novartis, which uses IPM to produce vegetables. Under this scheme, IPM systems can evolve through three stages of implementation. Stage one provides the framework and consists of seven basic rules for optimising crop protection inputs (such as the ability to be able to identify and monitor pests and adjust application decisions and product selection to pest and disease pressure). The second stage is the replacement phase during which inputs more appropriate to IPM are substituted for less appropriate inputs. This is achieved through specific prevention and observation methods (e.g. encouragement of natural antagonists, crop rotation, forecasting system, diagnostics, scouting) and intervention methods (chemical, biological, biotechnological, mechanical, optimisation of timing and dose, correct and safe application). The final phase involves continual evolution as new products and technology become available and new research is conducted.

Two case studies from Spain are presented in detail in Chapter 5 and Chapter6. Box 4.34 and Box 4.35 present outlines of these initiatives.

Box 4.34: Integrated citrus production in Valencia

Start date:
- 1997

Area covered:
- 9,560 hectares

Crop coverage:
- Citrus fruits

Organisation behind the scheme:
- Comunidad Valenciana (local autonomous region)

Objective:
- To produce high quality food while protecting the environment and human health

Scheme requirements:

There is a range of prescriptions which cover:
- irrigation
- fertilisation
- plant protection methods and products

Certification/control:
- Independent control and certification companies are responsible for ensuring that requirements have been met

Box 4.35: Integrated pome fruit in Cataluña

Start date:

- 1996

Area covered:

- 2,209 hectares

Crop coverage:

- Apples and pears

Organisation behind the scheme:

- DGPI (Council of the Integrated Production Generic Denomination)

Objectives:

- Obtain products of high quality
- Take care of the health of growers and consumers
- Apply environmentally safe production techniques
- Enhance agricultural ecosystem biodiversity, not disturbing the natural flora and fauna
- Minimise the use of agrochemicals (pesticides and fertilisers).
- Enhance the conservation function of agriculture (rural environment and landscape)
- Ensure the economic viability of the farms
- Carry out a correct management of natural resources

Scheme requirements:

There are regulations covering the following practices:

- planting material
- soils
- orchards characteristics
- orchard and fruit management
- fertilisation
- weed control and cover crop management
- irrigation
- pest and disease control
- biodiversity
- harvest
- quality rules
- spraying equipment
- field book
- post-harvest

Certification/control:

- Independent control and certification companies are responsible for ensuring that requirements have been met

4.3.14. Sweden

4.3.14.1. Research systems

Swedish research into Integrated Production systems was prompted by a shift in agricultural production objectives from higher production towards other, more environmentally conscious goals[25]. The Logården project is described in Box 4.36.

Box 4.36: Logården (1991-)

Start date:
- 1991

Area covered:
- 60 hectares

Crop coverage:
- Winter wheat, oats, peas, oilseed rape, field beans, vetch, rye, set-aside and triticale

Organisation behind the scheme:
- International Organisation of Biological and Integrated Control of Noxious Animals and Plants (IOBC) and EU Concerted action

Objective:
- To achieve a long term persistent, sustainable and productive food supply with minimum negative impacts on the environment
- to minimise external inputs

Scheme requirements:

This is a research project where actual prescriptions are in development and are therefore more vague than those in commercial systems. Prescriptions are being developed relating to:
- crop rotation
- plant protection products
- fertilisation
- soil tillage
- soil cover
- the management of ecological infrastructure

Certification/control:
- Output is sold through normal marketing channels so there is no certification or control

4.3.14.2. Commercial systems

Despite the lack of a clear definition in Sweden, many elements of ICM are already incorporated in conventional Swedish agriculture as a result of the high awareness of, and concern for, the environment. 'Swedish Seal' was introduced in 1995 and is a commercial ICM concept for cereals which incorporates 80,000 hectares (Box 4.37). Grön Produktion also introduced IP guidelines for field vegetables in 1999 (Box 4.38), and some food companies specify Integrated Production techniques in their contracts (for example, Swedish Nestlé). Danisco sugar insist on their sugar beet

[25] Helander, 1997.

growers following an ICM-type protocol (Box 4.39). There is also a Swedish network of demonstration farms.

Box 4.37: Swedish Seal

Start date:
- 1995

Area covered:
- 85,000 hectares

Crop coverage:
- Wheat, malting barley, barley, rye, oats

Organisation behind the scheme:
- Swedish Farmers' Crop and Supply Marketing Association (a co-operative of 61,000 farmers)

Objective:
- To grow sufficient quantities of high quality cereals at a reasonable price and to guide Swedish agriculture towards more sustainable production

Scheme requirements:
- Environmental check list to ensure adherence to Swedish environmental law
- Follow controls covering the production process including choice of seed, spraying and fertiliser restrictions, storage and transport
- No spraying of field margins
- Farm machinery must use Swedish environmental class 1 fuel
- Cadmium level in grain must be controlled

Certification/control:
- The scheme is independently audited at random on an annual basis

Box 4.38: Grön Produktion (Sweden)

Start date:
- 1991 as separate schemes, combined as one in 1998

Area covered:
- 40,505 hectares

Crop coverage:
- 6,570 hectares of vegetables crops including carrots and onions
- 27,600 hectares of potato
- 135 hectares of glasshouses production (tomatoes and cucumber)
- 2,200 hectares of apples
- 4,000 hectares of strawberries

Organisation behind the scheme:
- Swedish Growing Organisation

Objective:
- To grow sufficient quantities of high quality vegetables and fruit at a reasonable price and to guide Swedish agriculture towards more sustainable production

Scheme requirements:
- Environmental check list to ensure adherence to Swedish environmental law
- Follow controls covering the production process including choice of seed, spraying and fertiliser restrictions, storage and transport
- Attendance of ICM education programmes
- Farm machinery must use Swedish environmental class 1 fuel
- Special, more targeted requirements for individual crops

Certification/control:
- The scheme is independently audited at random on an annual basis

Box 4.39: Environmental management system for sugar beet growers (Sweden)

Start date:
- 1999

Area covered:
- 57,000 hectares

Crop coverage:
- Sugar beet

Organisation behind the scheme:
- Danisco sugar and the Swedish Growers Association

Objective:
- To guarantee that all sugar produced in Sweden conforms to a certain environmental level

Scheme requirements:

There are three main areas of requirements:
- general requirements (selection of varieties, rotational requirements, compliance with environmental laws, maintenance of equipment, storage of chemicals)
- fertiliser use (restrictions on type of fertiliser, where and how much can be used)
- pesticide use (restrictions on herbicide use in terms of quantity and where it can be applied)

Certification/control:
- Self-certification supplemented by random annual independent inspection of 50 growers

4.3.15. United Kingdom

4.3.15.1. Research systems

A range of research has been carried out in the UK that is now discontinued, although the lessons learnt have been incorporated into current research efforts and commercial schemes. This Chapter of the report is concerned only with current schemes and these historic research projects are therefore not considered. However, these projects are covered in Chapter 5 on the environmental impact of ICM schemes and in Chapter 6 on economic impact because they add to the body of evidence.

These early experiments referred to above were based on a field scale and could therefore be criticised as not being relevant at the farm scale. More commercial scale experiments were carried out under the LINK-IFS[26] research programme (as this is not a current project it is considered in Chapter 5 and Chapter6), the LIFE[27] (Less Intensive Farming and the Environment) trials, a case study covered in more detail in Chapter 5 and Chapter 6 (Box 4.40) and the Focus on Farming Practice (FOFP) Project, another case study in Chapter 5 and Chapter 6 (Box 4.41).

[26] Ogilvy, 2000; Bailey, Rehman, Park, Keatinge and Trantor, 1999; Holland, Frampton, Cilgi and Wratten, 1994; Ogilvy, 1993; Wall, 1992.

[27] Jordan, Hutcheon and Donaldson, 1997; Jordan, Hutcheon, Donaldson and Farmer, 1997; Holland, Frampton, Cilgi and Wratten, 1994; Jordan and Hutcheon, 1994; Ogilvy, 1993; Jordan, 1992; Jordan, Hutcheon and Perks, 1990.

Box 4.40: LIFE (1989-)

Start date:
- 1989

Area covered:
- 23 hectares

Crop coverage:
- Arable (cereals, break crops and set-aside)

Organisation behind the scheme:
- Research scheme

Objective:
- To provide fundamental information on the effects, interactions and ecological implications of an integrated farming systems approach for cereal growing in short rotations
- To develop and evaluate systems of less intensive production which are both economically and ecologically sound and sustainable in the long term

Scheme requirements:
There are management prescriptions relating to:
- crop varieties
- crop establishment
- soil management
- crop protection;
- fertilisation
- ecological infrastructure

Certification/control:
- Output is sold through normal marketing channels so there is no certification or control

Box 4.41: Focus on Farming Practice (FOFP) Project

Start date:
- 1989

Area covered:
- 125 hectares are covered by the trial itself. Three companies support the trial and between them they farm 40,000 hectares and advise on another 500,000 hectares

Crop coverage:
- Arable crops (winter wheat, beans, grass and set-aside)

Organisation behind the scheme:
- CWS Farms Group

Objective:
- To demonstrate that ordinary farmers can increase profitability, reduce off-farm pollution and increase biodiversity

Scheme requirements:
There are management prescriptions relating to:
- crop varieties
- crop establishment
- soil management
- crop protection
- fertilisation

Certification/control:
- Output is sold through normal marketing channels so there is no certification or control

4.3.15.2. Commercial systems

ICM is well developed in the UK and is well supported through LEAF and research and advisory bodies such as IACPA. The government and food companies are also considered supportive of ICM techniques. There are several schemes in operation:

- The Assured Combinable Crops Scheme (ACCS) implements many aspects of ICM and is an independently audited scheme for wheat, barley, oats, oilseeds and combinable pulses (Box 4.42). In 1998 50% of the grain harvest was from registered cereal farms (approximately a third of the total cereal farms).
- The Assured Produce Scheme (APS) is an equivalent scheme applied to fresh produce. In 2000 218,000 hectares of fresh produce were covered by the scheme (Box 4.43).
- The Guild of Conservation Grade Producers, whilst not technically an ICM scheme sets standards for growing a range of crops without certain pesticides and fertilisers (Box 4.44).
- Scottish Quality Cereals (SQC) is similar to ACCS, but applies in Scotland (Box 4.45).
- The Northern Irish Cereal Quality Assurance Scheme accounted for just under 50% of the Northern Irish cereal area in 1998.

Box 4.42: Assured Produce Scheme

Start date:

- 1991

Area covered:

- 218,000 hectares

Crop coverage:

- Beetroot, broad beans, broccoli, brussel sprouts, cabbage, carrots, cauliflower, cereriac, courgettes, squashes, pumpkins, green beans, onions, parsnips, peas, potatoes, radish, swedes, turnips, kohl-rabi, rhubarb, fennel, asparagus, bush fruit, cane fruit, culinary and pot herbs, celery, chicory, lettuce, leeks, runner beans, salad onions, strawberries, sweetcorn, top fruit, stone fruit, spinach, hops, tomatoes, mushrooms, cucumber, peppers, watercress, salad cress

Organisation behind the scheme:

- The National Farmers Union and multiple retailers[28]

Objective:

- To reassure consumers that fresh produce is grown in an environmentally sensitive manner, particularly with regard to pesticide use

Scheme requirements:

The protocols cover four key areas:

1. staff training and qualifications. All staff should receive appropriate training and retraining and should hold certificates of confidence where relevant
2. Integrated Crop Management. Integrated crop management systems embrace many husbandry disciplines including IPM, which relies on diligent and representative crop monitoring
3. pesticide use. There are no prescriptive listings as the UK government is the final word on pesticide safety. Growers must adhere to Government Codes of Practice
4. quality control. As farmers are now required to take certain responsibilities for their produce beyond the farm gate, traceability and quality assurance have become key features of primary food production. The protocols introduce the ‘Hazard Analysis and Critical Control Point’ (HACCP) concept into primary agriculture. The quality control of the final produce and determination of residue levels, if appropriate, remains the responsibility of all participants of the production process

Certification/control:

- producers are required to register annually and complete a self-assessment questionnaire on their compliance with statutory food safety requirements and the level of adoption of integrated crop management techniques and environmental best practice. The response to the questionnaire is subject to independent verification

[28] ASDA, CWS, Sainsburys, Marks and Spencer, Safeway, Somerfield and Waitrose.

Box 4.43: Assured Combinable Crops Scheme

Start date:
- 1998

Area covered:
- In excess of 2,000,000 hectares

Crop coverage:
- Wheat, barley, oats, oilseed rape, linseed, sunflowers, combinable peas, beans

Organisation behind the scheme:
- Industry wide initiative endorsed by the major buyers

Objective:
- To deliver traceability and assurance demanded by end users and to avoid a multitude of individual and differing schemes being imposed by end users

Scheme requirements:

There are four main areas of control:
- record keeping
- equipment maintenance
- crop production requirements
- post-harvest operations

Certification/control:
- Producers are required to complete a self-assessment questionnaire on their compliance with statutory food safety requirements and the level of adoption of ICM techniques and environmental best practice. The response to the questionnaire is subject to independent verification

Box 4.44: Guild of Conservation Grade Producers

Start date:
- 1985

Area covered:
- 4,306 hectares

Crop coverage:
- Oats, barley, wheat

Organisation behind the scheme:
- Producer run organisation

Objective:
- To produce cereals with fewer inputs

Scheme requirements:

There is a range of standards relating to *inter alia*:
- rotations and soil management
- manure and plant nutrient management
- weed, pest and disease control
- storage and transport

Certification/control:
- Annual inspection by Guild inspectors. 10% of farms receive a random second inspection annually

Box 4.45: Scottish Quality Cereals

Start date:
- 1994

Area covered:
- N/A

Crop coverage:
- Barley, wheat, oats, oilseed rape, triticale

Organisation behind the scheme:
- A limited company comprising members from: National Farmers' Union of Scotland; United Kingdom Agricultural Supply Trade Association (Scottish Council); Scottish Flour Millers' Association; Scottish Agricultural Organisation Society; Maltsters Association of Great Britain; The Scotch Whisky Association; The Malt Distillers Association of Scotland and The Scottish Agricultural College

Objective:
- To provide quality assurance and traceability of products to consumers and end users

Scheme requirements:

There are standards for:
- fertiliser use
- crop protection practice
- production and harvesting
- storage of crops
- sourcing and traceability

Certification/control:
- The Certification System is an independent, third party system for determining conformity with product standards. The Certification System requires examination of product, the production processes, the production environment, the distribution facilities and assessment of the quality management system. Acceptance after initial assessment is followed by ongoing surveillance. The Certification System is linked to a Certificate of approval and the SFQC Certification Mark

4.3.16. Summary

The above sub-sections have demonstrated the wide range of ICM-type systems that are currently in place in the EU[29]. On the basis of this review there are therefore at least 10 research-type systems and 32 commercial systems (although this latter figure is in reality expected to be significantly higher). Of these systems, 19 apply to arable crops, 17 to fruit, 20 to vegetables, 4 to grapes/wine and 3 to 'other crops', which include hops, medicinal plants, herbs, spice, ornamental plants and olives[30]. The weight of the systems examined here is therefore towards the vegetable and arable sector with fruit close behind. However, if the crop coverage is analysed according to whether the system is research or commercially driven, then a different picture emerges in that the majority of research protocols (10 from 13) relate to the arable sector whereas the majority of commercial protocols (34 from 50) relate to the fruit (16) and vegetable (18) sectors[31]. All the wine systems are commercial (see Figure 4.2).

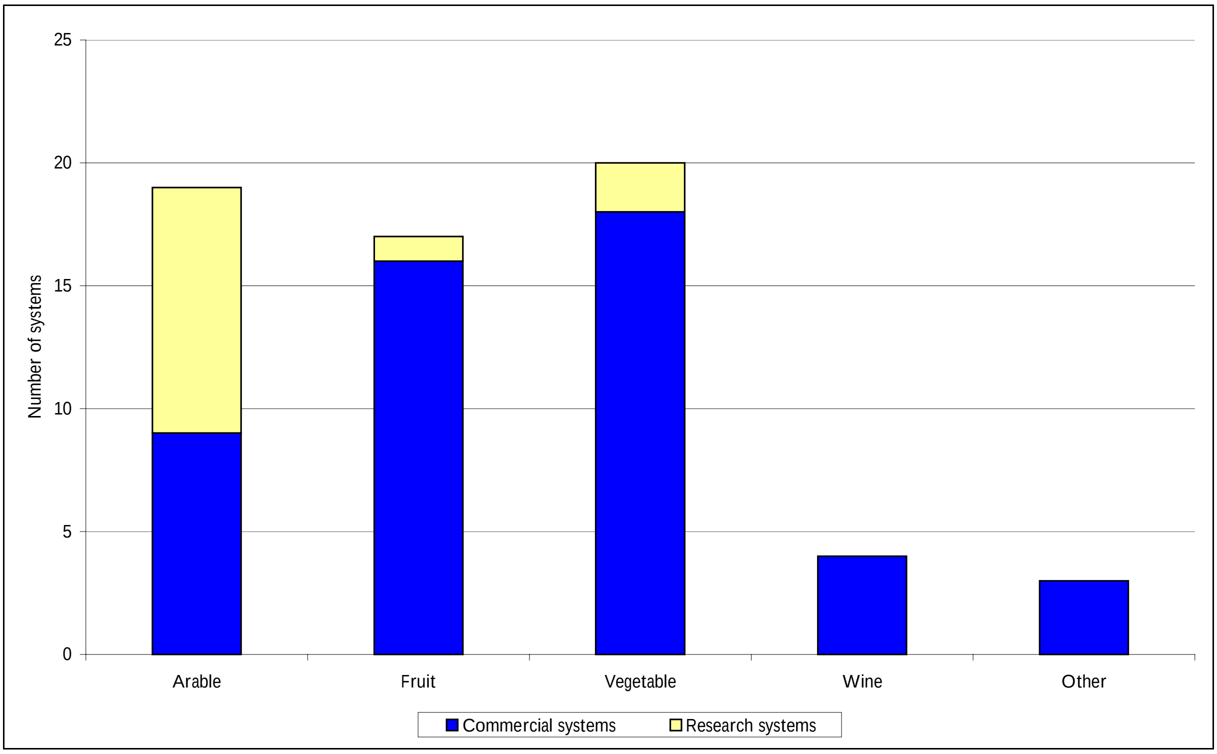


Figure 4.2: Distribution of crop sectors by type of system

Table 4.1 shows the relationship between schemes and protocols in order to demonstrate which elements of protocols are most frequently occurring (the protocol for Coop Italia- Prodotti con

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[29] It is worth stressing again that this is not intended to be a comprehensive list and the inclusion of certain systems and the exclusion of others does not suggest approval/disapproval and should not be interpreted in this way.

[30] There is clearly double counting in that many of the schemes apply to more than one of these cropping sectors.

[31] Including double counting where research is involved in more than one cropping sector.

Amore (Box 4.25) was not disclosed and was removed from the calculation, as was that for integrated fruit production in Schleswig-Holstein (Box 4.20)).

Table 4.1: Protocol elements and occurrence in schemes

Protocol elements	Proportion of schemes with protocol elements
Fertilisation strategies	95%
Plant protection prescriptions	93%
Soil husbandry/tillage restrictions	53%
Crop rotation/varieties	53%
Harvest and post-harvest restrictions	35%
Irrigation	33%
Record keeping	28%
Farm equipment	25%
Crop establishment	23%
Ecological infrastructure	18%
Quality	18%
Hygiene	15%
Soil cover/cover crops	15%
Education/training	10%
Traceability	10%

5. Environmental impact of ICM systems in the EU

This Chapter considers the environmental impact of ICM systems in the EU. Section 5.1 briefly explains the case study methodology used. Section 5.2 considers environmental impact from the research-based case studies, Section 5.3 from the commercially-based case studies and Section 5.4 considers environmental impact from ICM systems not used as case studies in this report, but where information is available.

5.1. Methodology

As requested in the TOR, the research undertaken has sought to quantify the environmental effects of ICM at the individual system level for 10 different systems with an emphasis on:

1. plant protection (including choice of plant varieties and effects on biodiversity) as a priority.

Where applicable, the research has also sought to evaluate the effects on

2. nitrogen;
3. erosion/soil protection;
4. irrigation;
5. waste management; and,
6. crop rotation.

The scope and timescale of this project could not permit Agra CEAS Consulting to carry out primary research on the environmental impact of ICM, such us by setting up and examining specifically designed experimental systems. This aspect of the project therefore had to be conducted using research and data on systems already established. It was thus primarily based on an extensive review of available research and field trials, carried out in each country by the respective members of our team, all of whom are established experts in this field. Where feasible and/or appropriate, the review was supplemented by limited field research.

Trade driven, i.e. commercial ICM projects are considered to be of more interest in the context of this report than research systems. Ideally the case studies would have all been commercial systems. However, by definition, commercial systems are not established in order to assess environmental impact and are therefore less useful in this respect than research systems. The ten case studies selected thus represent a balance between the desire to examine commercial systems and the need for the environmental impact to have been assessed. It was also important to examine systems concerned with a range of crops including arable systems, fruit and vegetable production and viticulture. In order to meet these criteria, ten systems were selected for examination in five Member States as follows:

France: Boigneville project and Champagne production. The Boigneville project represents long term research into arable ICM systems for which environmental impact data is available. ICM techniques are reported to be used extensively in French viticulture, best documented in the Champagne region, and this therefore represents an important case study. Environmental impact analysis is on-going, but early indications of some results have been made available for this research. The Biogneville case study was carried out by means of a literature review of published and unpublished information and also drew on the researcher's personal knowledge of the system. The Champagne case study was compiled through a literature review and telephone interviews.

Germany: the Lautenbach project and the AKIL project. Lautenbach is one of the longest established research sites into an arable ICM system in Europe and therefore has a good range of environmental data. AKIL represents a well established commercial arable ICM system. Both the Lautenbach and the AKIL case studies were compiled through an extensive literature review of both published and unpublished information. The researcher's in-depth knowledge of the systems was also drawn upon.

Italy: the CAMAR project and Chianti production. CAMAR is a well established arable ICM research system and Chianti represents a successful commercial viticulture system, although environmental impact assessments have yet to be carried out thoroughly. The CAMAR case study was compiled following a literature review and telephone interviews, whilst the Chianti case study required face to face discussions, in addition to a literature review and some telephone interviews.

Spain: citrus production in Valencia and pome fruit production in Cataluña. These two fruit production systems are arguably the most commercial of all the case studies selected and have been established for a reasonable length of time. However, being commercial, environmental impact data is not as comprehensive as for some other case studies. The Spanish case studies were compiled through a mixture of literature review and telephone interviews.

UK: Less Intensive Farming and the Environment (LIFE) and Focus on Farming Practice (FOFP). The UK has a long history of ICM research and these two arable research projects are the two longest running farm scale examples and between them provide a good range of environmental impact data. Both case studies followed extensive literature reviews of published and unpublished material and were compiled by researchers involved in the projects who could draw on their experience and thorough knowledge of the systems.

The case studies therefore provide five research and five commercial systems and six arable, two fruit and two viticulture systems.

It should be stressed that, with the exception of the Spanish systems, the above are defined by those working with them as Integrated Farming Systems rather than Integrated Crop Management Systems. However, although the difference between IFS and ICM is straightforward in theory, in practice, the terms are often used interchangeably. None of the systems considered have livestock enterprises (with the exception of some AKIL farms) and perhaps therefore should more correctly be termed ICM rather than IFS.

Each system was examined according to performance with respect to six areas: water, soil, air, biodiversity, landscape and economics. Because the information in this report is drawn from case studies which have all been established for different purposes it is not possible to select a consistent range of indicators against which to measure performance. In order to present as consistent a picture as possible the report focuses on the following by area of impact, although where additional information is available this has also been included:

Water: pesticide leaching; nitrate leaching.
Soil: pesticide residues; nutrient balance/soil nitrogen; soil erosion.
Air: air quality; spray drift.
Biodiversity: soil fauna; plant species.
Landscape: ecological infrastructure.
Economics: production costs; premium availability; yield; revenue; profitability.

As far as possible the information included has been quantitative, although in many cases this information is not available. Where this is the case, qualitative comments have been made. In the absence of even qualitative information, protocol restrictions have been linked to expected impact.

5.2. Environmental impact from research ICM systems

5.2.1. Boigneville (France)

Background:

This experimental project started in 1993 and covers the following crops: winter wheat, durum wheat, oilseed rape, spring barley and peas.

Protocol (for full details see Appendix 1):

- **Fertilisation:** apply only after on-site observation to determine need (400 hours of observation time are allowed per year). There are no guidelines on maximum fertiliser use, although the intention is that by observing and matching application to need, use will be reduced.
- **Plant protection:** as above.
- **Management guidelines:** the IOBC definitions and references are used as a guideline to management.

Box 5.1: Impact on environment, biodiversity and landscape (Boigneville)

Water

- Leaching of nitrates. The integrated system (I) actually presents a higher risk of potential nitrogen loss compared to the conventional system (H+) (42 kg N/ha and 27 kg N/ha respectively), which is largely due to the fact that the latter uses intermediate crops. However, in none of the 4 systems examined the relevant indicator used by the INDIGO method (I_N) scores particularly well (always less than 7, which is the reference value). The difference between the integrated and conventional systems is minimised when the latter apply ploughing and have no intermediate crops (which is the most regular cropping practice in the region). Similarly, in simplified calculations which do not take into account the intermediate crops factor, the integrated system has a better environmental performance than the conventional system.
- Leaching of pesticides. In the integrated system the quantity of used pesticides is only 55% of the conventional system. Furthermore the relevant pesticides indicator (I_{PHY}) that was used in the context of the INDIGO method took into account not just the quantity of products used but also their active ingredients, and the characteristics of the environment to which they were applied (e.g. leaching risk). In the case of all crops, the indicator was better under the integrated system than under the conventional, even more so where the conventional system was ploughed and had no cover crops. The favourable indicator values under the integrated system are primarily due to the reduced use of pesticides. A lower overall application is expected to have reduced the likelihood of pesticide residues in the soil and hence the risk of leaching.

Soil

- Soil physical and chemical properties. A complete data set is not available. However, in all cases the relevant indicator used by the INDIGO method was lower in the integrated system than the reference conventional value. Cropping area and total soil cover have an effect on the value of the indicator, notably a negative effect in the case of monocultures and small areas.
- Soil biological properties. This was evaluated in terms of the microbial biomass and the diversity of symbiotic organisms (*endomycorhize, lumbridicidae*). In all cases, there was a net advantage of the integrated system over the conventional alternative. Microbial biomass was 27-34% higher in the case of the integrated system, the biomass of *lumbridicidae* was higher (22.6 g/m^2 in the integrated system compared to 11.9 g/m^2 in the conventional) and the presence of *endomycorhize* was also higher under the integrated system, although less than in a comparable organic farm (1%, 15% and 40% respectively).

Air

- Air quality. No measurements of ammonium-N fractions or other N-volatile were made. The two relevant indicators used by the INDIGO method (I_N and I_{PHY}) include an 'air' component in their estimation, but results are not yet available.

Biodiversity

- Flora. Biodiveristy of wild and/or native plant species was not analysed in the project due to the relatively small size of the cropped plots.
- Microarthropode groups. Four groups were studied and their population density was found to be systematically higher in the case of the integrated system.
- Arthropode groups. There appears to be no significant advantage in the integrated system, either in terms of population density or diversity.

Landscape

- No specific analysis was conducted in this respect. Although a 'landscape' indicator exists in the INDIGO method, this was not applied in the project due to the relatively small scale of the cropped plots.

5.2.2. The Lautenbach project (Germany)

Background:

A total of 17 years of data comparing IFS and conventional systems. Crops covered are winter wheat, spring wheat, spring barley, oats, sugar beet, peas, beans, faba beans.

Protocol (for full details see Appendix 10):

- **Soil tillage:** non-inversion.
- **Drilling:** cereals larger inter-row spacing and double rows, faba beans as a row crop.
- **Cultivars:** resistant/tolerant cultivars, alternating varieties.
- **Fertilisation:** N reduced by 25% below recommended rates, slow release if possible, P_2O_2 33% below conventional. Distributed in rows for row crops.
- **Soil cover:** undersowing where possible, green manure prior to spring crops.
- **Plant protection:** lowest effective rates, only unleachable compounds with lowest side effects on non-target organisms. Partial, spot, strip or band treatment where possible. Equipment fitted with low drift nozzles.
- **Ecological infrastructure:** mandatory 4% of farmland as hedgerow/shelterbelts, shrubs and woodland, native vegetation on field margins, attractant flowering strips and less intensive headland treatments.

Box 5.2: Impact on environment, biodiversity and landscape (Lautenbach)

Water

- Leaching of nitrates. The ICM system uses on average 17% less nitrogen than the conventional system which reduces the risk of leaching. The efficacy of N-inputs was also greater in the ICM system reflecting a better up-take of supplied fertiliser leaving lower residues in the soil (although this was not quantified). Measurement of nitrate in soil strongly suggested that ICM contributes to a reduction of leachable N-fractions at sites with deep water tables. At shallow water tables the difference between the systems diminishes rapidly.
- Pesticide leaching. The protocol stipulates that only non-leachable compounds are to be used and as such it is expected that there will be a reduction in the risk of leaching.

Soil

- Soil physical properties. There were demonstrated, although not quantified, improvements in aggregate stability, infiltration rates, proportion of micro pores and bulk density in deeper soil layers under ICM compared to conventional. This led to improved infiltration and percolation and visible contributed to a reduction in soil erosion and run-off.

Air

- Air quality. No measurements of ammonium-N fractions or other N-volatile were made. Annual calibration of spray equipment and the use of low-drift nozzles (mandated in the protocol) reduce spray drift. It is assumed that CO_2 emissions are lower from non-inversion tillage (an ICM technique) than from ploughing.

Biodiversity

- Earthworm species. Although there was little difference in the number of earthworm species that could be attributed to the different systems, earthworm biomass was significantly higher in the ICM system (25.2 g/m^2 *c.f.* 4.4 g/m^2) and this resulted from higher numbers of Enchytraeids (24 individuals per litre of soil *c.f.* 15).
- Gamasid and Collembola species, caribid beetles, Diptera. Densities were significantly higher in the ICM system. Gamasid: 37 individuals per litre of soil *c.f.* 15; Collembola: 46 *c.f.* 29; species number of Dipterous larvae: 57 *c.f.* 51; density of Dipterous larvae: 3,625 individuals/m^2 *c.f.* 3,525; Carabid species: 190 per trap belonging to 43 species *c.f.* 110 from 37 species.
- Nematodes. There are higher saprophytic and predatory nematodes in the ICM system.
- Wild plant species. There was little difference between the systems in terms of numbers of different species, although the density of wild plants was higher in the ICM system. Four (non-threatened) species were present in the ICM system, but not in the conventional system. There were 17 species of trees and shrubs in the Lautenbach hedges.

Landscape

- 9 km of linear habitats were established. However, native floral communities were not re-established.

5.2.3. The CAMAR project (Italy)

Background:

Started in 1992, 15 hectares, plus an additional 6 for demonstration. Crops covered are sunflower, spring wheat, spring barley, field beans, sorghum and maize.

Protocol (for full details see Appendix 5):

- **Cultivars:** resistant/tolerant varieties.
- **Drilling:** non-inversion.
- **Fertilisation:** N application limited to between 35% and 70% of 'typical' application, depending on crop, P_2O_2 reduced by 30%. Decisions made according to nutrient balance.
- **Irrigation:** none used.
- **Soil cover:** undersowing when possible.

- **Plant protection:** seed dressing reduced by 50%. Weed control carried out by non-chemical methods where possible and chemicals are only used when necessary. Rates cut by 35-70% and compounds with lowest side effects used.
- **Ecological infrastructure:** mandatory 5% of farmland must be hedgerows, shrubs and woodland, native vegetation, field margins or natural vegetation strips.

Box 5.3: Impact on environment, biodiversity and landscape (CAMAR)

Water

- Leaching of pesticides. Pesticides (where necessary) are selected to be appropriate for the environment and are the least harmful, least volatile and least persistent available, therefore minimising problems of leaching. The maintenance of soil cover for a high proportion of the year also minimises leaching problems. The environmental exposure to pesticides in water decreased by 61% in the integrated system between 1992 and 1999.
- Leaching of nitrates. Integrated nutrient management techniques are used to reduce the risk of water contamination from both artificial fertilisers and organic manure. The maintenance of soil cover for a high proportion of the year also minimises the risk of leaching. There is a 44% reduction in the application of N on integrated compared to conventional systems for wheat. The reductions for barley and sunflower are 30% and 50% respectively.
- Irrigation. No irrigation is used.

Soil

- Soil pesticide residues. In the integrated system the environmental exposure to pesticides in soil increased by 9% between 1992 and 1999, but this remains 71% below the targeted maximum. This reduces the risk of contamination in the soil.
- Soil organic matter content. The ratio of input to output should be greater than 1. In 1999 it was 1.10 in the integrated system representing an increase of 51% since 1992.
- Soil nutrient balance. The ratio of inputs to output for K (based on crop requirements and environmental sensitivity should be below 1. In 1999 the ratio for the integrated system was 0. For P the ratio should be between 1.0 and 1.4, in 1999 it was 1.39 in the integrated system, which represents a decrease of 21% since 1992.
- Soil erosion. The soil cover index increased in the integrated system by 59% between 1992 and 1999 to 0.54. This indicator should be above 0.5.

Air

- Air quality. No volatile fertilisers (such as ammonia) are used and the minimisation of pesticide use reduces the risk of spray drift. The environmental exposure to pesticides in air decreased in the integrated system by 73% between 1992 and 1999.

Biodiversity

- Number of species. There were 17% more species in the integrated system compared to the conventional system, but 26% less than in the organic system. The use of field margins and a thick network of hedges help increase biodiversity through habitat provision. The plant species diversity index increased by 40% in the integrated system between 1992 and 1999. The species richness index was 12% higher in the integrated system in 1999.

Landscape

- Use of minimal tillage helps prevent soil erosion which preserves the landscape. The mandatory 5% of farmland for ecological infrastructure also makes a contribution to landscape. In 1999, 6.3% of the land under integrated production was covered by ecological infrastructure, an increase of 5% since 1992.

5.2.4. Focus on Farming Practice (UK)

Background:

This project was initiated in 1989. 125 hectares are covered by the trial itself. Three companies support the trial and between them they farm 40,000 hectares and advise on another 500,000 hectares. Crops grown are winter wheat and beans within an arable rotation.

Protocol (for full details see Appendix 9):

- **Cultivars:** high yielding varieties with good disease resistance, standing power and vigour to compete with weeds.
- **Drilling:** stubbles are cultivated immediately post-harvest to stimulate residue decomposition and weed volunteer germination. The crop is subsequently established through direct drilling.
- **Crop Protection:** a threshold based approach is used for weed control. A range of strategies are being examined including the use of low dose contact only materials, spring applied, to suppress weeds and combined techniques of low dose herbicide in conjunction with mechanical weeding. Products which are selective, of low leachability, volatility, mammalian toxicity and persistence, are preferred. Diagnostics and early warning systems are used for disease control and, where disease pressure is likely to be high, a low dose of fungicide is applied. Threshold levels are observed for the application of essential pesticide.
- **Fertilisation:** soil Mineral Nitrogen levels are established and inform optimal application rate and timing.

Box 5.4: Impact on environment, biodiversity and landscape (FOFP)

Water

- Leaching of pesticides. Not measured directly, but active ingredient input was halved in the ICM system, including those active ingredients known to be more mobile and therefore likely to enter water courses. Active ingredient used in winter wheat was on average 36% lower in the ICM system between 1994 and 2000. Total herbicide use was 21% lower and fungicide use 62% in the ICM system over the same period.
- Leaching of nitrates. Nitrate loss was 32% lower under the ICM system.

Soil

- Soil nitrogen. Not measured directly, but nitrogen usage was 8% lower on average in the ICM system between 1994 and 2000. Soil Mineral Nitrogen levels were between 5 kg/ha and 25 kg/ha lower indicating better targeting of nitrogen to crop demand.
- Earthworm population. Both earthworm number and biomass were greater in the ICM system (by 27% and 94% respectively).

Air

- No data available.

Biodiversity

- Polyphagous predators. Greater numbers were present in autumn in crops within the ICM system than within the conventional system. This was particularly associated with less intensive tillage practices.
- Bird numbers. There were 73% less bird numbers (five recorded species) in the conventional system compared to the ICM system.

Landscape

- No data available.

5.2.5. The LIFE project (UK)

Background:

Twenty-three hectares comparing conventional with two IFS versions – (i) IFS for 'feed' quality crops and (ii) IFS for 'bread/milling' quality crops. Crops covered: winter wheat; winter and spring oilseed rape, winter oats, winter and spring barley; spring beans.

Protocol (for full details see Appendix 10):

- **Cultivars:** selected primarily for disease resistance.
- **Drilling:** later using one-pass non-inversion tillage.
- **Fertilisation:** P and K crop demands met through the use of rotations and by incorporating residues and replacing that removed by crop off take. Soil analysis is used to determine N demand in order to achieve targeted yields.
- **Plant protection:** fungicide and pesticide inputs involve rational manipulation of crop husbandry practices to achieve an optimum balance between crop, cultivar and sowing date that allow optimal decision making processes to be implemented. Weed control strategies use rotations and are targeted to need in specific fields.
- **Ecological infrastructure:** maintenance, enhancement and creation of field margins were used to encourage biodiversity and in particular natural enemies of key pests.

Box 5.5: Impact on environment, biodiversity and landscape (LIFE)

Water

- Leaching of pesticides. Isoproturon applied at recommended rate to conventional system and half rate to ICM system. Isoproturon only detected in drain water from conventional system. Insecticide application was 75% lower in the ICM system between 1995 and 2000, fungicide 68% lower, herbicide 41%. No plant growth regulators were used in the ICM system and the use of other agrochemicals was 44% lower in the ICM system.
- Leaching of nitrates. Total oxidised nitrogen emissions in drain water discharges showed average loading losses were 82% lower for ICM as opposed to conventional systems in winter 1995/1996 and 87% lower in winter 1996/97. Soluble phosphate loading was 81% lower in discharges from the ICM system over the sampling period. When averaged annually between 1995 and 2000, nitrate concentrations were between 12% and 28% higher in the conventional system compared to the ICM system.

Soil

- Soil nitrogen. On average, 28% less nitrogen fertiliser was applied to the ICM system between 1995 and 2000, although levels of nitrogen in the soil were higher than in the conventional system. Soil nitrogen reserves were more depleted in spring in the conventional system.
- Soil erosion. Significantly and substantially reduced in the ICM system and consequent sediment associated phosphate loss was minimised. Run-off reduced by 48%, sediment loss by 68%, total phosphate loss by 81% (available phosphate loss by 73%), total oxidised nitrogen loss from soil reduced by 94% and soluble phosphate in soil by 78%.
- Earthworm population. Both earthworm number and biomass (by 36%) were greater in the ICM system.
- Soil biological activity. 52-65% greater degradation of cellulose material in the ICM system implies greater biological activity.

Air

- No data available.

Biodiversity

- Polyphagous predators. Greater numbers were present in autumn in crops within the ICM system than within the conventional system.
- Earthworm species. Individual species differed in their response. Most showed higher densities in the ICM system (92%, 56%, 52%, 41%, 25%, 12%, 8%, 4% higher) although one species density was 14% lower under ICM. Species diversity was consistently greater in the ICM system.

Landscape

- Hedgerows and trees cover 4.7% of the ICM system. With grass tracks and sown field margins, the 'ecological reservoir' is 8.67% of the total area. This reduces the monotony of the farmed landscape.

5.3. Environmental impact from commercial ICM systems

5.3.1. Champagne (France)

Background:

The interprofessional organisation for Champagne wine (CIVC) has been very active in promoting the application of integrated production practices in the region since the early 1990s, which are adopted by a growing number of winegrowers. In this study, data from 2 farm holdings, which apply conventional systems of plant protection and treatment are compared against four farm holdings that follow integrated protection principles.

This example is not a scheme as such, but rather a concerted effort to promote the application of integrated production principles in the Champagne wine industry. A growing number of winegrowers express interest in these production methods, precisely because they see them as an investment in the product's image, an opportunity both to promote product quality and to differentiate their product from competition. Thus commercial farms experiment with the application of some of these principles at their own initiative and at their own rate, under the support of CICV.

These 'experiments' are still at an early stage, having so far concentrated mainly on the monitored application of various pesticides. In this study, data from 2 farm holdings, which apply conventional systems of plant protection and treatment, are compared against four farm holdings that follow integrated protection principles.

Protocol (for full details see Appendix 2):
The examined systems do not follow a definite scheme as such but rather guidelines that wine growers can apply at their discretion and under the guidance of the CIVC. These guidelines are in accordance with the FARRE Charter on Vines and the IOBC definitions.

Box 5.6: Impact on environment, biodiversity and landscape (Champagne)

Water

- Leaching of pesticides. The integrated farms had notably better results than the conventional farms in terms of the pesticides indicator (I_{PHY}) used in the context of the applied INDIGO method (see Boigneville, France, Section 5.2.1). This was primarily due to less use of plant protection products and the improved efficacy of applications. Results between the 4 integrated farms varied depending on the pesticide application. However, it must be noted that only one of the examined integrated farms (farm F) had an environmental performance that was above the recommended guidelines (I_{PHY} > 7). A lower application of pesticide products is expected to have reduced the likelihood of leaching.

Soil

- Soil pesticide residues. No analysis was undertaken. However, the lower application of pesticide mentioned above is likely to result in lower residues in the soil.

Air

- No data available.

Biodiversity

- No data available.

Landscape

- No data available.

5.3.2. The AKIL project (Germany)

Background:

The AKIL scheme began in 1988 and covers the following crops: winter wheat, spring wheat, winter barley, spring barley, rye, oats, oilseed rape, sugar beet, sunflower, potato, dried peas, silage maize, sweetcorn, grass clover, set-aside. 5,000 hectares are covered between 50 farms.

Protocol (for full details see Appendix 4):

- **Cultivars:** these must match breeder recommendations and must meet processing quality parameters. They should also have the highest genetic tolerance against at least one of the main three crop diseases. There are also rotational requirements.
- **Drilling:** non-inversion tillage is the recommended tillage regime.
- **Fertilisation:** at least part of the fertilisation requirement should be met through organic or green manure and soil nutrient levels should be assessed and maintained. The highest input efficacy must be achieved using the most suitable techniques, e.g. band and row fertilisation, nitrification inhibitors, slow-release compounds, etc.. Growth regulators are not permitted.
- **Plant protection:** any direct control decision must be based on the economic value (losses) of the damage induced by the targeted noxious species (the threshold principles of IPM). Mechanical weed control should be implemented or combined with low-dose chemical compounds where possible. Biological control is the preferred option over standard insecticides. Active ingredients must be non-leachable, of the lowest available toxicity and must be reduced as far as possible. Spray machinery must also be well maintained to reduce drift.
- **Ecological infrastructure:** 3-5% of the total farm area should be non-crop vegetation. At least 100 metres per field should be allocated to natural habitats, flowering field margins or equivalents.

Box 5.7: Impact on environment, biodiversity and landscape (AKIL)

Water

- Leaching of pesticides. AKIL farmers have adopted less intensive pesticide input strategies. In some cases no pesticides at all are used and where they are considered necessary, reduced rates are applied. This will have reduced the likelihood of pesticide residues in the soil and hence the risk of leaching.
- Leaching of nitrates. There was a significant reduction in leaching and subsequently the potential for pollution of groundwater for AKIL farms.

Soil

- Soil erosion. Green cover, reduced soil tillage and established shelter belts both around and within fields reduce erosion. Comparisons between ploughed fields and those subject to non-inversion tillage showed a reduction of 80% in terms of soil erosion and 60% in terms of water fractions in the later case.
- Nutrient balances. An N surplus of 15.8 kg/ha was recorded for an area of 984 hectares averaged between 1993 and 1995. Soil NO_3 content fell from 75 kg N/ha in 1991 to 29 kg N/ha in 1996. Input:output ratio for Phosphorus showed 2.4 kg P_2O_2/ha/year, potassium was 27 kg K_2O/ha/year. Heavy metals are prohibited under the protocol.
- Soil pesticide residues. The protocol stipulates reductions in the treated area and in the toxicity of chemicals used. It is therefore likely that the risk of residues building up in the soil is reduced.

Air

- Spray drift. Regular maintenance of spraying equipment, as mandated in the protocol, will reduce the likelihood of spray drift.

Biodiversity

- Species range. By creating different habitat structures the range of biodiversity was increased under the ICM system. 260 wild plant species were recorded.
- Carabid species. 92% of the total number of identified species (39) were found after the introduction of ICM whereas 64% were found under conventional management.
- Staphylinids, spiders and mite species. The density of these species in pitfall traps was higher under ICM by 21%, 246% and 139% respectively.

Landscape

- Although the rotational requirements reduce the monotony of the landscape, boundary feature management was the most effective ICM component with regard to landscape. Shelter belts of multiple species composition, including shrubs and trees as well as sub-vegetation, provided the essential shelter and habitat for different faunal groups, including the required predators and parasites of pest species. These hosted birds and small mammals and functioned as wind breaks.

5.3.3. Chianti (Italy)

Background:

The Chianti Classico scheme began in 2000. The area farmed according to integrated methods is not known, but the whole region covers 70,000 hectares.

Protocol (for full details see Appendix 4):

- **Soil tillage:** this is only permitted between March and June. Non-inversion tillage is encouraged.
- **Fertilisation:** this is carried out according to a five year plan based on soil analysis. The use of volatile fertilisers such as ammonia is precluded and there are upper limits on the use of N, P_2O_2 and K_2. It is recommended that organic manure comprises up to 2% of organic matter.

- **Plant protection:** only registered, non-leaching compounds with the lowest side effects on beneficial species and low persistence are permitted. There is a limited number of treatments per pest per year. Weed control must use strip treatment with low side effects and low persistence products at reduced rates.
- **Irrigation:** not generally allowed, but is permitted in the first three years following vine establishment.
- **Cover crops:** vegetal greening maintained over the whole area from the fourth year of vine establishment or used in rotation with ploughing, one side of row green, the other ploughed.
- **Machinery maintenance:** more regular maintenance of spray equipment and use of low pressure nozzles is encouraged to reduce the likelihood of spray drift.

Box 5.8: Impact on environment, biodiversity and landscape (Chianti)

Water

- Leaching of pesticides. The maintenance of soil cover by total or rotational greening of vines is likely to reduce the leaching of pesticide residues from soil particles. The protocol restrictions on pesticides in terms of non-leaching compounds and use of chemicals with low impact on non-target organisms is likely to have also reduced the risk of pesticide leaching. The maximum number of annual pesticide treatments under the integrated system is 15 per single pest or disease compared to a typical 20-25 applications of Cu and S under conventional management.
- Leaching of nitrates. A 25% reduction in the application of N has resulted in reduced risk of leaching. There has been a recovery in species that had previously disappeared or been in decline.

Soil

- Soil erosion. The maximisation of green cover anchors the soil and helps prevent fluvial erosion.
- Soil quality. The reduction of intensive ploughing and the use of non-inversion or reduced tillage contributes to maintaining a biologically active top soil.
- Soil nitrogen. No nitrate soil contamination has been found in any of the farms. Soil chemical analysis helps match application with demand leading to a better nitrogen balance. There was a 25% reduction in the application of nitrogen.
- Soil pesticide residues. Although there is no quantitative data, the reduced use of pesticides and the favouring of low toxicity products will reduce the risk of pesticide residues being present in the soil. The maximum number of annual pesticide treatments under the integrated system is 15 per single pest or disease compared to a typical 20-25 applications of Cu and S under conventional management.

Air

- Air quality. More attention is paid under the protocol to the efficiency of spray equipment under ICM in order to maximise operator and environmental safety. Low pressure treatments are often used which can significantly reduce spray drift. No volatile fertilisers (such as ammonia) are used.

Biodiversity

- Range of species. Although vines make up the most part of the total farm area in all cases, other crops are grown and the vines are themselves surrounded by woodlands. In addition to the provision of these habitats, there are also hedgerows, field margins, etc., the extent of which has increased (approximately doubled) partly through Regulation 2078/92.

Landscape

- The holistic approach used in integrated farming makes it easier to support the regional agro-tourism programme aimed at preserving agricultural landscapes through the maintenance of rural communities.

5.3.4. Citrus production (Spain)

Background:

This scheme began in 1997 and there are now 9,560 hectares of citrus fruit.

Protocol (for full details see Appendix 7):

- **Soil tillage:** chemical soil sterilisation is not permitted. A one year fallow is recommended before replanting and residues of the previous crop must be eliminated.
- **Planting material:** there are restrictions on varieties and certified seed must be used.
- **Tree and fruit management:** use of plant growth regulators is limited to naturally occurring chemicals and there is a maximum limit. Pruning is compulsory every two years.
- **Fertilisation:** a fertiliser plan is compulsory and is based on a 5 yearly soil analysis, leaf analysis every 2 years and groundwater analysis every 3 years. Application of N must not exceed 200 kg/ha for drip irrigated plots and 240 kg/ha for flood irrigation plots. P_2O_5 is limited to 80 kg/ha and K_2O to 160 kg/ha.
- **Plant protection:** only permitted pesticides are used, some of which have additional restrictions relating to the number of applications per year and the timing of application. Integrated Pest Management is the concept underpinning plant protection.
- **Irrigation:** there are maximum water doses of 6,000 m^3/ha for drip irrigation and 7,000 m^3/ha for flooding irrigation. There are also controls on water quality.
- **Cover crops:** mandatory over autumn and winter.
- **Machinery maintenance:** sprayers are inspected every three years and there are recommendations on calibration for usage.
- **Harvest and post-harvest handling:** the optimum harvest time is recommended for variety. The fruit is 'identity preserved' from non-ICM production. Post-harvest chemical treatment is avoided if possible (although is not mandated). Finally, fruit must enter the packing house on the day it is picked.

Box 5.9: Impact on environment, biodiversity and landscape (Citrus production)

Water

- Leaching of pesticides. Although this is not perceived as a problem, the guidelines include measures for reducing pesticide input. Coupled with the reduction in irrigation water of 20%, this is likely to reduce the risk of nitrate leaching.
- Leaching of nitrates. Maximum nitrogen doses are established under the guidelines and these result in a reduction in the amount of nitrogen applied of between 15% and 35%. As above, the reduction in irrigation water is likely to reduce the risk of nitrate leaching.
- Irrigation. There is a 20% reduction in the use of irrigation water based on adherence to the guidelines.

Soil

- Soil nutrient balance. This is done every five years and the results relating to the nitrate concentration will be used to adjust the recommended nitrogen doses.
- Soil erosion. Cultivation equipment that destroys soil structure is banned. It is obligatory to allow a spontaneous green cover to develop from mid-autumn to the end of winter to anchor the soil thus reducing the risk of erosion.

Air

- Spray drift. This is minimised through three yearly checks on machinery, calibration recommendations and prohibitions on spraying above a certain wind speed.

Biodiversity

- Species variety. The use of green cover over winter provides a habitat for many species.

Landscape

- No data available.

5.3.5. Pome fruit production (Spain)

Background:

This scheme began in 1996. There are now 2,209 hectares of apples and pears.

Protocol (for full details see Appendix 8):

- **Soil tillage:** an examination of the soil is a prerequisite to planting. Chemical soil sterilisation is not permitted.
- **Planting material:** there are restrictions on varieties and certified seed must be used.
- **Tree and fruit management:** use of plant growth regulators is banned. Prophylactic use of fruit finishing, colouring or ripening agents is not permitted.
- **Fertilisation:** a fertiliser plan is compulsory and is based on a 4 yearly soil analysis, an annual leaf analysis and groundwater analysis every two years. Fertilisation is limited to 70-100 fertiliser units per year and fertilisers containing heavy metals are banned.
- **Plant protection:** only permitted pesticides are used, some of which have additional restrictions relating to the number of applications per year and the timing of application. Integrated Pest Management is the concept underpinning plant protection.
- **Irrigation:** an irrigation programme is compulsory.
- **Cover crops:** at least 70% of the alleyway surface must be covered.
- **Machinery maintenance:** sprayers are inspected every two years and there are recommendations on calibration for usage.

- **Harvest and post-harvest handling:** the optimum harvest time is recommended for variety. The fruit is 'identity preserved' from non-ICM production Post-harvest chemical treatment is forbidden for fruit marketed before January and where treatments are permitted, residues must be half the legally permitted maximums.

Box 5.10: Impact on environment, biodiversity and landscape (Pome fruit production)

Water
• Leaching of pesticides. Pesticide applications are reduced through the use of IPM to minimise leaching. Soil, leaf and groundwater analysis allows adjustments to doses to be made. The use of calibrated equipment also helps avoid over application. • Leaching of nitrates. Nitrate doses are adjusted to match application needs. Calibrated equipment is also used. Soil, leaf and groundwater analysis allows adjustments to doses to be made and a fertilisation plan is established taking into account the age of the orchard, soil type and expected yield. • Irrigation. Although there is no upper limit on irrigation, water must be matched to crop requirements and soil characteristics (texture and drainage). An irrigation programme is also compulsory.
Soil
• Soil erosion. Maintenance of green cover in at least 70% of the alleyways and the contour planting of trees minimise the likelihood of erosion. • Soil contamination. Poor quality water (with high salt and sodium content) is prohibited, as is the use of fertilisers containing heavy metals.
Air
• Spray drift. Sprayer inspections and calibration recommendations reduce the likelihood of spray drift.
Biodiversity
• Natural enemies. The numbers of natural enemies increase through the use of biological control. However, some experimental work has demonstrated that the number of pests increase when using biological control.
Landscape
• No data available.

5.4. Environmental impact from non-case study ICM systems

This section is concerned with the environmental impact of a range of European research into ICM and ICM-type systems. The information provided in this Section is not as detailed as the information provided under the case studies, but does provide supplementary evidence. Because all the systems covered in this Section are research systems, it is not possible to provide any degree of detail with respect to the system protocols. This is because in most cases the research was established, at least in part, to develop and refine protocols. Early research, especially in the UK, was also primarily concerned with reducing plant protection product input rather than examining systems holistically.

5.4.1. Lanxade (France)

Background:

This research investigated the integrated production of apples. It was started in 1996 and comprises 1 hectare dedicated to apples from a total of 70 hectares).

Protocol:

Because this is a research system, the protocol is under investigation and development. The main areas of focus are:

- integrated phytosanitary protection (reduce chemical inputs);
- controlled irrigation, soil maintenance and fertilisation.

Box 5.11: Impact on environment, biodiversity and landscape (Lanxade)

Water • Leaching of pesticides. There has been a reduction in the use of plant protection products, although data are not yet available to quantify this. This reduction is likely to have reduced the risk of leaching into water courses. • Leaching of nitrates. As above, there has been a (not yet quantified) reduction in the use of fertiliser, and as such the risk of leaching is likely to have been reduced.
Soil • Soil pesticide residues. In so far as there has been a reduction in the use of pesticide, it is likely that the risk of residues building up in the soil is also reduced. • Soil nitrogen. The reductions in the use of fertiliser will lesson the risk of an excess of nutrients in the soil.
Air • No data available.
Biodiversity • No data available.
Landscape • No data available.

5.4.2. INTEX (Germany)

Background:

The INTEX project ran from 1989 to 1997 and investigated the integrated production of an arable rotation (winter wheat, oilseed rape, winter barley and field beans) on a 94 hectare site.

Protocol:

Prescriptions were developed relating to:
- soil tillage;
- crop establishment;
- crop varieties;
- fertilisation;
- plant protection; and,
- ecological infrastructure.

Box 5.12: Impact on environment, biodiversity and landscape (INTEX)

Water
• Leaching of nitrates. Application of nitrogenous fertiliser was reduced by 23% and leachable nitrate was slightly reduced in the integrated system.
Soil
• Soil pesticide residues. There were reductions in the application of herbicides (53%), growth regulators (100%), fungicides (73%) and insecticides (54%). This is likely to have reduced the risk of residues building up in the soil. • Soil nitrogen. The reduction in use of nitrogenous fertiliser is likely to have reduced the risk of a nutrient build up in the soil.
Air
• No data available.
Biodiversity
• A qualitative investigation suggested that biodiversity was improved, although there is no quantitative data available to support this.
Landscape
• No data available.

5.4.3. Nagele (Netherlands)

Background:

The trial at Nagele began in 1979, covers 72 hectares and is concerned with the following crops: winter wheat, sugar beet, pasture, potatoes and carrot. Conventional, integrated and organic systems are compared.

Protocol:

This experiment investigated and refined prescriptions relating to:

- soil tillage;
- crop establishment;
- crop variety selection;
- plant protection products and practices;
- fertilisation; and,
- cover crops.

Box 5.13: Impact on environment, biodiversity and landscape (Nagele)

Water

- Leaching of pesticides. Annual pesticide input (in kilograms of active ingredients per hectare[32]) was 65% lower in the integrated system, 90% if nematicides are included. It is therefore likely that the leaching of pesticides into water courses is also reduced.
- Leaching of nitrates. Nitrate-nitrogen levels in run-off in the integrated system were 80% of those in the conventional system and those in the organic systems were only 30% of the conventional level.

Soil

- Soil pesticide residues. As above, the reduction in use of pesticides is likely to reduce the risk of residues building up in the soil.
- Soil nitrogen. Post-harvest cover crops successfully recovered mineralised nitrogen in the integrated and organic systems.

Air

- No data available.

Biodiversity

- No data available.

Landscape

- No data available.

5.4.4. Nagele, Vredepeel and Borgerswold (Netherlands)

Background:

In 1986, two more sites were added to the trial at Nagele in order to assess the performance of the system under different conditions. The crops grown are: winter wheat, spring wheat, maize, sugar beet, field beans, dwarf beans, pasture, grass seed, peas, potatoes and carrot. Conventional, integrated and organic systems are compared.

Protocol:

This experiment investigated and refined prescriptions relating to:

- soil tillage;
- crop establishment;
- crop variety selection;
- plant protection products and practices;
- fertilisation; and,
- cover crops.

[32] This measure has been criticised because some relatively benign chemicals (such as copper and sulphur used in organic apple growing) weigh more per hectare of use than synthesised chemicals. However, it is difficult to derive other ways of measuring the impact of pesticide applications.

Box 5.14: Impact on environment, biodiversity and landscape (Nagele, Vredepeel and Borgerswold)

Water
• Leaching of pesticides. Pesticide use in the integrated system was reduced by 50-65% across the three sites (excluding nematicides) and 85-95% including nematicides. Herbicide use was reduced by 60-75%, fungicide use by 50-65%. These reductions are likely to have reduced the risk of leaching into water courses. • Leaching of nitrates. The need for artificial nitrogen was removed. This reduction is likely to have reduced the risk of leaching into water courses.
Soil
• Soil pesticide residues. In so far as there has been a reduction in the use of plant protection products (see above), it is likely that the risk of residues building up in the soil is also reduced.
Air
• No data available.
Biodiversity
• No data available.
Landscape
• No data available.

5.4.5. Logården (Sweden)

Background:

This experiment began in 1991. It comprises an investigation into integrated production techniques for winter wheat, oats, peas, oilseed rape, field beans, vetch, rye, set-aside and triticale and covers 60 hectares.

Protocol:

Prescriptions are being developed relating to:

- crop rotation;
- plant protection products;
- fertilisation;
- soil tillage;
- soil cover; and,
- the management of ecological infrastructure.

Box 5.15: Impact on environment, biodiversity and landscape (Logården)

Water

- Leaching of pesticides. The integrated system uses around 8% of the insecticides (dosage and number of treatments) used in the conventional system, 14% of the fungicides and 72% of the herbicides. This is likely to reduce the likelihood of leaching.

Soil

- Available nitrogen reserves. These are most favourable in the integrated system at an average of 42 kg N/ha; the conventional system performs marginally better than the organic system (49 Kg N/ha *c.f.* 53 Kg N/ha).
- Nitrogen balance. This is most favourable for the organic system (79% N utilised); the integrated system shows the worst performance (60% N utilised) with the conventional system in the middle (75% N utilised).
- Soil pesticide residues. The reduction in the use of pesticides is likely to lessen the risk of a build up of soil residues.
- Soil erosion. The integrated system provides the best level of soil cover index (81%); the organic and conventional systems had cover indices of 76% and 79% respectively. This is likely to help anchor the soil and thus reduce the risk of erosion.

Air

- No data available.

Biodiversity

- Ecological infrastructure. 6% of the arable land is used for hedges, green belts and pathways.

Landscape

- No data available.

5.4.6. Boxworth (UK)

Background:

ICM-type research in the UK started with the Boxworth project[33] carried out by ADAS between 1981 and 1988. This project investigated an arable rotation of winter wheat and suitable break crops. It is perhaps more correctly described as an investigation into the impact of pesticide use, but is included because it represents an early UK example of what would later become ICM research.

Protocol:

The main focus of this project was to investigate the long term impact of different pesticide regimes and the main restriction therefore related to this requirement.

[33] Cooper, 1990; Greig-Smith, 1990; Jarvis, 1990; Greig-Smith, Frampton and Hardy, 1990; Bowerman, 1993; Holland, Frampton, Cilgi and Wratten (1994).

Box 5.16: Impact on environment, biodiversity and landscape (Boxworth)

Water
• Leaching of pesticides. In the systems where there was a reduction in plant protection products it is likely that there was also a reduction in the risk of leaching.
Soil
• Soil pesticide residues. Again, where there was a reduction in the use of plant protection products it is likely that the risk of residues building up in the soil was also reduced.
Air
• No data available.
Biodiversity
• Predators and parasitoids density. These were 50% lower in the conventional system than in either the integrated or 'supervised' systems[34];
• Lethal effects of pesticide use. This level was only detected in wood mice. There was no evidence to suggest that bird breeding performance was affected by pesticides. Rabbits and wild plants were similarly unaffected.
Landscape
• No data available.

5.4.7. SCARAB/TALISMAN (UK)

Background:

The Boxworth project was followed by two different trials: SCARAB[35] (Seeking Confirmation About Results At Boxworth) and TALISMAN[36] (Towards A Low Input System Minimising Agrochemicals and Nitrogen). Although the emphasis is on minimising the use of plant protection products, these trials, along with the Boxworth project, can be considered as early ICM research and are included for this reason. SCARAB investigated the same arable system (winter wheat with break crops) as Boxworth and was concerned with attempting to replicate the Boxworth results under different conditions. TALISMAN focused on the economic rather than the environmental impacts and there were therefore no environmental results.

Protocol:

As with the Boxworth project there was no protocol as such. The main intention was to investigate the impact of reduced pesticide applications.

[34] The supervised system used the concept of economic thresholds. The theory behind this approach is that using plant protection products is only profitable once a certain threshold of damage has been reached, i.e. it is more cost effective to suffer a limited amount of pest or weed damage than to buy and apply plant protection products.

[35] MAFF, 1998; Holland, Frampton, Cilgi and Wratten, 1994; Bowerman, 1993; Ogilvy, 1993; Cooper, 1990; Greig-Smith and Griffin, 1990.

[36] MAFF, 1998; Holland, Frampton, Cilgi and Wratten, 1994; Perks, 1994; Ogilvy, 1993; Greig-Smith and Griffin, 1990; Jordan, Hutcheon and Perks, 1990.

Box 5.17: Impact on environment, biodiversity and landscape (SCARAB/TALISMAN)

Water
- Leaching of pesticides. Use of insecticides, molluscicides and nematicides was eliminated and herbicide use was reduced by 43%, fungicides by 54%. In these systems it is likely that there was also a reduction in the risk of leaching.

Soil
- Soil pesticide residues. Again, where there was a reduction in the use of plant protection products it is likely that the risk of residues building up in the soil was also reduced.

Air
- No data available.

Biodiversity
- No data available.

Landscape
- No data available.

5.4.8. LINK- IFS (UK)

Background:

LINK-IFS ran from 1992 to 1997 and had the objectives of integrating the latest research results into production systems which optimised the use of inputs compatible with production needs, profitability and environmental concerns and then comparing these systems to conventional production. It was concerned with an arable rotation which comprised cereals, break crops and set-aside.

Protocol:

Prescriptions were developed relating to:

- crop establishment;
- crop varieties;
- soil tillage;
- plant protection products;
- fertilisation;
- cover crops; and,
- ecological infrastructure.

Box 5.18: Impact on environment, biodiversity and landscape (LINK-IFS)

Water

- Leaching of pesticides. Pesticide use was reduced on the integrated systems by 30% in cost terms and 18% in active ingredient terms. It is likely that this reduction reduced the risk of leaching.
- Leaching of nitrates. Nitrogen input was reduced by 20% and there was a small decrease in leachable soil mineral nitrogen in the integrated systems as a result.

Soil

- Soil pesticide residues. Again, where there was a reduction in the use of plant protection products it is likely that the risk of residues building up in the soil was also reduced.

Air

- No data available.

Biodiversity

- No data available.

Landscape

- No data available.

6. Economic impact of ICM systems in the EU

This Chapter focus on the economic impact of ICM systems in the EU. The main aim of this report was to examine the environmental impact and this Chapter is therefore more of an overview. It should also be mentioned that many of the research systems were designed to investigate the environmental impact rather than the economic impact of ICM and as a result, economic evaluations are more cursory where they exist.

6.1. Economic impact from research ICM systems

6.1.1. Boigneville (France)

Background:

This experimental project started in 1993 and covers the following crops: winter wheat, durum wheat, oilseed rape, spring barley and peas.

Box 6.1: Economic impact (Boigneville)

Costs
• Production costs are systematically lower in the case of the integrated system. Within this overall pattern, there is a marked reduction in seed, fertiliser and plant protection product costs in the integrated system, but this is balanced by increases in labour, machinery maintenance and (in some case) fuel costs.
Marketing/labelling/premium
• No premium is available for integrated produce. It should be noted that in any case, the possibility to label products of integrated production under this term is not legally available in France for the moment.
Yields
• Yields were systematically lower in the integrated system, with the exception of oilseed rape which had identical yields under the two systems.
Revenue
• Revenue was lower for the integrated system.
Profitability
• In terms of gross margins per hectare, the integrated system is very close to the conventional system. However, if product prices continue to decline, and with yield improvements and further cost reductions following technical progress, the integrated system can deliver more favourable results in the medium to long term.

6.1.2. The Lautenbach project (Germany)

Background:

A total of 17 years of data comparing IFS and conventional systems. Crops covered are winter wheat, spring wheat, spring barley, oats, sugar beet, peas, beans, faba beans.

Box 6.2: Economic impact (Lautenbach)

Costs • The costs of off-farm inputs were reduced in the ICM system, most significantly for plant protection chemicals, followed by fuel and fertilisers. Higher efficiency in soil tillage reduced the depreciation value of farm machinery.
Marketing/labelling/premium • No premium was available for ICM produce.
Yields • Yields were approximately the same.
Revenue • Revenue remained the same as for conventional production.
Profitability • The reduction in off-farm input costs was balanced by increases elsewhere. Coupled with revenue stability, profitability is therefore approximately comparable, however, risk is increased.

6.1.3. The CAMAR project (Italy)

Background:

Started in 1992, 15 hectares, plus an additional 6 for demonstration. Crops covered are sunflower, spring wheat, spring barley, field beans, sorghum and maize.

Box 6.3: Economic impact (CAMAR)

Costs • No data available.
Marketing/labelling/premium • No premium was available for ICM produce.
Yields • No data available.
Revenue • No data available.
Profitability • Average net surplus (revenue minus variable costs) between 1993 and 1999 was €243 for the integrated system and €220 for the conventional system. However, the actual surplus varied from year to year.

6.1.4. Focus on Farming Practice (UK)

Background:

This project was initiated in 1989. 125 hectares are covered by the trial itself. Three companies support the trial and between them they farm 40,000 hectares and advise on another 500,000 hectares. Crops grown are winter wheat and beans within an arable rotation.

Box 6.4: Economic impact (FOFP)

Costs
• Average cultivation and input application costs were 17% lower in the ICM system between 1994 and 2000.
Marketing/labelling/premium
• No special marketing channels, no label and no premium.
Yields
• Average yields were lower in the ICM system (on average by 7.5% for winter wheat between 1994 and 2000, 16% for silage), although were higher in certain years.
Revenue
• Lower yields and no premium results in lower revenue.
Profitability
• The whole farm margin was 2.5% lower under ICM, although this was highly variable and in some years was higher than under conventional management.

6.1.5. The LIFE project (UK)

Background:

23 hectares comparing conventional with two IFS versions – (i) IFS for 'feed' quality crops and (ii) IFS for 'bread/milling' quality crops. Crops covered: winter wheat; winter and spring oilseed rape, winter oats, winter and spring barley; spring beans.

Box 6.5: Economic impact (LIFE)

Costs
• Variable costs were reduced under the ICM systems by 27% and 5% for milling quality and feed quality systems respectively between 1995 and 2000. • Operation costs were 23% and 9% lower for milling and feed quality ICM systems respectively between 1995 and 2000.
Marketing/labelling/premium
• No special marketing channels, no label and no premium.
Yields
• Average yields for all crops were slightly higher for the milling quality ICM system compared to the conventional control (9%), but slightly lower for the feed quality ICM system (13%) between 1995 and 2000.
Revenue
• Revenue from straw sales was 80% and 32% lower for ICM milling and feed quality systems respectively between 1995 and 2000. However, total revenue was 5% and 7% lower for milling and feed quality respectively.
Profitability
• Gross margin was, on average, slightly higher for the milling quality ICM system (6%), but slightly lower for the feed quality variant (8%). Net farm margin was more substantially enhanced for the milling quality ICM system (35%), but was lower for the feed quality system (7%). Interestingly, if grain prices were to decrease, the competitive position of the ICM systems would improve.

6.2. Economic impact from commercial ICM systems

6.2.1. Champagne (France)

Background:

There are currently no economic data available. However, some comments can be made on the economic impact and these are addressed in Box 6.6

Box 6.6: Economic impact (Champagne)

Costs • The intensity of treatment was greatly reduced in the integrated systems, which would imply a reduction in production cost. However, this is expected to be rather small and may also have to be balanced against higher labour costs. The difference in production costs between the conventional and integrated systems is expected to be minimal due to the required intensity of input application in this sector.
Marketing/labelling/premium • There is no logo or price premium. It should be noted that in any case, the possibility to label products of integrated production under this term is not legally available in France for the moment. However, according to the CICV and the participating farmers, the key motivation for enrolling in these efforts is the market potential of the products. Farmers invest in these efforts in anticipation of a proper marketing scheme and price premium developing in the medium to long term.
Yields • No information is available, although yields are likely to be comparable given that revenue and costs are approximately the same.
Revenue • Revenue remained the same as for conventional production.
Profitability • As explained above, the primary motivation of participating producers has been the potential marketing benefit for the final product. Should labelling become available as an option producers are only likely to follow the scheme if it attracts a premium.

6.2.2. The AKIL project (Germany)

Background:

The AKIL scheme began in 1988 and covers the following crops: winter wheat, spring wheat, winter barley, spring barley, rye, oats, oilseed rape, sugar beet, sunflower, potato, dried peas, silage maize, sweetcorn, grass clover, set-aside. 5,000 hectares are covered between 50 farms.

Box 6.7: Economic impact (AKIL)

Costs
• The costs of off-farm inputs were reduced in the ICM system, most significantly for plant protection chemicals, followed by fuel and fertilisers. Higher efficiency in soil tillage reduced the depreciation value of farm machinery.
Marketing/labelling/premium
• No premium is currently available for ICM produce, although there was a premium initially.
Yields
• Yields were approximately the same.
Revenue
• Revenue remained the same as for conventional production.
Profitability
• The reduction in off-farm input costs was balanced by increases elsewhere. Coupled with revenue stability, profitability is therefore approximately comparable, however, risk is increased.

6.2.3. Chianti (Italy)

Background:

The Chianti Classico scheme began in 2000. The area farmed according to integrated methods is not known, but the whole region covers 70,000 hectares.

Box 6.8: Economic impact (Chianti)

Costs
• Production costs for bottled Chianti Classico are 250% higher than for generic not bottled Chianti.
Marketing/labelling/premium
• Production from the integrated system can be sold under the Chianti Classico label and therefore attracts a premium over not bottled Chianti.
Yields
• Approximately the same.
Revenue
• Production of Chianti Classico in bottles results in a revenue 119% higher than not bottled Chianti.
Profitability
• The margin (revenue minus production and bottling costs) is 75% higher for Chianti Classico in bottles.

6.2.4. Citrus production (Spain)

Background:

This scheme began in 1997 and there are now 9,560 hectares of citrus fruit.

Box 6.9: Economic impact (Citrus production)

Costs

- There is a reduction in pesticide and fertiliser costs, but an increase in other costs such as pest monitoring and soil, foliar and residual analysis. Although growers often do not consider their own time as a cost, they are aware that ICM requires more management time to undertake some tasks such as pest and natural enemies population monitoring. Overall costs are felt by growers and advisors to be higher under ICM than conventional production, however, a full economic study has not been undertaken.

Marketing/labelling/premium

- There is no premium in the market for ICM citrus fruits. However, it does make it easier to sell to multiple retailers and there is therefore a marketing advantage. This situation is specially important for exports.

Yields

- The yields under ICM are comparable to those under conventional production.

Revenue

- Revenue is approximately the same as yields are comparable and there is no premium. However, the increased certainty of sale is likely to reduce revenue risk.

Profitability

- With a similar revenue, but higher production costs, it is likely that profitability is slightly reduced for the ICM system. However, the risk of not finding a marketing channnel for perishable goods is reduced which could, in certain circumstances, increase overall returns.

6.2.5. Pome fruit production (Spain)

Background:

This scheme began in 1996. There are now 2,209 hectares of apples and pears.

Box 6.10: Economic impact (Pome fruit production)

Costs
• There is a reduction in some costs such as pesticide and fertiliser, but an increase in other costs such as management time and soil, foliar and residual analysis. On balance, costs are felt by growers and advisors to be higher under ICM than conventional production, however, a full economic study has not been undertaken.
Marketing/labelling/premium
• There is no premium in the market for ICM pome fruits, however, it does make it easier to sell to multiple retailers and there is therefore a marketing advantage.
Yields
• ICM yields are comparable to those achieved under conventional production.
Revenue
• Based on similar yields and no marketing premium, revenue should be comparable between the systems. There may be a higher degree of income certainty as ICM confers a marketing advantage.
Profitability
• With a similar revenue, but higher production costs, it is likely that profitability is slightly reduced for the ICM system. However, the risk of not finding a marketing channnel for perishable goods is reduced which could, in certain circumstances, increase overall returns.

6.3. Economic impact from non-case study ICM systems

6.3.1. Lanxade (France)

Background:

This research project, which is run by the interprofessional organisation Ctifl, investigated the integrated production of apples. It started in 1996 and comprises 1 hectare from a total of 70 hectares of this experimental site[37]. Results are, however, currently in the process of being collated by Ctifl.

[37] The site also runs field trials for the integrated production of glasshouse fruit and vegetables.

Box 6.11: Economic impact (Lanxade)

Costs • There has been a reduction in input costs due to lower (or more rational) input use, although on the other hand there has been an increase in labour costs due to the increased requirements in both time and the human skills needed for an effective application of Integrated Production methods. Exact data are currently unknown and the first findings will be published in the course of 2002/03 in the Ctifl review
Marketing/labelling/premium • No premium is available for integrated produce. It should be noted that in any case, the possibility to label products of integrated production under this term is not legally available in France for the moment
Yields • No data available.
Revenue • No data available.
Profitability • No data available.

6.3.2. INTEX (Germany)

Background:

The INTEX project ran from 1989 to 1997 and investigated the integrated production of an arable rotation (winter wheat, oilseed rape, winter barley and field beans) on a 94 hectare site.

Box 6.12: Economic impact (INTEX)

Costs • No data available.
Marketing/labelling/premium • Output is sold through normal marketing channels so there is no premium.
Yields • Yields in the integrated system were lower.
Revenue • The revenue is lower in the integrated system as a result of lower yields and the lack of a premium for output.
Profitability • Profitability was lower in the integrated system as a result of reduced yields and lengthened rotations to include legumes.

6.3.3. Nagele (Netherlands)

Background:

The trial at Nagele began in 1979, covers 72 hectares and is concerned with the following crops: winter wheat, sugar beet, pasture, potatoes and carrot. Conventional, integrated and organic systems are compared.

Box 6.13: Economic impact (Nagele)

Costs • Variable costs are lower in the integrated system.
Marketing/labelling/premium • Output is sold through normal marketing channels so there is no premium
Yields • Yields in the integrated system were lower.
Revenue • The revenue is around 6% lower in the integrated system as yields are lower and there is no premium for output.
Profitability • As a result of the trade off between variable cost and revenue, the farm net surplus was slightly higher in the integrated system compared to the conventional system although the conventional system outperformed the integrated one for some crops. The organic system produced the lowest net surplus as a result of high labour costs.

6.3.4. Nagele, Vredepeel and Borgerswold (Netherlands)

Background:

In 1986, two more sites were added to the trial at Nagele in order to assess the performance of the system under different conditions. The crops grown are: winter wheat, spring wheat, maize, sugar beet, field beans, dwarf beans, pasture, grass seed, peas, potatoes and carrot. Conventional, integrated and organic systems are compared.

Box 6.14: Economic impact (Nagele, Vredepeel and Borgerswold)

Costs • No data available
Marketing/labelling/premium • Output is sold through normal marketing channels so there is no premium
Yields • No data available
Revenue • No data available
Profitability • The gross margins were dependent on the integrated rotations selected and integrated gross margin was comparable to conventional at Nagele. Gross margins at Borgerswold were higher in the integrated system while the differences noted at Vredepeel were attributed to the crop rotation rather than the management strategy.

6.3.5. Logården (Sweden)

Background:

This experiment began in 1991. It comprises an investigation into integrated production techniques for winter wheat, oats, peas, oilseed rape, field beans, vetch, rye, set-aside and triticale and covers 60 hectares.

Box 6.15: Economic impact (Logården)

Costs • No data available
Marketing/labelling/premium • Output is sold through normal marketing channels so there is no premium
Yields • Average yields for the conventional and integrated systems are comparable, although yields for the organic system are considerably lower;
Revenue • No data available, but should be equivalent as there is no premium and yields are comparable.
Profitability • Conventional systems are the most profitable; organic systems are only profitable within the framework of the CAP (Sweden joined the EU during the course of the research) and integrated systems failed to return a profit, even within the framework of the CAP.

6.3.6. Boxworth (UK)

Background:

ICM-type research in the UK started with the Boxworth project[38] carried out by ADAS between 1981 and 1988. This project investigated an arable rotation of winter wheat and suitable break crops. It is perhaps more correctly described as an investigation into the impact of pesticide use, but is included because it represents an early UK example of what would later become ICM research.

Box 6.16: Economic impact (Boxworth)

Costs • No data available
Marketing/labelling/premium • This was a resaerch scheme and any output would have been sold through normal marketing channels with no premium.
Yields • The conventional system usually provided the highest yields, the integrated system produced the lowest yields.
Revenue • No information available, but on the basis of the above should have been lower.
Profitability • The supervised system was at least as profitable as the conventional system and the integrated system was the least profitable.

[38] Cooper, 1990; Greig-Smith, 1990; Jarvis, 1990; Greig-Smith, Frampton and Hardy, 1990; Bowerman, 1993; Holland, Frampton, Cilgi and Wratten (1994).

6.3.7. SCARAB/TALSIMAN (UK)

Background:

The Boxworth project was followed by two different trials: SCARAB[39] (Seeking Confirmation About Results At Boxworth) and TALISMAN[40] (Towards A Low Input System Minimising Agrochemicals and Nitrogen). Although the emphasis is on minimising the use of plant protection products, these trials, along with the Boxworth project, can be considered as early ICM research and are included for this reason. SCARAB investigated the same arable system (winter wheat with break crops) as Boxworth and was concerned with attempting to replicate the Boxworth results under different conditions. TALISMAN focused exclusively on the economic rather than the environmental impacts.

Box 6.17: Economic impact (SCARAB/TALISMAN)

Costs
• No data available.
Marketing/labelling/premium
• This was a resaerch scheme and any output would have been sold through normal marketing channels with no premium.
Yields
• The low input pesticide regime in the SCARAB project resulted in an average yield reduction of 12%. • The reduced input systems in TALISMAN resulted in a range of yield reductions for integrated systems (see notes).
Revenue
• No data available, but on the basis of the above, revenue should have been reduced.
Profitability
• The SCARAB low input pesticide regime had a gross margin 6.4% below the conventional system. • The TALISMAN low input regime resulted in a slightly higher gross margin (2%) than under the conventional system (see note).

Notes:

- a 50% reduction in nitrogen resulted in yield reductions of around 12% in integrated systems which led to a 10% reduction in gross margin;
- a 50% reduction in herbicides also resulted in yield reduction, but gross margin was often higher due to the savings made;
- a 68% reduction in fungicide use resulted in gross margin increases; and,
- a 73% reduction in insecticide use had little impact on yield or profitability.

6.3.8. LINK-IFS (UK)

Background:

LINK-IFS ran from 1992 to 1997 and had the objectives of integrating the latest research results into production systems which optimised the use of inputs compatible with production needs, profitability

[39] MAFF, 1998; Holland, Frampton, Cilgi and Wratten, 1994; Bowerman, 1993; Ogilvy, 1993; Cooper, 1990; Greig-Smith and Griffin, 1990.

[40] MAFF, 1998; Holland, Frampton, Cilgi and Wratten, 1994; Perks, 1994; Ogilvy, 1993; Greig-Smith and Griffin, 1990; Jordan, Hutcheon and Perks, 1990.

and environmental concerns and then comparing these systems to conventional production. It was concerned with an arable rotation which comprised cereals, break crops and set-aside.

Box 6.18: Economic impact (LINK-IFS)

Costs
• Production costs were lower in the integrated system, although management costs were higher by 50%.
Marketing/labelling/premium
• This was a resaerch scheme and any output would have been sold through normal marketing channels with no premium.
Yields
• Yields were lower in the integrated system.
Revenue
• No data available.
Profitability
• Integrated systems were almost as economically viable as conventional systems (2% reduction in average production margin), although there were significant variations according to site.

7. Conclusion

7.1. Background and definition of ICM

Integrated Crop Management can be thought of as a concept defining ideals and goals which then have to be 'translated' into definitions which can be implemented by producers. At a basic level, the concept is simply to integrate the management of individual crops in order to benefit from the interactions between them. In many respects integrating crop production strategies to provide benefits such as pest control, maintain soil fertility, etc. is an ancient technique. However, ICM also takes advantage of modern technology to improve on the system.

The International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC) redefined and published a conceptual framework for Integrated Production, within which ICM fits. In addition to this, a common codex for integrated farming was developed in January 2001 by the members of the European Initiative for Sustainable Development in Agriculture (EISA)[41]. More specific, 'working definitions' are used in order to translate the concept of ICM into practicable schemes.

A wide range of fairly similar 'working definitions' are used by various institutions throughout the EU. From these definitions, 'environmental sensitivity' emerges as the key component of ICM systems. This is closely followed by 'economic viability', reflecting the fact that food production is a business and hence must be profitable to exist. 'Modern techniques' are an important component and this reflects a key point of difference in comparison to organic farming which can be thought of, at least in principle if not always in practice, as rejecting modern techniques such as artificial inputs.

Although the concept of 'whole farm approach' is fairly prominent, two of the definitions that include this component are actually IFS or Integrated Production definitions. It is considered that it is possible to have an ICM approach within a single crop, although clearly some definitions suggest that multiple crops are often grown together in an integrated manner. In terms of two of the three least prevalent concepts, 'long term strategy', may be considered inherent in the use of 'integrated', but its inclusion is felt to be important as a reflection of the importance of the use of rotations in minimising weed and pest problems. 'Efficiency of input use' is not implied in the same manner, although it could be argued that rational producers would seek efficient input use in any case.

Finally, comments on food quality and consumer requirements in the definitions are not widespread. Whilst it is probably taken for granted that food produced through ICM techniques is of high quality, its inclusion in definitions might be a useful marketing aid.

[41] EISA was founded by various national research bodies promoting integrated farming to allow them to intensify their efforts on a pan-European basis.

Based on the above, one might summarise the main aspects of current ICM definitions by saying that it is an environmentally sensitive and economically viable production system or process which uses the latest available techniques to produce high quality food in an efficient manner.

Placing ICM on the scale between conventional production (as defined by the Codes of Good Agricultural Practice) and organic production is not straightforward. Although initial impressions would suggest that ICM is fairly closely aligned to organic production, their origins are very different and this has implications for their relationships with conventional production. Organic production represents a system distinct from conventional production and marketing, whilst ICM is clearly placed within the conventional framework. In terms of philosophy at least, ICM should therefore be placed closer to conventional farming than to organic production, representing as it does, modification of the existing system rather than abandonment of it.

7.2. EU review of ICM systems

There are two broad categories of ICM system: those established for research purposes and those set up and run commercially. The purpose of this project was not to provide a comprehensive listing of all current ICM systems, but rather to illustrate the range and diversity of current systems.

On the basis of this review there are at least 10 research-type systems and 32 commercial systems (although this latter figure is in reality expected to be significantly higher). Of these systems, 19 apply to arable crops, 17 to fruit, 20 to vegetables, 4 to grapes/wine and 3 to 'other crops', which include hops, medicinal plants, herbs, spice, ornamental plants and olives[42]. However, if the crop coverage is analysed according to whether the system is research or commercially driven, then a different picture emerges in that the majority of research protocols (10 from 13) relate to the arable sector whereas the majority of commercial protocols (34 from 50) relate to the fruit (16) and vegetable (18) sectors[43]. All the wine systems are commercial.

An examination of the protocols for these systems shows that fertilisation and plant protection restrictions/guidelines are virtually universal (appearing in 95% and 93% of schemes respectively), while protocol elements referring to soil husbandry and tillage practices and crop rotation and varietal choice appear in more than half the examples. More than a third of the system protocols refer to harvest and post-harvest and irrigation restrictions.

Although the proportion of ICM in the EU is small, under 3% of Utilisable Agricultural Area (UAA), there is considerable variation between Member States. The UK has by far the largest area under ICM at around 1.5 million hectares whilst this figure is only 268 hectares in Greece. ICM accounts for around 20% of UAA in Austria and Denmark, although accounts for less than 1% of UAA in Belgium, Finland, France, Greece, Ireland and Spain. However, these figures should be interpreted with a degree of caution because ICM systems differ from scheme to scheme.

[42] There is clearly double counting in that many of the schemes apply to more than one of these cropping sectors.
[43] Including double counting where research is involved in more than one cropping sector.

7.3. Impact of ICM systems

This Section summarises the environmental and economic results from the case studies. These summaries are split into protocols (Section 7.3.1), environmental impact (Section 7.3.2) and economic impact (Section 7.3.3). It should be stressed that the information contained in this concluding Chapter is a summary of more detailed information presented in Chapter 5 and Chapter 6 and the reader should refer to these Chapters for full information.

7.3.1. Protocols

7.3.1.1. Protocol summary tables

This Section contains the following:

- Table 7.1: Research systems: linking protocols to impact on water, soil and air
- Table 7.2: Research systems: linking protocols to impact on biodiversity and landscape
- Table 7.3: Commercial systems: linking protocols to impact on water, soil and air

- Table 7.4: Commercial systems: linking protocols to impact on biodiversity and landscape
- Table 7.5: Non-case study systems: linking protocols to impact on water, soil and air
- Table 7.6: Non-case study systems: linking protocols to impact on biodiversity and landscape

In each Table the protocol elements for each system that have an impact under the water, soil, air, biodiversity and landscape headings are described. Comparisons are made with reference to conventional systems.

Table 7.1: Research systems: linking protocols to impact on water, soil and air

System	Water	Soil	Air
Boigneville (France)	• Pesticide leaching: pesticides only applied after observation. • Nitrate leaching: fertilisers only applied after observation.	• Pesticide residues: pesticides only applied after observation. • Biological properties: pesticides only applied after observation.	• No protocol elements.
Lautenbach (Germany)	• Pesticide leaching: only non-leachable compounds are permitted, lowest effective rate used, partial, spot, strip or band application. • Nitrate leaching: mandated reduction in fertiliser use, slow release N if possible. Row application for row crops.	• Pesticide residues: lowest effective rate used, partial, spot, strip or band application. • Soil nitrogen: mandated reduction in fertiliser use, slow release N if possible. Row application for row crops.	• Spray drift: biannual equipment inspection, annual calibration, low drift nozzles. • CO_2 emissions: non-inversion tillage.
CAMAR (Italy)	• Pesticide leaching: varieties selected for resistance; reduced pesticide use; lowest side-effect compounds; no irrigation. • Nitrate leaching: mandated reduced N application rates; no irrigation.	• Pesticide residues: varieties selected for resistance; reduced pesticide use; lowest side-effect compounds. • Soil nutrient balance: mandated reduced N, P_2O_2 and K_2O application rates. • Soil organic matter content: non-inversion tillage. • Soil erosion: non-inversion tillage; cover crops.	• Air quality: no volatile fertilisers used.
Focus on Farming Practice (UK)	• Pesticide leaching: varieties selected for resistance; pesticide reduction strategies. • Nitrate leaching: fertilisation based on soil sampling.	• Pesticide residues: varieties selected for resistance; pesticide reduction strategies. • Soil nitrogen: fertilisation based on soil sampling.	• No protocol elements.
LIFE (UK)	• Pesticide leaching: varieties selected for resistance; rotational control of weeds, rational input use; lower fertiliser use reduces need for herbicide use. • Nitrate leaching: rotational management of fertility; rational input use. • Soluble phosphate: rotational management of fertility; rational input use.	• Soil erosion: non-inversion tillage. • Pesticide residues: varieties selected for resistance; rotational control of weeds, rational input use; lower fertiliser use reduces need for herbicide use. • Soil nitrogen: rotational management of fertility; rational input use.	• No protocol elements.

Table 7.2: Research systems: linking protocols to impact on biodiversity and landscape

System	Biodiversity	Landscape
Boigneville (France)	• Soil fauna: pesticides only applied after observation.	• No protocol elements.
Lautenbach (Germany)	• Soil fauna: only pesticide compounds with the lowest impact on non-target organisms used; non-inversion tillage. • Plant species: only pesticide compounds with the lowest impact on non-target organisms used; fertilisation strategy reduces application; ecological infrastructure provides habitats; cover crops provide temporary habitat, as does non-inversion tillage.	• Ecological infrastructure: 4% of farmland is mandated to comprise hedgerows/shelterbelts, shrubs and woodland, field margins, flowering strips and headlands.
CAMAR (Italy)	• Species range: only pesticides with lowest impact on non-target organisms used and rates reduced; use of seed dressing reduced; fertilisation reduced; ecological infrastructure provides habitats as does undersowing.	• Ecological infrastructure: 5% of farmland mandated to comprise hedgerows, shrubs and woodland, field margins and natural vegetation strips.
Focus on Farming Practice (UK)	• Bird population: reduction in pesticide use and selection of low persistence and toxicity compounds helps provide habitat and food sources. • Soil fauna: reduction in pesticide use and selection of low persistence and toxicity compounds; non-inversion tillage.	• No protocol elements.
LIFE (UK)	• Soil fauna: reduction in pesticide use and; use of rotations to reduce need for pesticide application; non-inversion tillage.	• Ecological infrastructure: 5% of farmland mandated to comprise hedgerows, shrubs and woodland, field margins and natural vegetation strips.

Table 7.3: Commercial systems: linking protocols to impact on water, soil and air

System	Water	Soil	Air
Champagne (France): grapes	• Pesticide leaching: fewer applications of pesticide.	• Pesticide residues: fewer applications of pesticide.	• No protocol elements
AKIL (Germany): arable crops	• Pesticide leaching: varieties selected for resistance; reduced pesticide use through use of IPM; non-leachable compounds and use of rotations to minimise pesticide requirements. • Nitrate leaching: fertilisation strategy matched to crop requirements, band application and slow release compounds are used; rotations are used to minimise fertilisation requirements.	• Nutrient balances: fertilisation strategy matched to crop requirements, band application and slow release compounds are used; rotations are used to minimise fertilisation requirements. • Soil erosion: non-inversion tillage.	• Spray drift: regular spray equipment maintenance.
Chianti (Italy): grapes	• Nitrate leaching: five year fertilisation plan involving reduction in application; irrigation only allowed for three years following vine establishment. • Pesticide leaching: only non-leachable compounds used; application rates reduced; irrigation only allowed for three years following vine establishment.	• Pesticide residues: low persistence and low toxicity compounds selected; reduced application rates. • Soil nitrogen: five year fertilisation plan involving reduction in application. • Soil erosion: non-inversion tillage, tillage restricted to certain times of the year; use of green cover crops. • Soil quality: non-inversion tillage; use of organic manure.	• Spray drift: regular spray equipment maintenance. • Air quality: no use of volatile fertilisers.
Citrus production (Spain): citrus fruit	• Nitrate leaching: fertilisation plan involving soil, leaf and groundwater analysis; irrigation control programme. • Pesticide leaching: a restricted list of pesticides is approved for use, IPM underpins pest control strategy; irrigation control programme.	• Soil nutrient balance: 5 year fertilisation plan involving reduction in application. • Soil erosion: use of green cover crops; soil tillage practices.	• Spray drift: regular spray equipment maintenance and calibration recommendations; restrictions on spraying according to wind speed.
Pome fruit production (Spain): apples and pears	• Nitrate leaching: fertilisation plan involving soil, leaf, groundwater analysis; irrigation control. • Pesticide leaching: a restricted list of pesticides is approved for use, IPM underpins pest control strategy; irrigation control programme.	• Soil erosion: use of green cover crops; contour tree planting. • Soil contamination: restrictions on irrigation water; no fertilisers with heavy metals permitted.	• Spray drift: regular spray equipment maintenance and calibration recommendations.

Table 7.4: Commercial systems: linking protocols to impact on biodiversity and landscape

System	Biodiversity	Landscape
Champagne (France): grapes	• No protocol elements.	• No protocol elements.
AKIL (Germany): arable crops	• Wild plant species: reduced use of nutrients and pesticides (see Table 7.3); enhanced ecological infrastructure. • Soil fauna: low rates of pesticide application; selection of compounds with lowest toxicity; minimisation of treated area; non-inversion tillage.	• Ecological infrastructure: 3-5% of total farm area is allocated to non-crop vegetation.
Chianti (Italy): grapes	• Flora and fauna: Protection of vineyards by belts of woodland.	• Ecological infrastructure: maintenance of farmed landscape in order to promote agro-tourism.
Citrus production (Spain): citrus fruit	• Flora and fauna: reduced pesticide use (see Table 7.3); mandatory green cover.	• No protocol elements.
Pome fruit production (Spain): apples and pears	• Flora and fauna: reduced pesticide use (see Table 7.3).	• No protocol elements.

Table 7.5: Non-case study systems: linking protocols to impact on water, soil and air

System	Water	Soil	Air
Lanxade (France): arable crops	• Pesticide leaching: reduced pesticide use; controlled irrigation. • Nitrate leaching: controlled fertilisation strategies, controlled irrigation.	• Pesticide residues: reduced pesticide use. • Soil nitrogen: controlled fertilisation strategies.	• No protocol elements.
INTEX (Germany): arable crops	• Nitrate leaching: reduced fertiliser use.	• Pesticide residues: varieties selected for resistance; reduced pesticide use. • Soil nitrogen: reduced fertiliser use.	• No protocol elements.
Nagele (Netherlands): arable crops	• Pesticide leaching: varieties selected for resistance; reduced pesticide use. • Nitrate leaching: reduced fertiliser use; use of cover crops.	• Pesticide residues: varieties selected for resistance; reduced pesticide use. • Soil nitrogen: reduced fertiliser use; use of cover crops.	• No protocol elements.
Nagele, Vredepeel and Borgerswold (Netherlands): arable crops	• Pesticide leaching: varieties selected for resistance; reduced pesticide use. • Nitrate leaching: reduced fertiliser use; use of cover crops.	• Pesticide residues: varieties selected for resistance; reduced pesticide use.	• No protocol elements.
Logården (Sweden): arable crops	• Pesticide leaching: reduced pesticide use; rotational control.	• Pesticide residues: reduced pesticide use; rotational control. • Soil nitrogen: reduced fertiliser use; use of cover crops; rotational control. • Soil erosion: non-inversion tillage; use of cover crops.	• No protocol elements.
Boxworth (UK): arable crops	• Pesticide leaching: reduced pesticide use.	• Pesticide residues: reduced pesticide use.	• No protocol elements.
SCARAB/TALSIMAN (UK): arable crops	• Pesticide leaching: reduced pesticide use.	• Pesticide residues: reduced pesticide use.	• No protocol elements.
LINK-IFS (UK): arable crops	• Pesticide leaching: varieties selected for resistance; reduced pesticide use. • Nitrate leaching: reduced fertiliser use; use of cover crops.	• Pesticide residues: reduced pesticide use; rotational control.	• No protocol elements.

Table 7.6: Non-case study systems: linking protocols to impact on biodiversity and landscape

System	Biodiversity	Landscape
Lanxade (France): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements.
INTEX (Germany): arable crops	• Fauna and flora: reduced pesticide use, ecological infrastructure.	• No protocol elements.
Nagele (Netherlands): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements
Nagele, Vredepeel and Borgerswold (Netherlands): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements.
Logården (Sweden): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements.
Boxworth (UK): arable crops	• Fauna: reduced pesticide use.	• No protocol elements.
SCARAB/TALSIMAN (UK): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements.
LINK-IFS (UK): arable crops	• Soil fauna: reduced pesticide use.	• No protocol elements.

7.3.1.2. Conclusions on protocols

Water

- Pesticide leaching: pesticide minimisation strategies coupled with the selection of pesticide products with minimal non-target impacts and varieties selected for resistance provide the main protection against pesticide leaching. Crop rotations are used in some cases to reduce the need for herbicide application. Rational fertilisation strategies will also help by reducing competition from non-crop plants and therefore reducing the requirement for pesticide application. Irrigation management strategies are also sometimes used.
- Nitrate leaching: fertiliser management strategies rely on either mandated reductions in use or on observation/soil sampling to determine requirements under the assumption that this will lead to reduced application. Crop rotations are also used to build up natural fertility and irrigation control programmes provide a better matching of water to crop needs which reduces leaching. Cover crops are also sometimes used to 'lock in' nutrients over winter.

Soil

- Pesticide residues: the main strategies for reducing pesticide residues are the pesticide minimisation strategies (including use of lowest effective rate and band or partial application) used in conjunction with the selection of resistant varieties to reduce pesticide requirement and rotational control. Rational fertilisation strategies will also help in that they will reduce the demand for pesticide.
- Soil nutrient balances/soil nitrogen: the main tactic for achieving a better soil nutrient balance is fertiliser reduction strategies. These more frequently refer to nitrogen, but in many cases are extended to cover other nutrients (P_2O_2, K_2O). This approach is augmented in some cases by row application and the use of slow release nitrogen. Rotational management to reduce demand for artificial nitrogen is also used, as are cover crops to 'lock in' nutrients.
- Soil erosion: where this is considered an issue, soil erosion is addressed through the replacement of ploughing with non-inversion tillage. Cover crops and/or green cover are used to anchor the soil. There are also restrictions on the times of year when soil tillage activities can take place and contour planting of trees is mentioned in the Spanish pome fruit production case study.
- Soil quality: soil fauna are protected through pesticide minimisation strategies and the use of low toxicity compounds. Non-inversion tillage also helps maintain good soil quality, as does the use of organic manure. The use of fertiliser containing heavy metals is sometimes banned in order to reduce soil contamination.

Air

- Air quality: this is usually not addressed in protocols, but where it is, the banning of volatile fertilisers such as ammonia is the main approach to addressing the issue.
- Spray drift: only addressed in half of the case studies and none of the non-case study systems, the risk of drift is reduced through more stringent machinery maintenance and calibration. The use of low pressure nozzles also helps.

- CO$_2$ emissions: this is addressed only in the Lautenbach case study where the use of non-inversion tillage is thought to reduce CO_2 emissions.

Biodiversity

- Soil fauna: the two main approaches that enhance soil fauna are the use of low toxicity pesticide compounds with minimal side effects on non-target organisms and reductions in the total application of pesticide. Non-inversion tillage also promotes soil fauna.
- Plant species: again, the use of low toxicity pesticide compounds with minimal side effects on non-target organisms and reductions in the total application of pesticide are the main protocol elements with a positive impact in this area. These are augmented by rational fertilisation strategies which both reduce the need to apply pesticides and reduce the risk of nutrient-rich soil which is not conducive to many endangered plant species. Finally, the promotion of ecological infrastructure provides a habitat reservoir in which plant species can thrive.
- Macro fauna: this was only investigated in one of the case studies (FOFP) and improvements in bird populations result from the use of low toxicity pesticide compounds with minimal non-target species impact which maintains a source of food for bird life. Ecological infrastructure provide habitat for larger fauna and the protection of smaller fauna through pesticide reduction strategies will also have a positive knock on effect.

Landscape

- Ecological infrastructure: there are no particular production protocols which will have an influence on landscape, and in many ways, ICM is concerned with micro rather than macro impacts. However, the monotony of monocropped landscapes is broken up in half of the case studies by mandated areas of hedgerows, shrubs and woodland, field margins, flowering strips and headlands.

7.3.2. Environmental impact

7.3.2.1. Environmental impact summary tables

This Section contains the following:

- Table 7.7: Research systems: impact on water, soil and air
- Table 7.8: Research systems: impact on biodiversity and landscape
- Table 7.9: Commercial systems: impact on water, soil and air
- Table 7.10: Commercial systems: impact on biodiversity and landscape
- Table 7.11: Non-case study systems: impact on water, soil and air
- Table 7.12: Non-case study systems: impact on biodiversity and landscape

Each Table lists the impact on water, soil, air, biodiversity and landscape for each case study system. Comparisons are made with reference to conventional systems.

Table 7.7: Research systems: impact on water, soil and air

System	Water	Soil	Air
Boigneville (France): arable crops	• Pesticide leaching: the integrated system used less pesticide treatments, both in terms of volume (45% less) and active ingredients. This is likely to lesson the risk of leaching. • Nitrate leaching: in terms of the whole rotation, losses per application are 56% higher in the integrated system compared to the conventional alternative. On a crop by crop basis the integrated systems performs better.	• Biological properties: microbial biomass was 27-34% higher in the integrated system; biomass of *lumbridicidae* was higher (22.6 g/m^2 *c.f.* 11.9 g/m^2); and, the presence of *endomycorhize* was also higher (15% *c.f.* 1%). • Pesticide residues: the protocol is designed to reduce pesticide application and as such the risk of pesticide residues remaining in the soil is reduced.	• No data available.
Lautenbach (Germany): arable crops	• Nitrate leaching: on average, N applications were reduced by 17% for IFS compared with conventional. There is no information on the impact of this on leaching. • Pesticide leaching: the protocol stipulates that only non-leachable compounds are to be used and as such it is expected that there will be a reduction in the risk of leaching.	• Soil nitrogen: N uptake from soil in IFS was better, leaving lower residues (no quantitative data available). • Pesticide residues: the protocol restrictions on pesticide use should reduce the risk of soil residue build up.	• Air quality: annual calibration of spray equipment and the use of low-drift nozzles (mandated in the protocol) reduce spray drift. • CO_2 emissions: it is assumed that CO_2 emissions are lower from non-inversion tillage (an ICM technique) than from ploughing.
CAMAR (Italy): arable crops	• Pesticide leaching: the environmental exposure to pesticides in water decreased by 61% between 1992 and 1999. • Nitrate leaching: there is a 44% reduction in the application of N on integrated compared to conventional systems for wheat. The reductions for barley and sunflower are 30% and 50% respectively.	• Pesticide residues: although the environmental exposure to pesticides in soil increased by 9% between 1992 and 1999, it remains below the targeted maximum. This reduces the risk of contamination in the soil relative to conventional systems. • Soil organic matter content: this increased by 51% between 1992 and 1999. • Soil nutrient balance: the presence of P in the soil decreased by 21% between 1992 and 1999. • Soil erosion: the soil cover index increased by 59% between 1992 and 1999 to 0.54 thus reducing the likelihood of erosion.	• Air quality: no volatile fertilisers (such as ammonia) are used. The environmental exposure to pesticides in air decreased by 73% between 1992 and 1999.

System	Water	Soil	Air
Focus on Farming Practice (UK): arable crops	• Nitrate leaching: consistently lower levels of N loss for IFS compared with conventional, ranging from approximately 35% less in March to 63% in November. • Pesticide leaching: pesticide inputs for IFS were halved compared to conventional and the risk of leaching is therefore likely to be lowered.	• Pesticide residues: pesticide inputs for IFS were halved compared to conventional, but there is no quantitative data on residues. • Soil nitrogen: averaged between 1994-2000, fertiliser use for IFS was reduced by approximately 10%. There is no quantitative data on soil nutrient balance.	• No data available.
LIFE (UK): arable crops	• Pesticide leaching: in autumn 1995, isoproturon was applied at the recommended rate for conventional and at half that rate for IFS. During 1995/96 isoproturon residues in drain water from conventional were 0.19-0.36 ug/l and did not exceed detection limits (0.08 ug/l for IFS. Reduced use of pesticide under the protocol should have resulted in a reduction in risk of leaching. • Nitrate leaching: total oxidised nitrogen emissions in drain water were 82% lower under ICM. Nitrate concentrations were between 12% and 28% higher in the conventional system. • Soluble phosphate: this was approximately 50-80% lower in drain water from IFS than conventional from December 1995.	• Soil erosion: this was reduced by 68% for IFS with non-inversion tillage. • Pesticide residues: the protocol results in lower pesticide applications (75% lower for insecticide, 68% lower for fungicide and 41% lower for herbicides) and the risk of pesticide residues in the soil is therefore likely to be reduced. • Soil nitrogen: 38% less nitrogen was applied, however, levels of N in the soil were higher in the ICM system. • Soil biological activity: 52-65% greater degradation of cellulose material in the ICM system implies greater biological activity.	• No data available.

Table 7.8: Research systems: impact on biodiversity and landscape

System	Biodiversity	Landscape
Boigneville (France): arable crops	• Microarthropode groups: population density was higher in the integrated system, although this is not quantified. • Arthropode groups: no significant difference.	• No data available.
Lautenbach (Germany): arable crops	• Wild plant species: the density of native plant species (non-crop species) on the cropped fields was significantly higher for IFS. Four (non-threatened) species were present in the ICM system, but not in the conventional system. • Earthworm species: the biomass of earthworms for IFS was 25.2 g/m^2 and significantly higher than conventional (4.4 g/m^2) and this resulted from higher numbers of Enchytraeids (24 individuals per litre of soil *c.f.* 15). • Gamasid and Collembola species, caribid beetles, Diptera: densities were significantly higher in the ICM system. Gamasid: 37 individuals per litre of soil *c.f.* 15; Collembola: 46 *c.f.* 29; species number of Dipterous larvae: 57 *c.f.* 51; density of Dipterous larvae: 3,625 individuals/m^2 *c.f.* 3,525; Carabid species: 190 per trap belonging to 43 species *c.f.* 110 from 37 species.	• Ecological infrastructure: 9 km of linear habitats were established.
CAMAR (Italy): arable crops	• Species range: after 7 years, species number and richness indices were as follows: (n) IFS=35 species (7.3), organic=47 species (9.4) and conventional=30 species (6.5).	• Ecological infrastructure: the mandatory 5% of farmland for this purpose makes a contribution to landscape. In 1999, 6.3% of the land was covered by ecological infrastructure, an increase of 5% since 1992.

System	Biodiversity	Landscape
Focus on Farming Practice (UK): arable crops	• Bird population: IFS showed bird populations higher than conventional by 400%, 330%, 638%, 270% for skylark, tree sparrow, linnet and yellowhammer respectively. For chaffinches, none were seen on conventional land. • Earthworm species: average biomass (1994-1999) for IFS was nearly 200% better than conventional.	• No data available.
LIFE (UK): arable crops	• Earthworm species: IFS showed significantly higher densities of earthworms (of between 4% and 92% higher) than in the conventional system. Earthworm biomass was 36% higher under ICM.	• Ecological infrastructure: hedgerows and trees cover 4.7% of the ICM system. With grass tracks and sown field margins, the 'ecological reservoir' is 8.67% of the total area. This reduces the monotony of the farmed landscape.

Table 7.9: Commercial systems: impact on water, soil and air

System	Water	Soil	Air
Champagne (France): grapes	• Pesticide leaching: there were fewer pesticide applications and this is likely to have reduced the risk of leaching.	• Pesticide residues: there were fewer pesticide applications and this is likely to have reduced the risk of residues remaining in the soil.	• No data available.
AKIL (Germany): arable crops	• Pesticide leaching: AKIL farmers have adopted less intensive pesticide input strategies. In some cases no pesticides at all are used and where they are considered necessary, reduced rates are applied. This will have reduced the likelihood of pesticide residues in the soil and hence the risk of leaching. • Nitrate leaching: there was a significant reduction in leaching and subsequently the potential for pollution of groundwater for AKIL farms.	• Nutrient balances: an N surplus of 15.8 kg/ha was recorded for an area of 984 hectares averaged between 1993 and 1995. Soil NO_3 content fell from 75 kg N/ha in 1991 to 29 kg N/ha in 1996. Input:output ratio for Phosphorus showed 2.4 kg P_2O_2/ha/year, potassium was 27 kg K_2O/ha/year. Heavy metals are prohibited under the protocol. • Soil erosion: comparisons between ploughed fields and those subject to non-inversion tillage showed a reduction of 80% in terms of soil erosion and 60% in terms of water fractions in the latter case.	• Spray drift: regular maintenance of spraying equipment, as mandated in the protocol, will reduce the likelihood of spray drift.
Chianti (Italy): grapes	• Nitrate leaching: there was a reduction in N use of 25%. There is no direct assessment of N leaching, but the risk is now lower (there has also been an increase in fish and other organisms that had been in decline). • Pesticide leaching: the protocol restrictions on pesticides in terms of non-leaching compounds and use of chemicals with low impact on non-target organisms is likely to have reduced the risk of pesticide leaching. The maximum number of annual pesticide treatments under the integrated system is 15 per single pest or disease compared to a typical 20-25 applications of Cu and S under conventional management.	• Pesticide residues: pesticides with reduced residual activity and low toxicity are used. This may have reduced the risk of residues building up in the soil. • Soil nitrogen: the reduction in use of N should provide for a better nutrient balance. No quantitative data available. There was a 25% reduction in the application of nitrogen. • Soil erosion: the use of a green cover should have reduced the incidence of soil erosion, although there is no quantitative data. • Soil quality: non-inversion tillage and the increased use of organic manure should have improved the soil quality, although there is no quantitative data.	• Spray drift: better machinery maintenance and low pressure sprayers reduces the risk of spray drift. • Air quality: no volatile fertilisers (e.g. ammonia) are used, although there is no quantitative data on impact on air quality.

System	Water	Soil	Air
Citrus production (Spain): citrus fruit	• Nitrate leaching: ICM has led to a reduction of N use by between 15% and 35%. This, in conjunction with limits on irrigation water is likely to have reduced the risk of leaching. • Pesticide leaching: the use of IPM will result in lower pesticide application and this will reduce the risk of pesticide leaching. As above, an irrigation control programme is also likely to help.	• Soil nitrogen: ICM has led to a reduction of N use by between 15% and 35%. No quantitative information on nitrogen levels in the soil. • Nutrient balances: restrictions on use of P_2O_5 (80 kg/ha/year) and K_2O (160 kg/ha/year) will avoid an excess of nutrients in the soil. • Soil erosion: the use of green cover and the banning of cultivation equipment that destroys soil structure is likely to have reduced the risk of soil erosion.	• Spray drift: better machinery maintenance and calibration recommendations are likely to reduce the risk of spray drift, as will restrictions on spraying in excessive wind.
Pome fruit production (Spain): apples and pears	• Nitrate leaching: maximum permitted dose of N is 36-51 kg/ha (70-100 fertiliser units) for apple and pear orchards. There is no quantitative information on the impact of this on leaching, but the restrictions are likely to have reduced the risk. An irrigation programme is also likely to reduce the risk of leaching by reducing the risk of excessive water application. • Pesticide leaching: the use of IPM will result in lower pesticide application and this will reduce the risk of pesticide leaching. As above, an irrigation programme is also likely to help.	• Soil erosion: this has decreased (although there is no quantitative evidence), mainly due to green cover crops in at least 70% of tree alleys and contour planting of trees. • Soil contamination: this is likely to be reduced through the irrigation programme and the prohibiting of fertilisers containing heavy metals. However, there is no quantitative data.	• Spray drift: better machinery maintenance and calibration recommendations are likely to reduce the risk of spray drift.

Table 7.10: Commercial systems: impact on biodiversity and landscape

System	Biodiversity	Landscape
Champagne (France): grapes	• No data available.	• No data available.
AKIL (Germany): arable crops	• Wild plant species: this was studied on 7 of the 17 farms in the AKIL project. A total of 260 wild plant species were recorded, but no data for comparisons are available. • Invertibrate species: comparisons showed 39 Carabid species, with 92% on IFS and 25% on conventional. Other invertebrates were not identified to species level, Staphylinids, spiders, mites, but recorded higher densities in pitfall traps under ICM (21%, 246% and 139% respectively).	• Ecological infrastructure: landscape monotony is reduced through rotational requirements. Boundary feature management was the most effective ICM component with regard to landscape. Shelter belts of multiple species composition, including shrubs and trees as well as sub-vegetation, provided the essential shelter and habitat for different faunal groups, including the required predators and parasites of pest species. These hosted birds and small mammals and functioned as wind breaks.
Chianti (Italy): grapes	• Flora and fauna: vines are protected from wind by belts of woodland and total hedgerow length has doubled. This is likely to promote an increase in biodiversity, although there is no quantitative data available.	• Ecological infrastructure: agro-tourism is an important source of income and the maintenance of the farmed landscape is therefore important. However, no quantitative data is available.
Citrus production (Spain): citrus fruit	• Flora and fauna: the reduced use of pesticides is likely to have reduced the risk of damage to non-target species.	• No data available.
Pome fruit production (Spain): apples and pears	• Fauna: although there is no quantitative evidence, the numbers of natural enemies have increased through the use of biological control.	• No data available.

Table 7.11: Non-case study systems: impact on water, soil and air

System	Water	Soil	Air
Lanxade (France): arable crops	• Pesticide leaching: pesticide use was reduced, although data are not yet available to quantify this. This reduction is likely to have reduced the risk of leaching. • Nitrate leaching: fertiliser use was reduced, although data are not yet available to quantify this. This reduction is likely to have reduced the risk of leaching.	• Pesticide residue: the reduction in pesticide use, although not quantified, is likely to have reduced the risk of residues building up in the soil. • Soil nitrogen: the reduction in application of fertiliser is likely to reduce the risk of an excess of nutrients in the soil.	• No data available.
INTEX (Germany): arable crops	• Nitrate leaching: application of N reduced by 23% and leachable N reduced as a result, although quantitative data is unavailable. • Pesticide leaching: pesticide use was reduced (see under soil). This reduction is likely to have reduced the risk of leaching.	• Pesticide residues: herbicide application was reduced by 53%, fungicides by 73% and insecticides by 54%. Growth regulators were eliminated completely. This is likely to have reduced soil residues. • Soil nitrogen: application of N reduced by 23%. This is likely to have reduced the risk of a build up of nutrients.	• No data available.
Nagele (Netherlands): arable crops	• Pesticide leaching: annual pesticide input was reduced by 65%, 90% if nematicides are included. Although the impact of this on pesticide leaching is not quantified, it is likely to be positive. • Nitrate leaching: N in run-off water was 20% lower in the integrated system.	• Pesticide residues: the reduction in pesticide application quantified under 'Water' is likely to have reduced the risk of pesticide leaching. • Soil nitrogen: cover crops successfully recovered mineralised N thus maintaining a suitable nutrient balance.	• No data available.

System	Water	Soil	Air
Nagele, Vredepeel and Borgerswold (Netherlands): arable crops	• Pesticide leaching: pesticide use was reduced by between 50% and 65%, 85% and 95% if nematicides are included. Herbicide use was reduced by 60-75%, fungicide use by 50-65%. This is likely to have had a positive impact on pesticide leaching. • Nitrate leaching: the removal of artificial N is likely to have had a positive impact on N leaching.	• Pesticide residues: the reduction in pesticide application quantified under 'Water' is likely to have reduced the risk of pesticide leaching.	• No data available.
Logården (Sweden): arable crops	• Pesticide leaching: insecticide application was reduced by 92%, fungicide application by 86% and herbicide application by 28%. This is likely to reduce the risk of leaching.	• Pesticide residues: the reductions in pesticide use are likely to lower the risk of leaching. • Soil nitrogen: available N reserves are lower in the integrated system (42 Kg N/ha) than the conventional system (49 Kg N/ha). This means that there is less N at risk of leaching. However, in terms of N balance, the integrated system performed less well with 60% utilisation compared to 75% in the conventional system. • Soil erosion: the high soil cover index (81%) helps to anchor the soil and reduce the risk of erosion.	• No data available.
Boxworth (UK): arable crops	• Pesticide leaching: the reduction in pesticide application is likely to have reduced the risk of leaching.	• Pesticide residues: the reduction in pesticide application is likely to have reduced the risk of residues building up in the soil.	• No data available.
SCARAB/TALSIMAN (UK): arable crops	• Pesticide leaching: use of insecticides, molluscicides and nematicides was eliminated and herbicide use reduced by 43% and fungicide use reduced by 54%. This is likely to have reduced the risk of leaching.	• Pesticide residues: the reductions in pesticide use are likely to have reduced the risk of residues building up in the soil	• No data available.

System	Water	Soil	Air
LINK-IFS (UK): arable crops	• Pesticide leaching: pesticide use was reduced by 18%. This is likely to have reduced the risk of leaching. • Nitrate leaching: N application was reduced by 20% and there was a decrease in leachable N as a result (although this was not quantified).	• Pesticide residues: the reductions in pesticide use are likely to have reduced the risk of residues building up in the soil	• No data available.

Table 7.12: Non-case study systems: impact on biodiversity and landscape

System	Biodiversity	Landscape
Lanxade (France): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.
INTEX (Germany): arable crops	• Flora and fauna: no quantitative data available, however, a qualitative investigation suggested that biodiversity had improved.	• No data available.
Nagele (Netherlands): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.
Nagele, Vredepeel and Borgerswold (Netherlands): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.
Logården (Sweden): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.
Boxworth (UK): arable crops	• Fauna: density of predators and parasitoids was 100% higher in the integrated system.	• No data available.
SCARAB/TALSIMAN (UK): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.
LINK-IFS (UK): arable crops	• Soil fauna: no data available, however, reductions in the use of pesticides are likely to have a positive impact.	• No data available.

7.3.2.2. Conclusions on environmental impact

The evidence concerning environmental impact gathered through the case studies is more thorough than that provided in the non-case studies. The conclusions below therefore draw primarily on the case study evidence, although this is supplemented where possible by the supporting evidence from the non-case studies.

Water

- Pesticide leaching:
  - *case study evidence:* two of the 5 research systems showed quantitative reductions in pesticide leaching. The other 3 all showed reductions in application which is likely to have reduced the risk of leaching. The commercial case studies all have protocols which will lead to reductions in pesticide use.
  - *non-case study evidence:* Six of the 8 non-case study systems showed a quantitative reduction in pesticide use, whilst the remaining 2 suggested qualitative reductions in application.
- Nitrate leaching:
  - *case study evidence:* two research systems showed quantitative reductions in leaching; the other 2 showed reductions in application which is likely to have reduced the risk of leaching. One research system showed higher leaching from the integrated system. Three of the commercial systems showed quantitative reductions in N application and 1 suggested a qualitative reduction in N leaching.
  - *non-case study evidence:* two of the non-case study systems had quantified reductions in N application and 2 reported a qualitative reduction. One system showed a quantitative reduction in N in run-off water and 2 others suggested qualitative reductions in N leaching
- Soluble phosphate:
  - *Case study evidence:* one research system showed a reduction in soluble phosphate in drain water.
- Summary: on balance it seems highly likely that ICM systems reduce the incidence of pesticide leaching, although more direct quantitative evidence linking reductions in application to reductions in leaching needs to be collected. The above evidence also suggests that ICM systems generally result in a reduction in the risk of nitrate leaching. Again, as with pesticide leaching, more quantitative evidence should be sought to investigate the link between reduced N application and reductions in N leaching. Although there is not enough evidence on soluble phosphate to make a firm statement, it is likely that ICM does generally contribute to reductions in application through fertiliser rationalisation/reduction strategies.

Soil

- Pesticide residues:
  - *case study evidence:* one research system showed quantitative reductions in residues compared to conventional systems and the implication from all another research systems is that pesticide use reduced as a result of protocol restrictions and this should reduce the risk of soil residues. Two commercial systems suggested a reduction in soil pesticide residues, 1

through reduced application and the other through the use of pesticides with reduced residual activity and low toxicity.
- *non-case study evidence:* six of the non-case study systems reported quantified reductions in pesticide application. The other 2 reported qualitative reductions.

- Soil nutrient balances:
  - *case study evidence:* although there is no quantitative evidence that soil N has been reduced, N application was reduced in 1 research system and another found that N uptake was better under integrated management. One research system showed a decrease in soil P. One commercial system reported quantitative reductions in the level of nutrients in the soil.
  - *non-case study evidence:* one of the non-case study systems reported a reduction in N reserves, although this was coupled with an inferior N use balance. Other non-case study systems showed quantitative and qualitative reductions in fertiliser use.
- Soil erosion:
  - *case study evidence:* 1 research system showed a quantitative reduction in soil erosion resulting from the use of non-inversion tillage, another system showed a greater degree of soil cover which should help reduce the risk of erosion. One commercial system provided quantitative evidence of a reduction in soil erosion and another suggested qualitatively that soil erosion had reduced. Two other commercial systems suggested that the risk of soil erosion was reduced through the use of green covers; this was also the case in one non-case study system.
- Summary: it seems clear that ICM systems, through a reduction in the application of pesticide, lead to a reduction in the risk of pesticide residues building up in the soil, although it is not possible to ascertain for definite on the weight of this evidence that they result in actual reductions in residues; more research is needed to establish the nature of any link. Where systems have restrictions on fertiliser use within the protocols (i.e. in the vast majority of cases), it is likely that nutrient application is better matched to crop demand. ICM systems generally appear to reduce the risk of excessive nutrients in the soil through lower or more rational fertiliser application strategies, although, as with pesticide residues, more research into the link between reduction in application and more appropriate soil nutrient balances should be conducted. Soil erosion is not considered an important issue in most systems, although where it is a consideration (in some cases a central one), the evidence suggests that the risk can be reduced.

Air

- Air quality:
  - *case study evidence:* two research systems suggested improvements in air quality as a result of protocol restrictions. One quantified the environmental exposure to pesticides. Another research system assumed improvements to CO_2 emissions through the use of non-inversion tillage. One commercial system suggested a qualitative improvement in air quality.

- Spray drift:
  - *case study evidence:* none of the research or non-case study systems commented on this issue. However, 4 of the commercial systems suggested a qualitative reduction in spray drift through better machinery maintenance and sprayer calibration.
- Summary: there is little evidence of the impact of ICM on air quality, although this does not mean that there is no impact in practice. However, ICM systems are likely to have a positive impact on spray drift.

Biodiversity

- Flora:
  - *case study evidence:* the density of native non-cropped plants was found to be higher under integrated management in 1 research system. Another found greater species richness in integrated systems. Two commercial systems concluded that there is qualitative evidence that ICM systems provide a benefit to flora.
- Micro-fauna:
  - *case study evidence:* 1 research system found that population density was higher, although this was not quantified. Three research systems demonstrated quantitative improvements in populations in terms of number of individuals and biomass. One commercial system also provided quantitative evidence of increased population density and 3 suggested qualitative improvements based on pesticide reduction strategies and the use of less toxic chemicals.
  - *non-case study evidence:* 1 study provided quantitative evidence of increased population density.
- Macro-fauna:
  - *case study evidence:* 1 research system quantified increases in bird populations.
- Summary: all systems that reduce the use of pesticide and fertiliser are likely to have a positive impact on non-cropped species. Although only 1 system examined this area, it is likely that there will be an increase in macro-fauna populations which depend on the habitats and food sources of both flora and soil fauna which are enhanced under ICM.

Landscape

- Ecological infrastructure:
  - *case study evidence:* 3 research systems showed a positive impact on landscape through the addition and/or maintenance of landscape features. Two commercial systems cited improvements in landscape through management of ecological infrastructures.
- Summary: landscape is not an element that is directly addressed in ICM protocols and the closest proxy for it refers to ecological infrastructure. In many cases landscape elements such as boundary features are encouraged under ICM.

7.3.3. Economic impact

7.3.3.1. Economic impact summary tables

This Section contains the following:

Table 7.13: Research systems: economic impact

- Table 7.14: Commercial systems: economic impact
- Table 7.15: Non-case study systems: economic impact

Each Table presents the impact on production costs, premium availability, yield, revenue and profitability impact for each case study system. Comparisons are made with reference to conventional systems.

Table 7.13: Research systems: economic impact

System	Production costs	Premium/yield/revenue	Profitability
Boigneville (France): arable crops	• Slight reduction in production costs.	• No premium, lower yields so reduced revenue.	• Similar as the yield reduction is balanced to some extent by the cost reduction.
Lautenbach (Germany): arable crops	• Reduction in production costs, although there are additional costs which mitigate this.	• No premium and yields approximately the same so revenue comparable with conventional system.	• Approximately the same, although risk is increased.
CAMAR (Italy): arable crops	• No data available.	• No premium, no data available on yields and no data available on revenue.	• Higher on average, although varies from year to year.
Focus on Farming Practice (UK): arable crops	• Reduction in production costs.	• No premium, yields lower on average and lower revenue as a result.	• Whole farm margin slightly lower on average, although this varies from year to year and in some years has been higher.
LIFE (UK): arable crops	• Reduction in production costs.	• No premium, yields higher for milling quality ICM system, but lower for feed quality system. Revenue slightly lower partly as a result of reduced straw yields.	• Gross margin slightly higher for milling quality ICM system, but slightly lower for the feed quality system.

Table 7.14: Commercial systems: economic impact

System	Production costs	Premium/yield/revenue	Profitability
Champagne (France): grapes	• Production costs were approximately the same.	• No price premium, yields are comparable and revenue remained similar.	• Comparable.
AKIL (Germany): arable crops	• Reduction in production costs.	• No price premium, yields approximately equal, revenue also approximately equal.	• Approximately comparable, although risk is increased.
Chianti (Italy): grapes	• Production costs higher.	• There is a premium and yields are approximately the same, so revenue is higher.	• Profitability is increased as a result of the increase in revenue exceeding the increase in costs.
Citrus production (Spain): citrus fruit	• Production costs lower with respect to inputs, but higher in terms of management time and cost of soil, leaf and groundwater analysis. On balance production costs are slightly higher.	• There is no price premium, although ICM does provide a marketing advantage in terms of supplying multiple retailers, especially in export markets. Yields are equivalent, as is revenue. Revenue risk is likely to be reduced as a result of the marketing advantage.	• Profitability is lower due to increased costs. However, the reduction in revenue risk conferred through the marketing advantage may, in certain circumstances, result in higher overall profitability.
Pome fruit production (Spain): apples and pears	• Production costs lower with respect to inputs, but higher in terms of management time and cost of soil, leaf and groundwater analysis. On balance production costs are slightly higher.	• No price premium, although there is a marketing advantage in terms of supplying multiple retailers. Yields are equivalent, as will be revenue. Revenue risk is likely to be reduced as a result of the marketing advantage.	• Lower profitability due to increased costs. However, the reduction in revenue risk conferred through the marketing advantage may, in certain circumstances, result in higher overall profitability.

Table 7.15: Non-case study systems: economic impact

System	Production costs	Premium/yield/revenue	Profitability
Lanxade (France): arable crops	• There has been a reduction in variable costs, but an increase in management and labour cost. Quantitative data will be released in 2002/03 by Ctifl.	• There is no premium and labelling for ICM is not currently possible in France. Quantitative data on yields and revenue is not available.	• No data available. Data should be released in 2002/03.
INTEX (Germany): arable crops	• No data available.	• There is no premium, yields in the integrated system were lower and as a result, so was revenue.	• Profitability was lower as a result of reduced revenue and lengthened rotations.
Nagele (Netherlands): arable crops	• Production costs are lower in the integrated system.	• There is no premium, yields are lower and this results in a revenue about 6% lower in the integrated system.	• Farm net surplus was slightly higher in the integrated system as a whole as a result of the trade off between reduced production costs and lower revenue. However, some crops performed less well under this system.
Nagele, Vredepeel and Borgerswold (Netherlands): arable crops	• No data available.	• There is no premium and no data are available on yields, nor on revenue.	• Profitability depended on the rotation selected and was comparable to the conventional at Nagele and higher at Borgerswold. The higher profitability at Vredepeel was attributed to rotation rather than management practice.
Logården (Sweden): arable crops	• No data available.	• There is no premium and yields are comparable. Revenue should thus also be comparable.	• The integrated system failed to return a profit.
Boxworth (UK): arable crops	• No data available.	• There was no premium and yields were lower in the integrated system. Revenue should therefore have been lower.	• Profitability was lower.
SCARAB/TALSIMAN (UK): arable crops	• No data available.	• There was no premium. Yields were reduced by 12% in SCARAB and most frequently by around 5% in TALISMAN, although a 12% reduction was recorded in one instance. Revenue would therefore have been lower.	• SCARAB returned a gross margin 6.4% below the conventional system whilst on average, TALISMAN showed a slightly higher gross margin for the integrated system (2%).
LINK-IFS (UK): arable crops	• Production costs were lower, but management costs increased by 50%.	• There was no premium and yields were lower in the integrated system. This would have reduced revenue.	• There was a 2% reduction in production margin on average, but there were variations from site to site.

7.3.3.2. Conclusions on economic impact

The assessment of economic impact was a secondary aim of this research and the evidence relating to this issue is therefore less robust than that relating to environmental impact. There is therefore no division into case studies and non-case studies in the conclusions below.

Production costs

- *Case study and non-case study evidence:* production costs refer to variable production costs and there may be other costs such as increased management time, education and changes in fixed costs which should be taken into account in a more detailed investigation of the economic impact of ICM. In only 1 commercial system (Chianti) were production costs higher under ICM, and then this is the result of further processing rather than ICM *per se*. In all other examples where data were available, variable production costs were lower. In some systems it was explicitly stated that the reduction in variable production costs was mitigated to some extent by increased costs elsewhere, namely management costs (for instance, the two Spanish case studies where these lower variable costs were outweighed by increases in management and analysis costs).

Summary: on balance, the evidence suggests that ICM results in lower variable production costs, mainly through savings relating to pesticide and fertiliser application.

Premium

- *Case study and non-case study evidence:* there were no premiums available for research systems (including non-case study systems which were also exclusively research driven), which is not unexpected given that these systems have been established to develop and investigate protocols and environmental impact rather than to produce commercial returns. Premiums are also the exception rather than the norm in commercial systems (only Chianti has a premium, although this results from bottling rather than ICM production). In 1 case (AKIL) the initial premium has now disappeared as supply of ICM produce has increased, in another (Champagne) labelling as ICM is not currently legal so it is impossible to attract a premium, and in both Spanish case studies (pome and citrus fruit production), ICM has provided a marketing advantage by become more of a right to supply multiple retailers rather than an identity preserved marketing niche.

Summary: premiums are generally not available for ICM production, although a marketing advantage is often conferred in that multiple retail outlets are more willing to source ICM rather than conventional production.

Yield

- *Case study and non-case study evidence:* the impact of ICM systems on yields appears mixed. Of the 9 case study systems that compared yields to conventional systems, 2 showed lower yields and the LIFE project showed lower yields for the feed quality system, but higher yields for the milling quality system. Six case study systems showed yields approximately equal to conventional systems. Of the 8 non-case studies, 5 recorded lower yields and 1 suggested that yields were comparable (2 did not compare yields). This is quite a mixed signal, although the non-case study research was primarily designed to examine environmental impact and therefore did not generally pay close attention to yield.

Summary: the yield in ICM systems tends to be lower at this point in time, however, further research could reduce this difference. Greater commercial interest may also result in greater investigation of the yield impact of ICM techniques.

Revenue

- *Case study and non-case study evidence:* revenue is a function of premium availability and yield. Of the 9 case studies for which there is revenue data, 3 had a lower revenue as a result of lower yields and no premium and 5 had revenues equating to conventional systems. One system (Chianti) had higher revenues reflecting the availability of premium. Because none of the non-case study systems attracted a premium, the impact on revenue follows the same pattern as for yield, i.e. of the 6 systems where there are data, 5 systems returned a lower revenue and 1 had a comparable revenue.

Summary: although revenue is generally lower for ICM systems (reflecting reduced yields and lack of premium, it certainly seems to be the case that the marketing advantage mentionhed above reduces revenue risk because it facilitates the sale of produce to multiple retailers. As with yield, further research and the possibility of attracting premiums in the future might result in increased revenues from ICM systems.

Profitability

- *Case study and non-case study evidence:* this is crudely defined as the difference between revenue and variable production cost, although it is recognised that this will not take into account other cost items (see under production costs, above). Four of the case study systems showed a profitability equivalent to that obtained under conventional management, 2 systems provided higher profitability and 3 systems lower profitability (including the 2 Spanish case studies where technically profitability, defined as revenue less variable costs, was higher, but the inclusion of increased management and analysis costs made whole farm profitability lower). The LIFE system showed a slightly higher profitability for the milling quality system and slightly lower profitability for the feed quality system. The evidence from the non-case study systems suggested that ICM resulted in lower profitability.

Summary: it is difficult to draw firm conclusions on profitability from the balance of the evidence, but the case study evidence at least suggests that it is possible to achieve similar levels of profitability using ICM techniques as a result of lower yields and hence revenue being balanced out by reductions in production costs.

8. References

Anonymous (1999) Integrated Production: Principles and technical Guidelines. 2nd edition. IOBC/WPRS Bulletin 22(4), 1999.

Bailey, A.P., Rehman, T., Park, J., Keatinge, J.D.H. and Trantor, R.B. (1999) '*Towards a method for the economic evaluation of environmental indicators for UK integrated arable farming systems*'. In: Agriculture, Ecosystems and Environment 72, pp 145-158.

Bowerman, P. (1993) '*Sequels to the Boxworth Project - studies of environmental, agronomic and economic effects of reduced crop inputs*'. In: Journal of the Royal Agricultural Society of England 54: 45-59.

Cooper, D.A. (1990) '*Development of an experimental programme to pursue the results of the Boxworth Project*'. In: Proceedings of the Brighton Crop Protection Conference - Pest and diseases, 1990.

El Titi, A. (1989) '*Farming System Research at Lautenbach, Oedheim, FR Germany*'. In: Vereijken, P. and Royle, D.J. (eds) (1989) Current Status of Integrated Farming Systems Research in Western Europe. IOBC/WPRS Bulletin 1989/XII/5 Wageningen, pp21-36.

El Titi, A. (1990) '*Farming System Research at Lautenbach, germany*'. In: Schweizerische Landwirtschaftliche Forschunhg 29 (4), pp237-247.

El Titi, A. and Landes, H. (1990) Integrated Farming System of Lautenbach: A practical contribution toward sustainable agriculture in Europe. In Edwards, Lal, Madden, Miller and House (eds) "*Sustainable Agricultural Systems*". Soil and Water Conservation Society pp265-287.

El Titi, A. (1992) '*Integrated Farming: an Ecological Farming Approach in European Agriculture*'. In: Outlook on Agriculture Vol. 21 No. 1, pp33-39.

El Titi, A. (1999) Lautenbacher Hof Abschlussbericht 1978-1994. Ein langfristiger Vergleich integrierter und konventioneller Bewirtschaftungssysteme im Ackerbau in Baden-Württemberg.- Agrarforschung in Baden-Württemberg, Band 30, 129 pp Verlag Eugen Ulmer Stuttgart.

Gerowitt, P. and Wildenhayn, M. (1997) Ecological and economic effects of extensifying arable farming systems. Results of the Göttingen INTEX project 1990-94.

Greig-Smith, P.W. (1990) '*Origins and aims of the Boxworth Project*'. In: Greig-Smith, P.W., Frampton, G.K. and Hardy, A.R. (eds) (1990) Pesticides, cereal farming and the environment: The Boxworth Project. London: HMSO.

Greig-Smith, P.W., Frampton, G.K. and Hardy, A.R. (eds) (1990) Pesticides, cereal farming and the environment: The Boxworth Project. London: HMSO.

Greig-Smith, P.W and Griffin, M.J. (1990) *'Summary and recommendations'*. In: Greig-Smith, P.W., Frampton, G.K. and Hardy, A.R. (eds) (1990) Pesticides, cereal farming and the environment: The Boxworth Project. London: HMSO.

Harwood, R.R. (1990) '*The History of Sustainable Agriculture*'. In: Edwards *et al* (eds) Sustainable Farming Systems pp3-19.

Hellander, C.A. (1997) '*The Logården project: development of an ecological and an integrated arable farming system*'. In: Ittersum, M.K. van and Geijn, S.C. van de (eds) (1997) Perspectives for Agronomy – Adopting Ecological Principles and Managing Resource Use. Elsevier Science B.V..

Holland, J.M., Frampton, G.K., Cilgi, T. and Wratten, S.D. (1994) '*Arable acronyms analysed – a review of integrated arable farming systems research in Western Europe*'. In: Annals of Applied Biology 125, 399-438.

Jarvis, R.H. (1990) '*Performance of crops and economics of production'*. In: Greig-Smith, P.W., Frampton, G.K. and Hardy, A.R. (eds) (1990) Pesticides, cereal farming and the environment: The Boxworth Project. London: HMSO.

Jordan, V.W.L. (1992) '*Effects of less intensive inputs of agrochemical on cereal yields and profitability'.* In: Scottish Crop Res. Inst. Bull. 9: 16-19.

Jordan, V.W.L. and Hutcheon, J.A. (1994) '*Economic viability of less-intensive farming systems designed to meet current and future policy requirements: 5-year summary of the LIFE project*'. In: Aspects of Applied Biology 40, pp61-67.

Jordan, V.W.L., Hutcheon, J.A. and Donaldson, G.V (1997) '*The role of integrated arable production systems in reducing synthetic inputs*'. In: Aspects of Applied Biology 50, pp419-429.

Jordan, V.W.L., Hutcheon J.A., Donaldson, G.V. and Farmer D.P. (1997) '*Research into and development of integrated farming systems for less-intensive arable crop production: experimental progress (1989-1994) and commercial implementation*'. In: Agriculture, Ecosystems and Environment 64, pp141-148.

Jordan, V.W.L., Hutcheon, J.A. and Perks, D.A. (1990) '*Approaches to the development of low input farming systems'*. In: Unwin, R. (ed) (1990) BCPC Monograph, number 45, pp9-18. Farnham: BCPC.

MAFF (1998) Reducing Agrochemical Use on the Arable Farm.

Mikkelsen, G. and Mikkelsen, S.A. (1989) '*Start of farming systems research in Denmark'*. In: Vereijken, P. and Royle, D.J. (1989) Current status of integrated farming systems research in Western Europe IOBC/WPRS Bulletin 1989/XII/5 Wageningen, pp6-15.

Morris, C. and Winter, M. (1999) '*Integrated farming systems: the third way for European agriculture?*' In: Land use policy 16 (1999). Pages 193-205.

Ogilvy, S. (1993) '*A programme of research into integrated farming in the UK*'. In: Proceedings of the Third Wye International Conference.

Ogilvy, S. (ed) (2000) '*LINK Integrated Farming Systems (a field scale comparison of arable rotations). Volume I: Experimental work*'. HGCA Project Report Number 173.

Perks, D.A. (1994) '*SCARAB and TALISMAN: Investigating the arable systems interface with the environment*'. Abstract from Farming for the Environment. Organised by the SCI Agriculture and Environment and Pesticides Groups, 15/3/1994. SCI, 15 Belgrave Square, London.

Vazzana, C. (1989) '*Preparing farming systems research in Tusdcany, Italy*'. In: Vereijken, P. and Royle, D.J. (1989) Current status of integrated farming systems research in Western Europe IOBC/WPRS Bulletin 1989/XII/5 Wageningen, pp37-40.

Viaux, Ph., Fougerous, A., Hilaire, A., Cavalier, A. and Lescar, L. (1989) '*Planning of integrated farming systems experiments in France*'. In: Vereijken, P. and Royle, D.J. (189) Current status of integrated farming systems research in Western Europe IOBC/WPRS Bulletin 1989/XII/5 Wageningen, pp16-20.

Wall, C. (1992) '*A LINK collaborative Research Programme on Technologies for Sustainable Farming Systems*'. In: Brighton Crop Protection Conference- Pests and Diseases, 1992, pp1,107-1,114.

Wahl, S.A. and Hurle, K. (1988) '*Einfluß langjähriger pflanzenbaulicher Maßnahmen auf die Verunkrautung- Ergebnisse aus dem Lautenbach-Projekt*'. In: Zeitschrift-fur-Pflanzenkrankheiten-und-Pflanzenschutz 11, pp109-119.

Wijnands, F.G. (1997) '*Integrated crop protection and environment exposure to pesticides: methods to reduce use and impact of pesticides in arable farming*'. In: European Journal of Agronomy 7, pp251-260.

World Commission on Environment and Development (WCED) 1987. Our Common Future. Oxford University Press, Oxford.

Zeddies, J., Jung, G., El Titi, A. (1986) Integrierter Pflanzenschutz im Ackerbau - Das Lautenbach-Projekt. II. Ökonomische Auswirkungen. -Z. Pflkrankh. Pflschutz 93, pp449-461.