Integrated Arable Farming Systems and their potential uptake in the UK

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INTEGRATED ARABLE FARMING SYSTEMS AND THEIR POTENTIAL UPTAKE IN THE UK

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Integrated Arable Farming Systems are examined from the perspective of the farmer considering the use of such techniques, and data are presented which suggest that the uptake of the approach may expose the manager to a greater degree of risk. Observations are made about the possible uptake of such systems in the UK and the implications this may have for agricultural and environmental policy in general.

Introduction

Over the last 50 years in much of north-western Europe improved varieties, better technology and good agricultural management has led to higher yields per hectare and, in many cases, an improvement in the quality of food being produced. However, this has been achieved against the backcloth of increasing concern about the environment in terms of agriculture's effects on the soil ,water, air and habitat resource. Awareness of the impacts of agricultural production coupled with the current excess of some products has highlighted the need to find more sustainable farming systems.[4,14] Integrated Arable Farming Systems (IAFS) are seen by some as one way of achieving this goal, leading to a plethora of activity throughout Europe concerning these "innovative" cropping practices.

Integrated agricultural production has been defined as :-

"an holistic pattern of land use which integrates natural resources and regulation mechanisms into farming practices to achieve maximum but stepwise replacement of off farm inputs , to secure quality food and to sustain income".[2]

A number of IAFS are now being examined in Europe[7] in attempts to evaluate their benefits in comparison with the so-called "conventional rotations". These evaluations are often interpreted in purely financial terms. In this paper, the effect of such systems on the actual process of the management of farms is considered.

What do IAFS mean in terms of management practice?

IAFS have implications for the management of farmland via the use of more complex and perhaps longer rotations, changes in tillage practice (particularly non-inversion tillage) and a reduction in both the level of pesticide and fertiliser use where appropriate. This is in part related to the concept of Ecological Infrastructure Management, the aim being to improve habitats and thus biodiversity at a whole farm level. Clearly, this has the potential to influence the decision-making processes related to husbandry practices and expectations with regard to financial rewards on farms. Several projects investigating crop rotations are being undertaken in the UK at the moment to explore IAFS (or similar lower input farming systems). Three of the most important ones are outlined below:

LINK-IFS (LINK-Integrated Farming Systems Project) which is based on six sites throughout England and Scotland, is partly funded by the Ministry of Agriculture, Fisheries and Food (MAFF) together with a number of industrial sponsors. The principal aim is to compare integrated and conventional rotations, concentrating on the practical feasibility and economic viability of the rotations, but also taking into account the level of input use and their environmental impact.[12]

LIFE (Less-Intensive Farming and the Environment) which is based at the Biotechnology and Biological Sciences Research Council's (BBSRC) Long Ashton Research Station near Bristol with a number of extension sites. The main experiment compares a conventional rotation with an integrated rotation each managed according to either standard farm practice or under a less-intensive regime. The underlying philosophy of this experiment is to treat the whole farm as an integrated system whilst recognising the need to improve the various parts or components of it.[8]

FOFP (Focus on Farming Practice) is being undertaken by the Co-operative Wholesale Society (CWS) in conjunction with other industrial sponsors. The objective of this long-term project is to examine how fertiliser and other agrochemicals can be most effectively applied to obtain satisfactory levels of returns from arable farm businesses.[9]

These experiments and their supporting organisations have recently joined forces with Linking Environment and Farming (LEAF), the Scottish Natural Heritage's Targeted Inputs for a Better Rural Environment (TIBRE project), the Farming and Wildlife Advisory Group (FWAG) and the Rhone Poulenc Management Study to create IACPA, the Integrated Arable Crop Production Alliance. The underlying philosophy behind these different experiments and organisations is one in which the management and inputs used in arable rotations can be adapted in such a way that farming has a more benign impact on the environment, whilst maintaining or improving food quality but at the same time sustaining at least the original levels of financial returns. Although guidelines for integrated production have been published,[2] different experiments and organisations[8,9,12] appear to be selectively examining, and using principles and techniques derived from, an integrated approach suggesting that some systems are "more integrated" than others (i.e. there are degrees of integration with some systems being highly integrated and others not). A research network, co-ordinated from the Netherlands, is currently concerned with the design and testing of prototypes associated with both integrated and ecological farming systems[16], in order to develop a common methodology for exploring and disseminating information from these systems. Some of the important techniques employed as part of IAFS, and their influence on management practices are presented in Figure 1 and discussed below:

Figure 1 : The range of techniques used as part of an IAFS approach

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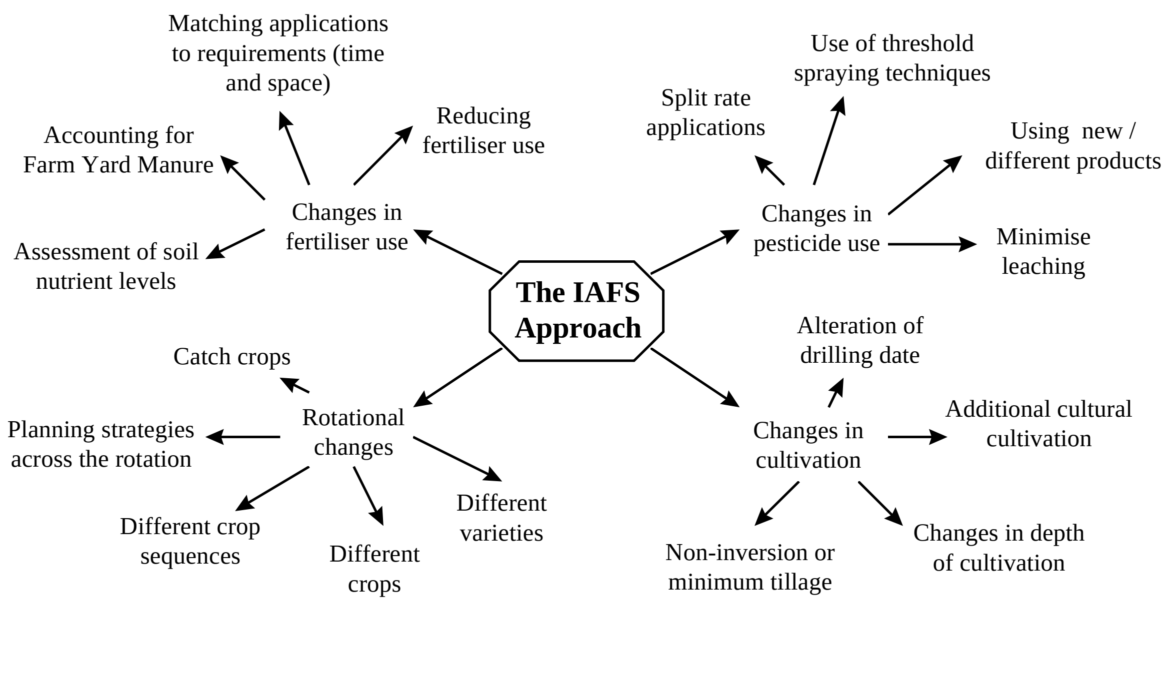

Changes in rotation : A primary aim of IAFS is to utilise different crop varieties and species which are likely to enhance soil fertility over a rotation, or reduce the inputs required over that time period**.** This can mean that a combinable rotation includes oilseed rape and a leguminous break, the aim being to provide the maximum opportunity for effective pest, weed and disease control during the rotation using cultural techniques as well as chemical applications. Additionally, growing a leguminous crop in the rotation may reduce expenditure on nitrogen fertiliser and leave residual nitrogen to be exploited by the following crop .

The use of varietal resistance to disease as a means of reducing inputs is another important consideration within the rotation. For instance, the use of a winter wheat variety such as "Spark", which has reasonable overall disease resistance, may allow pesticide reductions when compared to a variety such as "Riband" which, although popular with farmers, is susceptible to *Septoria tritici* and various rusts.

Additionally, the growing of different varieties can allow market premiums to be obtained, for example when growing quality milling wheats as opposed to feed wheats where there is currently a premium of £20 per tonne. However, this price differential between feed and milling wheat can be marginal in some years and farmers have to set this against a likely yield penalty from growing milling wheats and the extra costs required to secure milling quality (i.e. nitrogen application). Similarly, weather conditions at certain periods of growth can severely effect the quality of the final product (i.e. poor Hagbergs if the summer is very wet).

Substantial changes in rotation also need to be assessed in the light of existing practices which, in many cases, have evolved over time in part because of the technical knowledge or preferences of individual farmers or from local custom. Existing rotations will take into account labour and machinery availability and the need to work within restricted harvest and cultivation windows.

Changes in cultivation : A number of cultivation techniques have been suggested as part of an IAFS approach to farming. These include non-inversion or minimum tillage to create the seedbed and the use of mechanical tools for weed control. Ploughing is an expensive form of land preparation but has benefits in terms of effective trash disposal, soil aeration and tilth creation. The average cost of ploughing, pressing and subsequent cultivation (power harrow, drilling and rolling) has been estimated at £90 per hectare for cereals.[11] The actual cost of direct drilling cereals is about £30 per hectare with a range of £40-80 hectare for minimum till systems.[11] In some areas minimal cultivation may also reduce soil erosion and minimise the risk of leaching associated with nitrogen mineralisation.

From an environmental perspective, evidence suggests that cultivation has a deleterious effect on soil dwelling invertebrates.[1] Additionally, many cultivations are energy intensive processes, emitting previously stored fossil carbon to the atmosphere. Research undertaken as part of the LA-LIFE experiments,[5] illustrates an energy saving of between 10-20% for low input IFS over conventional farm practice. Initial results from the LINK-IFS project illustrate similar trends. However, many arable units have well co-ordinated machinery systems adapted to their specific farm conditions. For instance, abandoning ploughing on farms where blackgrass is endemic is unlikely to be a viable option, although farmers may be able to plough less frequently i.e. one year in three or four.

Changes in timings of operations : Another technique suggested as part of IAFS is the manipulation of drilling date. This can mean drilling the crop later to avoid disease build-up and to reduce the need for autumn insecticide for Barley Yellow Dwarf Virus (BYDV) control. However, on many arable farms the autumn is a well-orchestrated time of opportunist harvesting and drilling whilst the weather and soil conditions hold. An increase in farm size, accompanied by efficiencies in terms of labour use, has meant that little if any freedom exists to delay drilling considerably, even though research has shown that drilling into mid-October only has a small impact on yields.[6] The main drawback with such an approach is associated with the risk of wet autumns. However, some manipulation of sowing date may be appropriate in terms of the order in which fields are drilled (partly governed by the species and variety grown).

Changes in fertiliser and pesticide use : One of the primary objectives of IAFS is to reduce inputs of fertiliser and pesticide into the system (in terms of quantity and toxicity), minimising the potential for environmental degradation, whilst at the same time maintaining margins. This may be achieved via the following four main mechanisms:

(i) Threshold spraying : In some areas of the country, certain diseases are more common such as *Septoria tritici* and Mildew, especially in certain weather conditions. Under such conditions, some farmers may apply fungicide as an insurance measure although the disease itself may only be present at low levels at the time of spraying. This managed disease programme is usually growth-stage dependent. IAFS techniques attempt to overcome such prophylactic practices via closer crop monitoring and the use of thresholds to make decisions on when to apply the appropriate fungicide. This can be a very successful approach in prevailing conditions. However, in some circumstances delaying fungicide application to the crop until the disease reaches a threshold on the plant can result in a full-rate application which may be more than that used if a low dose prophylactic spray had been applied. Threshold values can also be difficult to interpret if, as is often the case, several diseases are present. Individual pathogens may remain below the threshold but their combined effect may

result in economic returns from prophylactic spraying. Additionally, evidence from IAFS research projects suggests that management costs associated with crop walking and monitoring are likely to be higher when adopting an IAFS approach.[3] This is especially true with disease assessment as action is only triggered when a specific threshold is reached.

(ii) *Reducing pesticide loading:* Pesticide loading can be reduced via the selection of more disease resistant varieties (i.e. Spark or Hussar instead of Brigadier or Riband). This may allow lower quantities of pesticide to be applied but also may reduce the total toxic load of pesticide applied. Thus, chemicals could be selected on the basis of their toxicity class (LD5O) as referred to in the BCPC's Pesticide Manual. Chemicals are also assessed for soil persistence, drifting, leaching and crop safety. For example, reviewing the rate or avoiding the use of IPU (on cereals) or Simazine (on beans) may give environmental benefits. However, this must be set against the increased costs of alternatives such as fenoxaprop-ethyl (cereals) or cycloxydim (beans). By definition some less toxic chemicals may also be less effective and crops may require further treatments. The use of herbicides in conjunction with some form of mechanical operation can also be used to reduce rates of application but additional costs may be incurred due to the need for more field passes.

(iii) Reduction in nitrogen and pesticide loss from the system : A principal aim of IAFS is to reduce the amounts of chemicals both applied and lost from the system. This has obvious direct implications for the farmer in that it will reduce input costs, but also has wider benefits in terms of reducing chemical contamination of groundwater (particularly by nitrate and pesticide). Techniques to improve the efficiency in use of nitrogen include the more precise timing of applications, soil nitrogen testing and the more accurate application of FYM as outlined in the Code of Good Agricultural Practice for the Protection of Water.[10]

However, quantification of the nitrogen cycle is still not straightforward and it is something that is far from fully understood.[15] Soil nitrogen testing is certainly becoming more accurate, but availability of soil nitrogen to the plant can vary considerably because of differences in spatial availability and climatic conditions. Similarly, techniques for the testing of the nutrient loads of farmyard manure and slurry are both costly and only give a rough estimate of the fertiliser availability to the plant.

(iv) Exploitation of residual fertility, for instance, from legumes : Rotations can be designed (and always have been to some extent) to improve or exploit the transition from one crop to another in order to maintain the natural fertility of the soil. Although several non-leguminous crops (i.e. Oilseed Rape and Potatoes) can leave residual nitrogen in the soil this is related to nitrogen application during crop growth. Some legumes can leave substantial quantities of biologically fixed residual nitrogen which can be of value to the following crop. Additionally, there is evidence to suggest that legumes may not exploit soil nitrogen reserves to as greater extent as some crops and this too can add to the residual nitrogen available to the following crop. Grain legumes have traditionally been used as a break crop and are attractive because they can be harvested by combine.

What are the likely management consequences of integrated systems?

Many of the techniques suggested as part of an IAFS approach have been tried and even been popular at various times in recent and more distant agronomic history. The novelty of their use in the IAFS context is associated with their use in the highly technical environment of the modern farm business.

An underlying aim of crop husbandry is to reduce some of the uncertainty during the growing season which is associated with climate, disease and pests. This has allowed individuals to manage larger areas effectively whilst achieving good crop yields and high returns. Although the technology surrounding these growing systems is complex, the actual growth of a crop at the farm level is now relatively well understood and good yields can be achieved by following a number of procedures (usually related to crop growth stages) from seedbed preparation through to harvest. In effect, the adoption of an IAFS approach can complicate this formalised procedure, particularly as farmers are, at present, uncertain about some aspects of IAFS. This may be a small change, for instance in the date of drilling to more radical changes for instance with respect to cultivation management. Threshold spraying may mean that more crop walking is required and a more diverse rotation implies that the manager will require knowledge on a wider range of disease, insects and input regimes as well as crop markets. This general increase in complexity associated with an IAFS approach may mean that some individual farmers and managers have to rely on the support of specialists and advisors trained in IAFS to aid their decision making. At present, the availability of suitably qualified advisors is limited.

Another important impact of adopting IAFS is associated with the concept of risk and uncertainty.[3] Utilising certain techniques such as later drilling or threshold spraying will expose the enterprise to greater overall risk. This increased risk may be dependent upon the regional location of the farm or the markets into which products are sold. For example, Table 1 illustrates the yields of a number of crops in the MAFF East Midland region together with Coefficients of Variation. This analysis not only gives an impression of the mean yield in a crop, but also the degree of variability in yield around the mean. The data suggests that yield

Table 1: Crop yields and variability in the East Midland regions of MAFF census data, 1995.

Crop	Winter Wheat	Winter Barley	Spring Barley	Winter Oats	Winter OSR	Spring OSR	Peas	Beans
No. of farms	364	218	146	39	77	8	75	136
Mean Yield	7.7	6.5	4.8	5.8	3.3	1.8	3.7	2.8
COV*	20	19	27	29	21	45	30	28

*COV - Coefficient of Variation which is the Standard Deviation x 100 divided by the mean; as such it is a measure of the variability or dispersion of yield around the mean with larger coefficients implying greater variability.

Source : MAFF 1995 census data.

variability within a given region maybe greater in some crops than in others. This variability also exists between different regions. For instance, Table 2 shows variability of yield for Winter Wheat and Winter Beans in four MAFF regions. This can be interpreted to suggest that growing certain crops (for instance grain legumes) is more risky than other crops in a given region.

Table 2 : Winter wheat and winter bean yields and variability across four MAFF regions, 1995

	MAFF Regions			
	Yorks	*E. Mids*	*E. Anglia*	*S. East*
Winter Wheat				
No. of farms	313	364	380	382
Mean Yield	7.98	7.71	7.81	7.41

COV *	19.8	20.2	17	24.3
Winter Beans				
No. of farms	44	136	138	198
Mean Yield	3.1	2.8	3.0	2.41
COV*	32	28	32	35

* COV - Coefficient of Variation which is the Standard Deviation x 100 divided by the mean; as such it is a measure of the variability or dispersion of yield around the mean with larger coefficients implying greater variability.

Source : MAFF 1995 census data.

The overall balance of crops in the rotation will be important. For instance, rotations with more wheat and barley have in the past produced a high rotational margin. Including spring sown combinable crops may reduce margins but will also provide more opportunity for weed control. Legumes in the rotation may reduce the required inputs, leave residual nitrogen in the soil and provide a break from cereal cropping. However, the rotational gross margin may be lower if a higher proportion of "break crops" are included in the cropping sequence, although this is dependent on the crops included. Additionally, financial accounts will give little indication of the riskiness of changing an established rotation to include crops with which the individual farmer or manager is not familiar.

Will farmers convert to integrated farming systems?

If it is assumed that farmers tend to be profit maximisers, it may be possible to interpret data being produced by current experiments to illustrate that the IAFS approach can be financially viable. For instance, considering the first five years of the LA-LIFE project, it was suggested that quality production in less-intensive integrated systems can be maintained without economic loss.[8] Preliminary analysis of the LINK-IFS project[13] illustrates that (although data for the whole rotation is not yet available), in some cases, incomes can be maintained. However, it is much more difficult to assess the degree of risk embodied in IAFS when compared to conventional systems. Moreover, this paper has largely ignored the environmental benefits that may accrue from the adoption of integrated systems. These benefits (whether perceived or real) may be of great importance to individual managers if only to assure themselves and/or outsiders that they are environmentally aware. But, it is presently difficult to quantify or to attribute a monetary value to these benefits from the perspective of the individual farmer via a profit and loss account. The perceived financial return to the farmer from increased numbers of beetles or earthworms is likely to be small in comparison to the changes made, and the constraints imposed on, their farming system. The real tangible benefits occurring from the wider adoption of the IAFS approach may lie at a national level in terms of habitat preservation, reduced nutrient and carbon dioxide emissions and a preservation of biodiversity. However, environmental benefit will be related to the degree to which farmers adopt the whole integrated approach as opposed to its individual techniques. Clearly a distinction needs to be made between farmers adopting a few integrated techniques which fit in well with their existing farming system and those who are more aggressive in adopting a comprehensive integrated approach along the lines of that being demonstrated on experimental farms. Organisations such as LEAF have a key role in demonstrating that individual integrated techniques can be relatively easily adopted on some farms, although, few farms in the UK are currently following the strict integrated guidelines as laid out in the IOBC/WPRS Bulletin.[2]

Thus, the issue of whether Government should underwrite IAFS with financial support is complex. It raises questions about whether Government should be willing to pay farmers, and/or what instruments could it use to encourage farmers to convert to systems which are, on the whole, more risky and time consuming than their current practices. A current project at The University of Reading[13] is evaluating these issues, primarily providing information on the practical adoption of IAFS techniques at a farm level, but also introducing environmental accounting methods into standard farm accounting procedure to provide some indication of the cost or benefit of adopting the IAFS approach and the scale (if required) of Government support that may be required to encourage change.

It could be argued that some IAFS techniques are being adopted due to market forces, e.g. the rising cost of fertilisers and pesticides, combined with potentially lower product prices means that farmers are looking more closely at their use. However, allowing the market to drive the adoption of methods using lower inputs accounts for only part of an IAFS approach and may mean that the overall rate of change is likely to be slow. This suggests that if Government is keen to encourage the wider adoption of the IAFS approach, then some financial encouragement for farmers to change may be required as well as a package of extension and education. Such measures could include penalties for non-use of IAFS, direct area payments or some form of cross-compliance (for instance relating the adoption of an integrated farming approach to area aid payments). This already occurs in some European countries, for instance the MEKA system in the Baden-Wurttemberg region of German allows farmers to claim additional subsidy depending on the “integrated techniques” they adopt. Indeed, it seems that on mainland Europe generally, IAFS are both more widely practised and more widely accepted by the public.[7] Its spread probably mirrors the rise in organic farming which is especially popular in Germany, Austria, Scandinavia and the Benelux countries.[17]

Government could also introduce regulations insisting on the IAFS approach in certain key areas or zones. Alternatively, quality labels (similar to the RSPCA's Freedom Foods) could be introduced to indicate a range of products grown in an environmentally friendly manner. This would fit in with the increasing demands for audit trails or Identified Product Sourcing by retailers, processors and consumer groups. Whether this would be a good thing for the industry as a whole, or indeed the individual farmer, must be questioned. The likelihood is that this will mean retail outlets putting pressure on farms by increasing constraints on the way in which they produce food. This may lead to further inflexibility and a lack of diversity in production systems, thus reducing the ability of individual farmers to adapt to (unforeseen) changes in the future (markets, policy, climate).

Conclusions

The adoption of the whole IAFS approach by farmers is likely to be limited at present if only because of the perceived risk and uncertainty and increased time required by some of the techniques involved. However, some farmers are adopting, and will continue to adopt, individual IAFS-type techniques as a method of reducing costs, and this transition should be helped by existing experiments and demonstrations which can show the practicalities of a number of such techniques in a range of farming situations. It is difficult to draw conclusions about the increased risk associated with the IAFS approach simply because individual farmers have differing perceptions and attitudes to risk and risk-taking. Similarly, the visual perception associated with crops containing weeds can influence the decisions of many farmers and therefore their attitudes toward IAFS. A thorough financial and economic evaluation of the IAFS approach is not yet available, as the kind of data on which it can be based are currently either not available or not amenable to a rigorous quantitative analysis.

This is clearly an area requiring further research. Nevertheless, many of the techniques suggested either do not fit in well with current farming systems or increase the degree of risk the manager is exposed to. As such, they are likely either not to be adopted or will be taken up only slowly by relatively few. Thus, the adoption of a fully integrated arable farming system approach as defined by the IOBC/WPRS guidelines is also likely to be slow.

In an industry that is inherently uncertain in terms of both the physical, economic and political climate in which it operates, individual producers need to maintain the ability to respond to change. This suggests that the successful manager should be able to maintain business flexibility whilst at the same time sustaining at least current levels of financial return. Viewing the IAFS techniques as part of the managers' toolbox rather than as a prescribed approach may be the most appropriate management philosophy in this context. However, if a few individual techniques are adopted as opposed to a comprehensive approach, environmental benefits are unlikely to be substantial.

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