MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Research and Development

Final Project Report

(Not to be used for LINK projects)

Date project completed:

31/03/1998

Section 1 : Identification sheet

1. (a)	MAFF Project Code	**OF0112**	
(b)	Project Title	Organic Arable Systems at ADAS Terrington	
(c)	MAFF Project Officer	Dr Peter Costigan	
(d)	Name and address of contractor	ADAS Terrington Terrington St Clement King's Lynn Norfolk Postcode PE34 4PW	
(e)	Contractor's Project Officer	Dr W F Cormack	
(f)	Project start date	01/04/1995	Project end date 31/03/1998
(g)	Final year costs:	**approved** expenditure	
		actual expenditure	
(h)	Total project costs / total staff input:	**approved** project expenditure	
		actual project expenditure	
		***approved** staff input	
		***actual** staff input	
(i)	Date report sent to MAFF	30/04/1998	
(j)	Is there any Intellectual Property arising from this project ?		NO

***staff years of direct science effort**

Section 2 : Scientific objectives / Milestones

2. Please list the scientific objectives as set out in CSG 7 (ROAME B). If necessary these can be expressed in an abbreviated form. Indicate where amendments have been agreed with the MAFF Project Officer, giving the date of amendment.

1. a) To complete the conversion of an initial 16 ha to organic production to UKROFS standards.

   b) Continue with the post-conversion organic rotation on the stockless and FYM systems.

2. Compare the fertility building effects, over a two year conversion period, of contrasting legume species.
3. Determine the optimum point(s) in the rotation to apply composted livestock manure.
4. Prepare and publish a final report on the performance of pigs finished outdoors during conversion.
5. To initiate a new experiment to determine the best crop for the final year of the rotation.
6. To identify ten primarily arable organic farms undergoing, or post, conversion. To prepare a financial analysis comparable to that in objective 1b above.
7. To set up a steering group to advise MAFF on the progress of the work.
8. To communicate results of the project to MAFF and the industry.

3. List the primary milestones for the final year.

It is the responsibility of the contractor to check fully that ALL primary milestones have been met and to provide a detailed explanation if this has not proved possible

Milestones		Target date	Milestones met?	
Number	Title		in full	on time
8/4	Report to MAFF (1996 harvest year)	30/06/1997	Y	Y
8/5	Prepare a paper for publication in a refereed journal	31/12/1997	N	N
8/6	Report to MAFF (1997 harvest year)	30/06/1998	N	N

If any milestones have not been met in the final year, an explanation should be included in Section 5.

Section 3 : Declaration

4. I declare that the information I have given in this report is correct to the best of my knowledge and belief. I understand that the information contained in this form may be held on a computer system.

Signature		Date	
Name			
Position in Organistation			

Section 4 : Executive summary

Project OF0102 contributes to MAFF's main policy focus of encouraging conversion to organic farming methods. It is part of a long term rotational study that began in 1990 as OF0102 and has recently been extended to 2001 as OF0145. The overall objective of these three projects is to evaluate the cost of conversion to organic arable production on a fertile soil, to assess the physical and financial performance of the organic rotation, to identify and overcome limitations to sustainability and to compare the results with conventional arable production. The project comprises a field-scale unreplicated systems comparison and associated replicated experiments at ADAS Terrington, and a financial analysis of ten commercial "linked" organic farms.

The silty clay loam soil at Terrington has proved ideal for organic production, primarily because it has very good water and nutrient retention. As expected, organic crop yields have been less than conventional, averaging 70% for winter wheat; yields have been, on average, double that of the linked farms, and reached a peak of 10 t/ha in 1996. Variable costs have been lower and organic prices have been twice or more that for conventionally grown potatoes and wheat. Crop gross margins (i.e. the value of the crop harvested minus the direct variable costs of growing it) have been consistently higher from organic than conventional. Even allowing for the lower value of the other three crops in the rotation, *i.e.* beans, spring cereal and clover (Set aside), overall gross margin from organic was higher than from conventional (average from 1993 to 1997 was 1,878 v. 1,290 £/ha).

Crop yields and gross margins were generally lower on the linked farms, probably mainly because they were on lighter soils more prone to leaching losses. However, all were viable businesses and had similar profitabilities to conventional farms of their size. The most profitable rotations included potatoes and/or vegetables.

In the absence of animal manures and synthetic fertilisers, the main driver of crop yield and key to success, will be the fixation of sufficient atmospheric nitrogen by the *Rhizobium* bacteria in the root nodules of legumes. Replicated experiments comparing a range of species have shown that in terms of gross accumulation of nitrogen in the cut foliage, and in the yield of a following wheat crop, red clover, lucerne and white clover are all very effective fertility builders, with red clover on average just the best. A second experiment has compared wheat, barley and oats as cover crops for the undersowing of red clover. In 1997 clover dry matter at harvest under oats was only 4.5 kg/ha compared with 88 under wheat and 174 under barley. Barley was also the most profitable crop, however this was affected by relative grain prices which vary between years. A third experiment tested timing of manure application across the rotation. The modest quantity applied (30 t/ha per rotation) was chosen as what could have been produced form animals fed on crops grown within the rotation. There was only one isolated response in crop yield over four years and four different crops. This was probably a reflection of the high inherent fertility and nitrogen retention capacity of the silty clay loam soil at Terrington.

Results have been presented at conferences, in farming journals and at site visits. The highlight was a private visit by HRH Prince of Wales.

There are real current business opportunities for conversion to arable organic production. The linked farms, mostly with mixed arable livestock rotations, show profitability comparable with conventional; stockless arable production was consistently more profitable than conventional on the fertile nutrient retentive soil at Terrington. However there remain questions about the longer term sustainability of a stockless arable rotation, even on such a well suited soil. The next phase of the project (OF0145), which has just started, will focus on sustainability studying potential threats from perennial weeds, nutrient supply and soil-borne pests and diseases. The use of manure will be discontinued and, in that part of the study area, vegetables will be introduced in place of potatoes to test an alternative rotation.

Section 5 : Scientific report

This report covers a three-year part of a long term project which began in 1990 and has recently been extended to 2001.

OF0102 - 1990 to March 1995
OF0112 - April 1995 to March 1998 (the subject of this CSG13)
OF0145 - April 1998 to March 2001

Full reports (in addition to CSG12s) have been prepared annually for MAFF. Pairs of reports are attached covering the 1995 and 1996 harvest years. One of each pair covers the Linked-farm results (Objective 6) and the other covers the main Terrington systems comparison and replicated experiments (Objectives 1 to 5). As planned, reports for 1997 harvest year will be presented to MAFF in September and October 1998 after discussion and agreement by the steering group (Primary Milestones in OF0145). The report below includes results for 1997, and objectives 8 and 9, not covered by the appended reports.

The overall objective of this project is to assess the cost of conversion, on a fertile soil, from intensive arable to a primarily stockless organic arable production system, and subsequently to determine the biological and financial sustainability of such a system. Assuming results are positive, the ultimate objective is to encourage organic arable conversion to help meet MAFF's objectives of supplying an increasing consumer demand from home-grown produce and of benefiting the environment.

All scientific objectives as laid out in the CSG7 have been fully met.

Of the 37 milestones, all apart from two have now been met in full. The first outstanding milestone is the preparation of a refereed paper due by 31/12/97 (8/5). Work is underway but has been delayed by the prolonged serious illness of the dedicated statistician. Alternative arrangements for data analysis are being made and a paper will be presented for publication during 1998. The second outstanding milestone is the presentation of the 1997 harvest year report to MAFF (8/6). However, this is not due until 30/06/98, and it has been incorporated as a primary milestone in OF0145.

Objective 1.

a. To complete the conversion of an initial 16 ha to organic production to UKROFS standards as described in the ROAME B for the initial phase of the project (OF0102).

Conversion was completed on schedule in autumn 1995. The core of the project is an unreplicated systems comparison/demonstration with field scale plots. Large plots were used to allow normal farm machinery to be used to get meaningful costings, to allow real patchy problems such as perennial weeds and potato cyst nematodes to be encountered and researched, to give confidence to farmers that the system could work on a farm scale and to allow space for replicated small-plot experiments to be done in an organic context.

Following conversion, the initial 16 ha was all in the same crop rotation of potatoes, winter wheat, spring beans, undersown spring wheat and fertility building year (Set aside). Of the total, approximately 10 ha was in an entirely stockless rotation with conversion and fertility building as mulched red clover, 2.5 ha as the stockless rotation but with the addition of 30 t/ha of composted pig manure per rotation (the "FYM" system) and 3.5 ha with the red clover replaced by a white clover - ryegrass ley with finishing pigs during conversion. Each of the three "systems" was split into five equal plots. The five course rotation was phased-in over three years so that from 1997 each of the five plots was in a different crop. (The "Pig" system was discontinued in 1995 (*see Objective 4*)).

b. To continue with the post-conversion organic rotation on the stockless and FYM systems and compare physical and financial performance with a conventional rotation.

The crop rotation on both systems is:

Potatoes
Winter wheat
Spring beans
Spring wheat (undersown)
Red clover (one year fertility building crop - Set aside)

The earliest converted plot completed conversion and one full crop sequence with the 1996 harvest. Crop yields have averaged 70% of conventional but the differential has varied between years. From 1995 to 1997, winter wheat averaged 7.1 t/ha and potatoes 29.6 t/ha. Variable costs have been lower due to the non-use of fertilisers and pesticides apart from copper fungicide on potatoes. Organic crop prices have been excellent throughout the life of the project averaging 189% of conventional for wheat and 240% for potatoes. This has resulted in consistently higher crop gross margins from the organic crops. When modelled over a full crop rotation, organic has every year given a greater average gross margin (1,878 v. 1,290 £/ha using five-year rolling average yields and prices). Fixed costs have been similar, resulting in a significantly greater net margin (1,566 v. 992 £/ha).

Pests and diseases have not been significant limitations to yield apart from severe potato blight which terminated crop growth early in July 1997. Annual weeds are increasing but have so far been kept at a sustainable level. Perennial weeds, particularly creeping thistles and couch grass, are spreading from an insignificant baseline level, and pose a greater future problem. Single year clover crops proved difficult to establish successfully, suffering from Sitona weevil and winter kill damage when direct sown in late summer. Following completion of conversion and the phasing-in of the crop rotation, clover has been established by undersowing. This has proved more reliable but we may have a future legacy of reduced yields in some plots where clover crops were poor in 1995 and 1996.

The longer term nutrient sustainability of this rotation is also doubtful. Will a single year of red clover every five years supply sufficient nitrogen to maintain adequate crop yields? Will phosphate and potassium levels remain adequate and can organically approved external sources supply enough in a stockless rotation?

This excellent performance will come under pressure from these and a number of other potential limitations as we go into the second crop rotation. Sustainability will be the focus of project OF0145, the successor to OF0112.

Objective 2. *Compare the fertility building effects over a two-year period of contrasting legume species and management systems.*

This study began in 1990 as part of OF0102. Red clover, white clover, lucerne, sainfoin, white clover/ryegrass and lucerne/meadow fescue were grown for two years as conversion crops. They were managed by various sequences of mulching, conservation cuts and seed harvests. Two following test crops of winter wheat were grown. There were three separate experiments, each lasting four years, with the starts staggered by a year. The field work was completed with harvest 1997.

Sainfoin was slow to establish in all experiments and made poor growth in the first year allowing extensive growth of weeds. The other legumes all established well and made good growth although the grass soon dominated the white clover/ryegrass mixture with infrequent cutting on a fertile soil. On average, gross foliar dry matter accumulation over the two years was greatest from lucerne (18.5 t/ha) and red clover (17.9 t/ha). White clover gave 12.6 t/ha and the lowest yield was from sainfoin at 10.5 t/ha. Gross foliar nitrogen accumulation showed a similar pattern with the greatest from Lucerne at 631 kg/ha and least from Sainfoin at 262 kg/ha. Grain yield from the first wheat test crop indicated that yield following Sainfoin at 6.1 t/ha was less than from the other legumes. Yields following red clover, white clover and lucerne were similar at 6.8, 6.4 and 6.5 t/ha respectively. Effects of crop management were smaller than effects of legume species and were inconsistent.

The conclusion of this study, pending full data analysis, is that red clover is an appropriate choice for a fertility building crop in a stockless arable rotation on a silty clay loam soil. The excellent performance in the main system comparison (*Objective 2b*) supports this conclusion as do the difficulties encountered in establishing lucerne by undersowing (*Objective 5*).

Objective 3. *Determine the optimum point(s) in the rotation to apply composted livestock manure when a limited quantity is available.*

This experiment, sited within stockless plot 3, ran from 1994 to 1997 through all four arable crops in the rotation. Each year, the experiment was in the same crop as the remainder of the plot. Apart from the untreated control, all treatments received 30 t/ha, per crop rotation, of straw-based farmyard manure from the conventional pigs at Terrington. The manure was either composted or stockpiled without turning for a minimum of six months. There was a range of timing combinations from all applied to one crop to a split between combinations of two crops. Over the four harvest years, there was only one crop response recorded. This was in 1997 in spring wheat when grain yield and protein content were increased by the application of 30 t/ha of stockpiled manure for that crop. This manure had an unusually high ammonium nitrogen content (equivalent to 74 kg/ha compared with only 1.6 kg/ha in the composted manure). The lack of effect from manures of more typical composition underlines the inherent fertility of the silty clay loam soil and in particular its ability to retain nitrogen. The December 1997 steering group meeting recommended that this work be re-directed to a lighter land site where a response would be more likely. This action has been taken in OF0145, the follow-on to OF0112.

Objective 4. *Prepare and publish a final report on the performance of the pigs finished outdoors during conversion.*

Outdoor summer finishing pigs on grass/clover leys was the conversion phase of the third system compared in OF0102. The pigs were conventionally indoor reared commercial genotypes. Conversion was completed in autumn 1994 and the results were published in 1995 in CAB Pig news and Information (copy appended).

Objective 5. *To initiate a new experiment to determine the best crop for the final year of the rotation.*

This experiment has compared spring wheat, barley and oats for the final phase of the crop rotation. The two main objectives are to determine which of these crops is the most profitable and which is the best host for undersown legumes for the following fertility building year. The legume was either red clover or a mixture of red clover, lucerne and perennial ryegrass. Experiments were completed for 1996 and 1997 harvest years. Barley gave the greatest yield in 1996 (5.7 t/ha) and oats in 1997 (5.1 t/ha). The most profitable in both years was barley because of a strong market price for organic feed wheat and barley. Drought in spring/early summer 1996 severely restricted legume establishment and growth; there was insufficient biomass at harvest for a meaningful assessment. The lucerne and ryegrass failed to emerge in the dry conditions. However, sufficient clover plants survived to give a satisfactory plant stand for the fertility building crop in 1997. For the 1997 experiment, spring was again very dry but rainfall in June was above average. Clover established well but growth of lucerne was patchy and grass again failed to appear. Clover biomass at harvest was greatest under barley at 174 kg/ha DM compared with 88.5 under wheat and only 4.5 under oats. This experiment continues in OF0145, including assessments of legume growth in the year following cereal harvest.

<u>Objective 6.</u> To identify ten primarily arable farms undergoing, or post, conversion. To record inputs and outputs and management decisions on these farms and prepare a financial analysis comparable to that in Objective 1.

Ten farms were identified and monitoring started with the 1995 harvest year. The farms range from Humberside to Oxfordshire and are on a range of mainly light soil types. Only two farms could be found with a stockless rotation, the others operate mixed livestock / arable rotations. Seven of the farms were fully costed to provide a management account, balance sheet and gross margin. The remaining three were parts of more complex businesses and could only be costed to gross margin level. Data have been analysed for 1995 and 1996 harvest, and analyses are underway for 1997 data.

In both years, all farms were financially viable and, on average, gave similar profitabilities to equivalent sized conventional farms as assessed by the Nottingham University Farm Business Survey. The most profitable farms grew potatoes and/or vegetables, although these were also associated with higher fixed costs. Beef and sheep enterprises were of relatively low profitability. This was mainly because on most farms the stock was conventional, not organic, meaning that there were no price premiums to compensate for the lowered intensity of production on the organic land. The negative effect of BSE on beef prices from March 1996 also reduced margins..

The results highlighted how well suited is the Terrington soil to arable organic production. For example, average winter wheat yield in 1995 was 3.5 t/ha compared with 6.8 t/ha at Terrington, and in 1996 it was 5.5 v. 10.2 t/ha. Potato results were more variable due to the lack of irrigation at Terrington, particularly in the very dry 1995. In 1995, yields averaged 26.6 t/ha on the linked-farms compared with 18.0 t/ha at Terrington. In the wetter 1996, the potential of the silt soil was evident with an average of 31.4 t/ha compared with 41.2 t/ha at Terrington. Variable costs on the linked-farms were similar to Terrington resulting both in generally greater crop gross margins for the main arable crops of potatoes and winter wheat, and a consistently greater projected whole farm margin from organic at Terrington (*Objective 1b*).

<u>Objective 7.</u> To set up an advisory group, to be chaired by MAFF, to meet twice per year to receive and comment on annual reports, to ensure that the work remains focused on the needs of the industry and MAFF.

A steering group was set up and has met as planned. The views and advice of the group have been very helpful to the contractor and the members have also been active in disseminating the results.

<u>Objective 8.</u> To communicate results of the project to MAFF and the industry.

In addition to the CSG12 annual reports, full annual technical and financial reports have been prepared for MAFF. All reports have been discussed by the steering group and their views incorporated in the final versions. In addition to steering group meetings, MAFF visitors to the project have included Andrew Cruikshank, Richard Carden, John Sherlock and Peter Costigan.

Conference papers were presented at the national Organic Farming Conference, Cirencester, in January 1997, and at an RASE Conference at Stoneleigh on 4 November 1997.

Posters were presented at a joint SFS/BGS conference on Legumes in Sustainable Farming Systems in Aberdeen in September 1996, and at the Royal Show each year.

Articles were published in Farmer's Weekly, New Farmer and Grower, and Crops Magazine.

The results of the pig finishing system were published in CAB Pig news and Information. A refereed paper on the legume comparison experiment is in preparation.

Interviews were broadcast by BBC Radio 4 in September 1996 and by BBC Look East Television in August 1997.

The project leader is an active member of Elm Farm Research Centre Arable Farmers Group, they visited Terrington on 22 July 1997. The Soil Association /BOF visited on 21 April 1998.

International links have been maintained through membership of EU ENOF Concerted Action AIR3-CT94-2143. (paper appended) The project leader attended meetings in Barcelona in 1992 and Ancona in 1997. A paper was presented in Ancona. A poster was presented at the 11th IFOAM International Conference, Copenhagen. This activity has been funded by EU and ADAS, not from this project.

Farmer groups and individuals, totalling several hundred, have visited and seen and discussed the work.

HRH Prince Charles made a private visit in March 1997.