CONVERSION TO ORGANIC MILK PRODUCTION

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FOREWORD

The Ministry of Agriculture, Fisheries and Food (MAFF) wants to encourage an increase in organic farming, recognising that this is one of the options available for more environmentally sensitive production. Expanding production will also help to meet the growing consumer demand for organic food and contribute to the Ministry's wider policies for minimising pesticide use and optimising other farm inputs. It is preferable that consumers buy British organic produce so that the environmental benefits of the farming system are enjoyed here.

An important issue is the impact of conversion to organic production on outputs and farm incomes. Following Competitive Tendering, MAFF contracted the Institute of Grassland and Environmental Research to carry out a 3-year study on the conversion of dairy farms to organic production. This publication reports the results of the study which was co-ordinated by Professor R.J. Haggar of IGER, with aspects of the work sub-contracted to ADAS and the University of Wales, Aberystwyth.

The study involved monitoring the conversion of IGER's Ty Gwyn dairy farm from conventional intensive production to organic production and study of ten commercial farms that were undergoing conversion in south west England and in Wales. The impressive body of evidence collected shows that the conversion process can be carried out with little long term impact on herbage or animal production, and relatively small effects on farm incomes. Grassland production fell by some 15% during the first year of conversion, but recovered to values similar to pre-conversion levels, yields of over 8 t dry matter per ha were achieved with swards having high clover contents. Average milk yields per cow were maintained during the conversion period, despite reductions in concentrate use of some 15%. The adoption of organic management did not give rise to any significant problems with mastitis or lameness. Reductions in variable costs resulted, on average, in increased gross margins per cow and, despite reductions in stocking rates, whole farm gross margins increased during the conversion period, albeit at a somewhat slower rate than comparable farms continuing to farm conventionally. The data suggest average costs of conversion of approximately £50 per ha per year in the first three years of conversion, but this average hides considerable variation. Once the conversion process has been completed, the results indicate that, with access to organic premium prices, farm profits should be at least as good as with conventional production, and they may even be higher. Certainly, at the moment, the demand for organic milk is strong.

The Ministry welcomes the results of this study which indicates a large potential for the efficient production of milk from organic systems and the ability to sustain production during conversion. This report deserves wide attention by farmers, policy makers and others in the agricultural industry.

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Chief Scientists Group, MAFF

Chairman, Project Steering Group

SECTION 1: EXECUTIVE SUMMARY

In the UK fewer than 50 dairy farms were registered as organic in June 1995. The slow increase of farmers willing to convert to organic milk production was seen as one impediment for development of the organic milk market. The overall objective of this joint 3-year project was to monitor the physical, environmental and financial implications of conversion to organic milk production on a research farm (Ty Gwyn) and ten commercial farms in south-west England and Wales, in order to provide policy makers and farmers with more information about the consequences of conversion. Although the size of the sample is comparably small it represents about 20% of all organic dairy farms in the UK and an even larger proportion of farms converting in the South Western region at the time.

Land use and farm management

The majority of the commercial farms, ranging from 45 to 450 ha and 37 to 320 dairy cows, were specialised dairy farms. They converted in two or more stages, which allowed for losses in forage productivity and financial costs and risks to be spread over a long period. Only on three farms (including Ty Gwyn) was all land converted in one stage. Forage area increased on most farms, to compensate for lower forage productivity in the early years of conversion; cropping area declined and some farms increased in land area.

Farmers converted for a variety of reasons: financial motivations; health issues and the use of alternative remedies; preference for extensive farming systems, and general environmental concerns.

Soil nutrients

Monitoring of soils at Ty Gwyn and on the commercial farms provided no evidence of a marked decline in pH or content of extractable P and K in soils during conversion. Nutrient indices for most of the fields were satisfactory and similar to those reported for non-organic fields. However, soil K in two-thirds of fields declined during the investigation and herbage P was sometimes less than recommended.

Nitrate leaching studies at Ty Gwyn indicated that soils in early winter contained similar quantities of potentially leachable N to those reported for other organically farmed or moderately fertilised grass fields. There was no evidence that cultivation increased nitrate leaching. Direct measurements of leaching in one field indicated that nitrate-N concentrations in soil water remained below 5 mg N/l. Concentrations of up to 20 mgN/l were measured in a second field, treated with applications of "dirty water" during the winter.

Calculation of whole-farm nutrient balances showed that inputs of N, P, K and Ca exceeded outputs in agricultural products. Nutrient budgets highlighted the importance of bought-in concentrates as a source of nutrients. The relatively low proportion of N input recovered in milk, together with additional input by fixation, resulted in significant surpluses of N, which may contribute to losses to the environment. Nevertheless, surpluses were less than those reported for intensive, conventionally managed dairy farms.

Herbage production

Following the cessation of fertilisers, herbage growth fell by 15% during the first year of conversion at Ty Gwyn but, by year 3, herbage yields had recovered to 93% of pre-conversion values. Similar trends were apparent on the collaborating farms.

The white clover content of the herbage at Ty Gwyn increased substantially throughout the transition, from less than 5% to over 30% by year 3. Red clover/Italian ryegrass proved particularly useful in filling the check in herbage production during the early stages of conversion, producing up to 14t DM/ha. Total herbage produced on a whole-farm basis increased during years 2 and 3, compared with year 1, allowing more herbage to be ensiled as conversion proceeded. Herbage quality also increased during conversion, due to earlier cutting for silage and the increased legume content.

There were wide variations in herbage yields between the collaborating farms. However, within any one farm, yield differences between the mean of the "best" and the "worst" fields (as selected by the farmers) were only about 25 per cent. Herbage yields were closely related to site class and level of available P in the soil.

Overall, the results illustrated that high levels (e.g. over 8t DM/ha) of grassland productivity are achievable from organic systems containing high levels of white clover.

Biodiversity

A grassland survey of the collaborating farms showed that during conversion there was an increase in ground cover of white clover and broad-leaved species, e.g. buttercups, dandelions and nettles, at the expense of perennial ryegrass.

Weeds, other than docks, were not considered a major problem on most farms; docks posed the greatest problem in newly sown leys, especially those cut for silage. Grazing appeared to reduce the presence of docks.

Trapping of small mammals along four young hedges at Ty Gwyn showed that, whereas numbers of wood mice and bank voles remained static during conversion, shrews began colonising the hedges a year or so after planting.

Five species of birds reappeared at Ty Gwyn during the course of conversion, whereas a further two species disappeared on the adjacent conventionally managed land of Lodge Farm.

Animal production

Average milk yields per cow for all commercial farms were similar to pre-conversion figures. Following conversion the average quantity of concentrates fed per cow was reduced by 15%. This led to increases in milk produced from forage per cow. Average fat and protein contents of the milk were similar to those recorded in conventional herds.

Initially stocking rates fell sharply, because of reduced forage productivity. However, in year 4 they were about 10% lower than in the last year of conventional management. The greatest reductions occurred on farms with stocking rates above 2 LU/ha before conversion.

An all-the-year-round calving pattern was considered essential for many of the farms as the organic premium was dependent on regular supplies of milk of consistent quality. Some farmers crossed Holstein-Friesian cows with breeds having genetically higher milk quality.

Animal health

No major health problems were recorded during the study and alternative remedies were used for the successful treatment of many ailments at both Ty Gwyn and on the collaborating farms.

On all farms many cases of clinical mastitis were treated with alternative remedies, with antibiotics only used for the more severe cases. The average number of cases of clinical mastitis was only slightly higher than on many conventional farms, despite the withdrawal of routine use of long-acting antibiotics in the dry period and the different approaches during lactation.

Although all of the organic herds continuously grazed clover-rich swards, the incidences of bloat were low. The number of cases of retained foetal membranes, metritis, fertility and milk fever problems were relatively low on all farms and there was no indication of mineral imbalance in the diets.

While local veterinary surgeons were supportive and knowledgeable in the use of alternative remedies on some farms, other farmers sought extra advice from veterinary surgeons from other areas and increased their own knowledge in the use of alternative remedies.

Economic performance

The initial reductions in milk production and stocking rate led to reduced milk sales, because most farmers were not able to obtain premiums in the first three years; reductions were compensated by increases in other dairy income (*e.g.* quota leasing), which led to a similar output per cow as for the national average of dairy farms of about £1,240 per cow in year 3 of conversion.

Reduction in variable costs of about 20% resulted in slightly better gross margin per cow and per litre milk in the first three years of conversion compared to the national average. In the fourth year of conversion most farms were able to sell some or all milk at a premium, which further improved dairy gross margins. Only one area lacked a market outlet for organic milk.

Even though milk was the major source of income, whole-farm performance did not follow the same pattern as the dairy enterprise, because of reductions in stocking rates. After initial reductions the over-all output returned to pre-conversion levels by the third year of conversion, of about £1,400 per ha (range £565 to £ 2,059), whereas similar conventional farms increased output during the study period. Reductions in variable costs led to steady increases in average whole-farm gross margins to £1,164 per ha in year 4, but the increase was smaller than for similar conventional farms.

Fixed costs, after an initial increase, returned to pre-conversion levels, even though average values were higher before conversion started than for the conventional cluster. The conventional group increased fixed costs in the same period at a higher rate.

Average Net Farm Income (NFI) increased from £201 per ha (range £-66 to £526) in the last conventional year to £244 per ha (range £-95 to £649) in the third year of conversion, after reductions (to approximately £170 per ha on average) in the first two years. Comparable conventional farms only showed a reduction (range £260 to £240 per ha) in what would have been the first year of conversion of the sample farms. The study farms achieved a better result (£271 per ha, range £-343 to £649) in the fourth year, once premium prices were available for more than half of the farms, but no data for conventional comparison is available for that year.

The average reduction in NFI was caused mainly by income losses on mixed and arable farms and specialist dairy farms that converted the whole farm in one year; other farms showed continuous improvement of the NFI per hectare.

On average, the farms incurred costs of conversion (difference between what the farm actually achieved and what it might have achieved had it followed the same trend as similar conventional farms) of approximately £50 per ha per year in the first three years of conversion. Higher costs of up to £185 per ha per year occurred on mixed dairy and arable farms and on rapidly converting specialist dairy farms, whereas those specialist dairy farms that converted in stages had no conversion costs and gained financially up to £180 per ha per year. However, because of the small sample size (10 commercial and 1 experimental farm), care is needed in the interpretation of the results.

Aberystwyth, 31 December 1995.

SECTION 2: GENERAL INTRODUCTION

By N.H. Lampkin, S. Padel and R.J Haggar

2.1 Background

2.1.1 Significance of the organic milk sector

As of 30 June 1995, there were 784 farms with 46,069 hectares certified organic or in-conversion in the United Kingdom. Of these, fewer than 50 farms were certified for organic milk production. Recent estimates suggest that approximately 7 million litres of organic milk are now marketed or processed annually (Campbell, 1995), with an emphasis on processing into yoghurts (Rachel's Dairy, Yeo Valley) and cheese (Welsh Organic Foods, Alvis Brothers and various farmhouse cheese makers). A limited amount of organic milk is sold through the liquid market. The location of certified organic milk producers (and the producers selected for this study) reflects the geographical location of the major processors and distributors as well as the more usual climatic and land quality constraints.

One factor behind the small scale of the organic dairy industry has been the slow growth in demand for organic milk and milk products, which has resulted in some organic farmers not opting for certification of the dairy herd because of a lack of a premium price available to justify the expense. Conversely, in some regions such as west Wales and south-west England, where demand is stronger, the long lead-in periods associated with conversion to organic milk production, and the lack of farmers converting their herds, have led to supply shortages and high transport costs, and have acted as a brake on expansion.

2.1.2 Conversion to organic milk production

Despite the relatively favourable results from comparisons of established organic and conventional dairy farms, the conversion or transition from conventional to organic farming systems is subject to a number of physical, financial and social influences which differ from those associated with established organic farming systems. The process is complex, involving restructuring of the whole farm system and a significant number of innovations due to new production and processing activities as well as changes in production methods. During the conversion process, the farmer needs to: adjust the stocking rate to the natural carrying capacity of the farm; improve soil fertility by introducing legumes into the rotation and swards; change the management of the system to maintain animal and plant health with the limited inputs available; work towards the establishment of a balanced and sustainable ecosystem (Lampkin and Measures, 1995; Padel and Lampkin, 1994a). This entails commitment to the approach and increased levels of observation, flexibility, skill, management expertise and confidence on the part of farm personnel. The time required and the difficulties associated with the necessary changes depend on a number of elements including: the intensity of conventional management and the condition of the farm before conversion; the extent to which new enterprises and marketing activities are introduced; and the possibility of additional yield and financial penalties related specifically to the conversion process.

2.1.3 Length of conversion period and conversion strategy

Organic production standards specify that land must be converted for at least two years before it may qualify for organic status (UKROFS, 1995). The dairy herd itself must go through an additional conversion period of at least three months, in which a diet conforming to standards must be fed. The 'minimum' conversion period is therefore 2 years and 3 months before the produce may be marketed as organic. Because grazing livestock often forage across the whole farm, dairy producers would be at a significant disadvantage compared with their crop-producing counterparts if they converted their farm in stages (see below), since it could take as long as 7-10 years to qualify for certification for milk, whereas individual crops would qualify after only two years. For this reason, UK standards permit feed rations consisting, on a dry matter basis, of: at least 50% organic, no more than 20% conventional, with the balance either fully organic or in conversion.

In practice, the conversion period lasts longer than specified by production standards and consists of different phases. The early stages of conversion usually involve visits to, and discussions with, other organic farmers, attendance at seminars and conferences, discussions with advisers and reading available literature. This information gathering exercise may then be followed by a 'trial' phase, or by a full-scale conversion. There are some difficulties associated with the 'trial' phase approach: although trying organic management on one field allows direct experience to be gained, it does not allow for the establishment of a whole-farm system, including the development of a suitable rotation with fertility building crops, the integration of livestock, and the management of the farm ecosystem for crop protection. An alternative strategy of gradual de-intensification can also be interpreted as a way of experimenting with the withdrawal of inputs, but again does not provide direct experience of organic farming as a complete system. The 'trial' phase can often be replaced by conversion planning, aiming to assess the feasibility of a conversion for the individual farm (Padel and Lampkin, 1994a; Lampkin and Measures, 1995). Conversion planning can help identify potential problems relating to labour requirements, other resource constraints, financial returns and cash flow, and may include steps to enhance animal welfare, environmental and nature conservation characteristics of the farm.

Once the decision to convert the farm has been taken, there are two main approaches which can be chosen:

Staged conversion: The desire to spread capital investments and to restrict learning costs during conversion, especially the costs of mistakes made with new enterprises or production practices, is a major reason why many farmers adopt a *'staged'* approach to conversion (Padel and Lampkin, 1994a). In the first year only part of the land is converted, typically 10-20 %. During this time, experience can be gained whilst the costs and risks are carried by the remainder of the farm still under conventional management. Once the implications of organic management are better understood and confidence has been gained, the remainder of the farm may be converted more rapidly. Another advantage of this approach is that fields can be transferred into organic management with a fertility-building legume crop. The length of time of a staged conversion varies from farm to farm.

Single-step: The alternative is to convert the whole farm in one step or *'all at once'*. This can have the advantage that the farm gains quickest access to premium prices, but it also means that the learning costs, capital investments and risks are concentrated into a short period of time and rotational disadvantages can arise because not all of the farm can be put down to fertility-building crops at the same time. The farm business needs to have sufficient financial flexibility to absorb these costs. This approach may be appropriate where a new business is being created and there is no established system to provide a 'cushion' (Lampkin, 1993). If mistakes are made, the impacts are likely to be severe. As a consequence, this approach may turn out to be more costly, despite the apparent attractions of earlier access to premium prices.

2.1.4 Crop and forage yields during conversion

There is some evidence of a decline in crop yields during the conversion period greater than that which would be expected in an established organic system, because biological processes such as nitrogen fixation and rotational effects on weeds, pests and diseases take time to become established. In a rotational system, these effects can be minimised by starting the conversion with the fertility-building phase of the rotation, such as a clover/grass ley, followed by cash-cropping after two to three years.

In many cases, conversion-specific yield reductions may be due to mistakes or inappropriate practices, such as the removal of nitrogen fertiliser without taking action at the same time to stimulate biological nitrogen fixation using legumes. These reductions can often be avoided when the farmer has access to information and the opportunity to learn about organic management before starting conversion, and with careful planning.

From the literature, no clear evidence exists that forage yields under established organic management have to be dramatically lower than under conventional management (Newton, 1992; Newton, 1994). Nevertheless, *livestock feed shortages* are reported frequently during the process of conversion to organic farming. Farmers may purchase more forage and concentrates than before conversion and they have also been observed to increase the forage area (Rantzau *et al*, 1990; Schulze Pals, 1994). Forage crops are the one area where conversion-specific yield decline may be inevitable, with production lost as a result of reseeding grassland with new mixtures containing legumes, or waiting for clover to become established naturally following the withdrawal of nitrogen fertiliser. The loss of output can place significant pressure on stocking rates for livestock on predominantly grassland farms, particularly where permanent grassland is involved.

2.1.5 Animal nutrition, health and welfare

For many consumers, some intensive farming systems include practices that are associated with unacceptably low standards of animal welfare, such as poor housing conditions, the use of hormones to stimulate production and the feeding of recycled animal wastes, that may pose a risk both to the health of animals to whom it is fed and to consumers of the animal products. The selection of high genetic merit cows with the potential for high milk production can also lead to other related responses which may be deleterious to the health and welfare of the cow (Webster, 1993). The feeding of unbalanced diets, including those with a high concentrate content, to boost the milk yield of the individual cow often increases total production but with the negative effect on the animal's immune system and health, particularly in relation to metabolic disorders. The high incidence of mastitis, lameness and reproductive problems in some intensively-kept dairy herds results in the routine use of large quantities of conventional medicines, high levels of stress within the herd and unacceptably high culling rates. Baars and Buitink (1995) reported significant relationships between the standard of housing facilities and the incidence of both disease and metabolic disorders.

Organic dairy farming has the potential to improve the acceptability of milk production to the consumer, by providing a management system that is more balanced in all aspects of livestock husbandry, resulting in less stress for the animals within the herd and the maintenance of high standards of welfare. Many of the problems associated with intensive systems can be reduced or eliminated by improving the facilities in which the cows are kept, reducing high stocking levels and providing a more balanced diet (Offerhaus *et al*, 1994).

Apart from the necessary changes in forage production, changing to organic management for the dairy herd involves further changes in the diet. The proportion of concentrates in the total ration is restricted to 40% and, if certification of the milk is envisaged, the dairy herd can only be fed a concentrate mix made up from acceptable ingredients, such as cereals and grain legumes, preferably from organic origin. Up to 20% of the ration may consist of conventional ingredients from a limited range of components, such as maize gluten, prairie meal, full fat soya and linseed cake.

Changes in animal health practices imply a move to preventive management rather than preventive treatment, which is potentially the most difficult area for many farmers to comply. By improving the level of stockmanship within the organic dairy herd and improving the immunity of the cow to disease, many problems can either be prevented or detected in the early stages of development and effectively treated with alternative remedies, without the need to routinely use conventional medicines. In many cases, the key issue during the conversion period is confidence to stop routine medication, such as dry-cow therapy, in favour of these alternative approaches.

Organic standards contain detailed animal welfare provisions, which are an important component of successful organic management. Outside access and housing appropriate to behavioural needs are required. Depending upon the system on the farm, some changes to the housing conditions might therefore be inevitable; a change to loose housing for the dairy herd, even though not strictly prescribed, might be seen as beneficial by the individual farmer and implemented as part of the conversion process. In terms of breeding, emphasis is given to maintaining a closed herd, rearing of the herd's own replacements and the feeding of whole milk to calves (Lampkin and Measures,1995).

2.1.6 Environmental impact and natural resource use

The environmental impacts of organic farming systems have been examined in a number of reviews (Arden-Clarke, 1988a, 1988b; Lampkin, 1990; Redman, 1992; Greenpeace, 1992; ADAS, 1995). These indicate potential benefits in terms of: improved soil fertility, organic matter content and biological activity; better soil structure and reduced susceptibility to erosion; reduced pollution from nutrient leaching and pesticides; and improved plant and animal bio-diversity, including the presence of many rare species. In addition, organic systems generally use fewer non-renewable resources such as fossil energy and mineral fertilisers, both per hectare and per unit of output.

However, most of the comparative studies of the environmental impact of organic farming have focused on arable production, and have compared established organic and conventional systems. Few, if any, have analysed changes in environmental impact either on grassland-based livestock farms or during the conversion period. Concerns have been expressed that negative environmental impacts may arise due to the ploughing-in of permanent grassland and/or inappropriate use of livestock manures and slurries, although these aspects are regulated by production standards. Little attention has been paid to the impacts on insect and bird life of the (re-)introduction of flowering clovers into grassland, and to the impacts of changes in fertiliser and herbicide use practices on grassland botanical composition, hedges and small mammal populations.

2.1.7 Labour requirements

Studies of the conversion process reviewed by Padel and Lampkin (1994a) indicate that increases in labour use over the conversion period are typically in the range 10 to 25% and are associated with: the introduction of more labour-intensive (but high-value) crops and/or production techniques; on-farm cleaning, grading, processing and marketing of produce; small-scale experimentation with new crops; increases in farm size. There may be conversion-specific increases in labour requirements associated with market development, innovations, and delays in labour-saving investments such as mechanisation due to cash flow constraints, but little evidence is available on this issue. There is little evidence that labour requirements for *existing* enterprises increase during conversion, although labour use per animal may increase where intensive livestock enterprises are converted to free-range systems.

2.1.8 Financial performance

A number of European studies have attempted to compare organic and conventional milk production (for reviews, see Lampkin (1993) or Padel and Lampkin (1994b)). In general, these studies indicate that milk yields per cow may be 10% lower and stocking rates 20-30% lower, resulting in milk yields per hectare 30-40% lower on organic farms than on conventional. Reductions in concentrate use (typically 35%) and in fertiliser use for forage production (typically 50% or more) result in similar gross margins per cow and higher gross margins per litre, even without the benefit of premium prices and despite sometimes higher prices for purchased organic cereals. On a per hectare basis, financial performance is generally lower unless significant price premiums (25% or more) can be obtained. The results from the limited previous UK studies are broadly in line with these generalisations (Table 1).

The evidence on whole-farm performance of specialist and mainly dairy farms in the United Kingdom is more mixed (Table 2). The variability, even between conventional farm groups, illustrates the need for careful selection of comparison groups with respect to farm type, size, location and other factors such as the role of on-farm processing.

From the results presented in Tables 1 and 2 it seems possible that, under certain circumstances, organic dairy farmers might achieve performance levels similar to conventional farming *without* recourse to premium prices. This may be due to resource use, efficiency gains from low concentrate/high forage diets, a shift from fertiliser inputs to clover as the source of nitrogen for forage production, and the added nutritional value of clover compared to grass (Holliday, 1989).

Table 1 Dairy enterprise performance, UK studies

	Houghton & Poole (1990)		Redman (1991)	
Year	1989/90		1990/91	
System (no. of farms)	Organic (11)	Conv. (a)	Organic (13)	Conv. (b)
Herd size	57	102	73	109
Stocking rate (LU/ha)	1.56	2.37	1.78	2.22
Output:				
Yield (l/cow)	4589	5049	5332	5838
Price (p/litre)	0.200	0.206	0.21	0.188
Total (£/cow)	1010	1111	1123	1095
Variable costs:				
Conc. use (kg/cow)	930	1448	1153	1462
Conc. cost (£/t)	155	139	154	132
Conc. cost (£/cow)	170	226	178	193
Forage (£/cow)	34	86	8	54
Total (£/cow)	310	425	186	247
Margins (excluding premium):				
£ per cow	700	687	764	848
p per litre	0.153	0.136	0.143	0.145
£ per hectare	1092	1628	1360	1883

a Milkminder, weighted to reflect breed composition of organic sample.
b Milkminder, not weighted for breed.

Table 2 Whole farm performance of dairy farms in the UK, 1989/90

	No. of farms	Size (ha)	Output (£/ha)	Variable costs (£/ha)	Gross margin (£/ha)	Net farm income (£/ha)	NFI (£/farm)
Murphy (1992)							
Organic	27	161	969	312	657	87	14071
Conv.	485	74	1590	695	895	318	23500
Lampkin (1994)							
Organic	6	37	1126	299	827	406	14870
Conv.	14	46	981	356	625	183	8413
Lampkin (1993)							
Organic	Case A	46	1582	376	1206	548	25317
Conv.	9	42	2593	975	1618	796	33352
Organic	Case B	102	1251	370	881	186	18894
Conv.	35	116	1247	481	766	185	21460

2.1.9 Conversion costs

The costs specific to the conversion process vary widely according to individual circumstances, arising from a combination of one or more of the following:

- *Output reductions* due to changes in husbandry practices, enterprise mix (including a possible conversion-related emphasis on fertility-building legumes at the expense of cash-cropping), or as a result of mistakes or inappropriate actions which could be avoided through improved information and planning.
- *New investments* in land, machinery, livestock, buildings, fences, water supplies, feeding systems, manure handling systems and other facilities, in particular when converting from very specialised arable or livestock systems - some of these may be financed by capital released through reductions in livestock numbers and sale of quotas.
- *Information and experience gathering* including direct costs, e.g. for literature, training courses, advisory services, study tours, seminars and conferences, and indirect costs, such as replacement labour to cover for absences on training courses and crop failures/poor performance where new enterprises or techniques are being tried out.
- *Variable cost reductions* as prohibited inputs are withdrawn and other inputs such as purchased livestock feeds are restricted - although some additional costs may be associated with reseeding grassland, establishing green manures and other fertility-building measures.
- *Fixed cost increases* - normally restricted to labour use, depreciation of conversion-related investments, and certification charges. Higher depreciation costs may also be associated with the writing-off of investments in discontinued enterprises (such as battery cages).
- *Lack of access to premium prices,* particularly for crops, during the official two-year conversion period. Where premium prices are available, significant *market development costs* may be associated with obtaining them.
- *Eligibility for subsidies,* including loss of eligibility for arable area or livestock headage payments, or cross-compliance restrictions on subsidies available to conventional producers, as well as access to support for conversion and environmental improvements.

2.1.10 Case studies of dairy farms in conversion

Case studies of the conversion of two English dairy farms (one specialist, one mixed dairy/arable) conducted before the 'CAP Reform' of 1992 indicated that conversion costs over a five year period could be up to £100 per ha per year for specialist dairy farms (Lampkin, 1993; Lampkin, 1994a).

Although stocking rates and arable crop yields declined on both farms due to a reduction in purchased feed and fertiliser use, milk yields from forage per hectare increased on both farms in relation to the previous conventional management. Changes in physical output levels and input use at the start of the conversion were also influenced by exogenous factors, such as the introduction of milk quotas in 1984. Lower variable costs on the specialist dairy farm compensated for output changes to give dairy gross margins similar in most years to the average for comparable dairy farms, even on a per hectare basis and without the benefit of premium prices. The reduced stocking rates on the mixed dairy/arable farm resulted in a lower gross margin per hectare despite similar per cow performance, a result more in line with the findings of other studies of organic milk production. Conversion-related expenditure was incurred on both farms, including modifications to farm buildings and advice, training and certification costs but the overall impact on farm financial performance was small.

Net farm income on the specialist dairy farm was comparable to the average for the conventional farms for much of the conversion period, but declined relatively and absolutely towards the end of the study. Any conversion-related income reduction was masked by economic circumstances affecting all dairy farmers. Net farm income on the mixed farm also followed similar trends to the conventional farms, reflecting wider economic pressures, although there is more evidence of a conversion-related reduction in income in this case, linked to changes in stocking rates, output and gross margins and without the benefit of premium prices. Premium prices obtained at the end of the study period were found to contribute £100 to £200 per ha per year toward net farm income.

The results from these case studies illustrate the need to relate performance assessments to the previous performance of the farms under conventional management, as well as to the performance of other conventional and organic farms. They also indicate the need for studies of the conversion process to be conducted over a sufficiently long time period for trends to become apparent.

In 1994 the UK government introduced the Organic Aid Scheme to support conversion to organic farming under the agri-environment measures of the CAP reform (EC, 1992) paying an average of £50/ha per year over five years in lowland areas and £10/ha in the Less Favoured areas of England and Wales. None of the studies conducted to date have analysed the impact of these payments on the costs of conversion to organic production, and none of the farms in the current study made use of the payments as part of the conversion process.

2.1.11 Key issues for research

A number of issues relating to the impacts of conversion arise from the previous research studies and anecdotal experiences reported by farmers:

- *Soil nutrient resources*. Within individual dairy farms, especially those situated in high rainfall areas, the cessation of fertiliser inputs, plus the constant cutting of grass for silage and the continuous removal of nutrients in the form of milk and meat products, represent a potential threat to soil nutrient reserves and pH levels.
- *Herbage productivity*. Following the cessation of fertiliser application, grass yields can be anticipated to fall at least until white clover becomes fully established in the sward. There is little information regarding the extent to which this reduced forage production leads to fodder shortages and reduced stocking rates, noting especially the need to build up forage reserves because of the virtual impossibility of purchasing organically grown forages.
- *Forage quality*. Although clover-based swards generally have higher nutritional values than all-grass swards, this may not be realised during the conversion period due to lack of experience with clover production and conservation. This may mitigate against the potential for reducing concentrate feeding.

- *Stocking rates.* There is some evidence that forage production during the conversion period leads to fodder shortages which may be countered by: purchasing additional feedstuffs or permitted fertilisers (e.g. organic manures); reducing livestock numbers; or by accepting reduced yield per animal. The extent and significance of these changes required evaluation.
- *Animal production.* There were concerns about possible difficulties of maintaining total milk production from the farm and raising milk protein levels to meet market demands.
- *Animal health.* Little information was available on the consequences of stopping the routine use of conventional medicines (e.g. antibiotics) on animal health status, especially mastitis. Similarly, more information was required on the effect of diet changes on the incidence of animal lameness.
- *Environmental impact.* Organic systems, once established, have the potential for increasing general levels of biodiversity and reducing pollution of ground water. However, during the process of conversion, disruptions associated with reseeding could lead to environmental costs.
- *Conversion-specific costs.* It is necessary to distinguish between cost and income changes which occur as part of normal organic management of a unit, and costs which are specific to the conversion process. Previous studies have left open questions about the extent of conversion-specific costs in relation to labour, capital investments and other fixed costs. It may also be difficult to disentangle more general, exogenous changes in variable input costs and output prices from those related specifically to the adoption of organic farming.
- *Innovations, information requirements, conversion planning, rate of change, and risk and uncertainty.* Little attention has been paid to the extent of the innovations and the related information requirements of conversion. Conversion planning and the adoption of staged conversions, are believed to reduce the risk and uncertainty associated with conversion. The relative costs and risks of different conversion strategies have not been compared in order to identify 'optimal' approaches.
- *Farm type and intensity.* Previous case studies (Lampkin, 1994a) focused on farms of moderate intensity and identified some significant differences between smaller, specialist dairy and larger, mixed dairy/arable farms. Some of the conclusions reported above might not hold for high-intensity dairy farms, or might be unique to the farms studied.
- *Production standards and two-year conversion period.* Organic production standards can place significant management constraints upon farmers, particularly during the conversion period when flexibility may be required. These standards require organic management practices to be adhered to, often without access to specialist, premium markets to provide recompense for output reductions or certification costs. This regulatory lack of access to premium prices may represent one of the most significant financial costs of conversion on arable farms, but little information exists as to its significance on livestock farms.
- *Impact of policy changes.* Following the CAP Reform, it is difficult to estimate the full impacts of changes in subsidy payments on previous conversion cost estimates. It is likely that the shift from commodity price support to arable area payments, and the introduction of quotas on eligibility for some livestock premiums, could have a significant impact on the financial performance of farms converting to organic production. Dairy farms are less likely than the other farm types to be influenced significantly by these changes due to differences in farm enterprise structure and the nature of policy support for dairying.

2.2 Objectives and work programme of this project

2.2.1 Main aims

The overall aim of the programme was to produce physical, financial and environmental data to support the development of organic milk production in response to consumer demand and in full compliance with the UK Register of Organic Food Standards (UKROFS) requirements.

The main thrust of the programme was to identify and monitor changes in physical resources, related financial costs and selected environmental benefits during the process of conversion from intensive conventional dairy production to organic milk status.

The broad approach involved (i) detailed monitoring during the setting up of a 63 ha self-contained organic dairy farm at IGER Trawsgoed, (ii) relating the physical and financial performance of this research farm with 10 other commercial dairy farms undergoing conversion to organic milk production, and (iii) comparing the findings to the performance of comparable conventionally managed dairy farms.

2.2.2 Specific objectives

(i) To convert the dairy unit at Ty Gwyn (which had previously been part of on all-grass dairy farm receiving about 380 kg N/ha per annum and heavily stocked with Friesian cows) to a self-contained organic dairy farm, by the most direct route.

(ii) At Ty Gwyn:

- (a) to measure annual changes in soil nutrient status on all fields and levels of nitrate leaching on selected fields.
- (b) to record total herbage produced on all fields and analyse for quality.
- (c) to monitor livestock performance by measuring milk output and quality, monthly changes in individual animal weight and body condition, and indicators of fertility.
- (d) to record incidence and treatment of animal ill health, with special reference to mastitis incidence (as indicated from weekly bulk milk bacteriology and cell counts) and lameness.
- (e) to monitor significant changes in plant biodiversity and animal wildlife, particularly birds and small mammals.

(iii) To identify 10 commercial dairy farms undergoing conversion, grouped in south-west England and Wales, willing to collaborate in farm recording.

(iv) On the collaborating farms:

- (a) to measure annual changes in soil nutrient status on 10 fields per farm.
- (b) to record total herbage produced from 4 fields (2 grazing and 2 cut for silage) per farm.
- (c) to carry out a general survey of the botanical composition on each farm.
- (d) to monitor livestock performance, as per Ty Gwyn.
- (e) to record incidence of ill health on each farm.

(v) To contrast the physical data (soils, plants, animals) collected from all farms with existing baseline data from conventional farms.

(vi) On the basis of the physical inputs and outputs (plus the associated costs and revenues) recorded at Ty Gwyn and on the 10 collaborating farms:

(a) to generate enterprise gross margins.

(b) to record fixed costs and calculate whole-farm results according to standard income definitions.

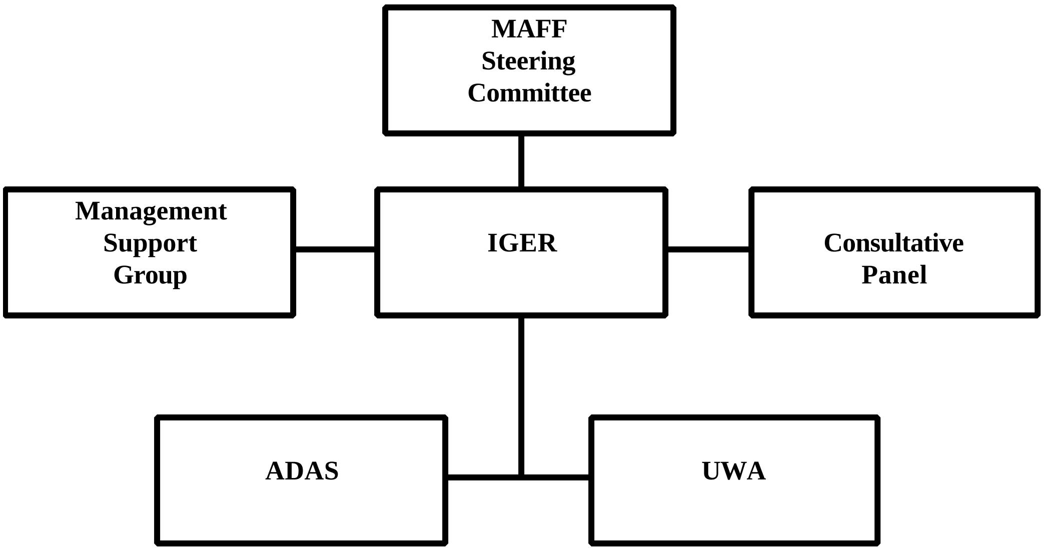
(c) to contrast the enterprise and whole-farm performance data against data from comparable conventional farms.

(d) to discuss the results in the context of the wider economic environment for dairy farming in England and Wales.

2.2.3 Organisation of work programme

The following diagram shows the links between the various organisations involved in the contract.

Figure 1 The organisation of the project



The roles of the participating organisations are outlined below.

MAFF Steering Committee

This Committee consisted of representatives of MAFF, the research collaborators and the dairy industry. It was responsible for advising, monitoring and commenting on the overall direction of the programme. It met every 6 months throughout the duration of the programme. Membership of the Committee included: J C Caygill (MAFF, Chairman), J Byng (MAFF, Policy Division), A Hacking (ADAS, Trawsgoed), R J Haggar (IGER, Secretary), P Holden (British Organic Farmers), M Houghton (Andersons), B Kenworthy (ADAS, Camarthen), P Midmore (University of Wales), C J Pollock (Director, IGER), G Rowlands (Rachael's Dairy), R Unwin (MAFF/ADAS), R J Wilkins (IGER, North Wyke) and L Woodward (Elm Farm Research Centre)

IGER

As the main contractor, IGER was responsible for:-

i. Setting up and running the farm at Ty Gwyn.

ii. Carrying out the bio-physical monitoring at Ty Gwyn and on the collaborating farms with special reference to soil nutrients, herbage production, animal production, and biodiversity.

iii. Issuing and co-ordinating sub-contracts to ADAS and UWA.

ADAS

ADAS was subcontracted to collect detailed financial records from Ty Gwyn and the 10 collaborating farms, as well as monitoring milk quality, cow lameness and small mammals at Ty Gwyn.

UWA

University of Wales, Aberystwyth, was contracted to supervise the collection of economic data on Ty Gwyn and the commercial farms, to carry out an analysis of the data and compare with data from conventional dairy farms. UWA also agreed to organise meetings of the Consultative Group and to produce a newsletter.

Management Support Group

This informal group, led by Gareth Rowlands and supported by Nic Lampkin and Bruce Kenworthy, met frequently, especially during the early stages of setting up Ty Gwyn, to advise the farm manager on practical aspects of organic grassland farming, including assistance with drafting the Conversion Plan.

The Consultative Panel

This group of 10 commercial dairy farms in the process of conversion to organic farming was selected to provide information about their experiences with the conversion. This group, referred to from the outset as the Consultative Panel, was also involved in commenting on progress of the conversion at Ty Gwyn and on conversion issues in general.

2.3 The participating farms

2.3.1 Farm selection

The task of identifying a representative group of ten farms, each with a significant dairy enterprise, either starting on, or in the process of, conversion to organic production, proved to be quite complex. For reasons of geographical likeness and easy gathering of information, it was decided to look for farms in the more westerly areas of England and Wales. Those selected needed to agree to extensive observations of both the biophysical and business aspects of their farms, and also to participate in the consultative group.

At the time of selection, the general economic environment for dairying was not conducive to risky changes in management. Since some prospects of future aid schemes for conversion existed, it was possible that some prospective farms delayed their decision until this question was settled. At the time the study started it was not possible to identify 10 farms that were at the beginning of their conversion process and were committed to aim for certification of the farm in the future. Therefore, the decision was taken to include farms in the sample which were some way through the conversion process. Table 3 summarises the steps taken to arrive at the final farm selection. In addition to 10 commercial farms, for which whole-farm data could be obtained, an eleventh farm, for which costings from two dairy herds (conventional and organic) could be obtained, was included.

Table 3 Summary of farm selection procedure

Action	Comments	No. of farms identified
Contact with relevant organisations	UKROFS, the Soil Association, British Organic Farmers, The Organic Advisory Service and British Organic Milk Producers	55
Initial letter followed by phone call	Farmers no longer considering conversion, or insufficient commitment	24
	Conversion too advanced	14
Visits and further phone calls	Two farms in very early stages and unsure of commitment	10-initial sample
	Ill-health	
	Dairy herd too advanced in conversion	
One farm leaves the study	Two farms added from the four rejected above, as changed circumstances no longer make them unsuitable	11

After the withdrawal of one of the original ten farms, two other farms were considered suitable for inclusion (the farmer whose health was poor decided to continue dairy farming and a second farm was no longer marginal). Both farmers could supply sufficient records for a socio-economic analysis of the whole conversion period. It was decided to include them both bringing the sample up to eleven, as in the event of the loss of another farm, the study could still be completed with the intended number of ten. This resulted in the final distribution of the farms being: two farms in Somerset and three each in Devon, Dyfed and Gloucestershire. A full description of these eleven farms and their resources is provided in Section 2.3.2.

The sample of farms included in this study does not, for obvious reasons, meet the rigorous criteria necessary for full statistical significance. Nevertheless, our socio-economic monitoring covers virtually the whole of the very small population of farms converting to organic dairy husbandry over the period of research in south-west England and Wales: we have treated each almost as a separate case-study. Although this in itself is not sufficient to make generalisations about how farms which subsequently convert might fare, at present it is the only basis from which fresh evidence and insight into the dynamics of the process can be drawn. It has also established an important link between economic researchers and the wider organic movement that facilitates the study of conversion strategies, rapid feedback of the understanding gained into farming practice, and the development of policy towards the organic sector which more effectively meets its objectives.

The invitation to join the Consultative Panel was received positively by the farmers of the sample, but two problems arose: the distance and the fact that most of the farmers, before joining this project, were already active members of other organic farming organisations. The Consultative Panel met twice on different farms: the first meeting was held in the first year at Ty Gwyn, to give members an opportunity to get to know the farm and to become familiar with the research. The next meeting was held jointly with the Organic Advisory Service dairy group at a farm in Somerset. It included an extended farm walk in the morning and presentations about dairy cow feeding and information on the progress of the research in the afternoon. A third meeting was planned to be held at one farm in Wales but had to be cancelled due to seasonal farming pressures. All farmers were invited to participate in a Seminar on organic livestock production held at IGER in May 1995, which was preceded by another farm walk at Ty Gwyn. A walk on the farm where the third meeting was to have occurred was arranged so that the farmers could make the most of their trip to Wales. The farmers received three newsletters during the first three years that contained details about the meetings, information about the conversion at Ty Gwyn farm and some interesting results of research at Trawsgoed.

2.3.2 Description of Ty Gwyn and the commercial farms

This section briefly describes the participating farms in this study. Due to the small sample size, knowledge of the specific circumstances on the individual farms is important for the interpretation of the results, but has to be presented in a way which does not offer the possibility for the farms to be identified.

Farm history and tenure

Like Ty Gwyn, two of the commercial farms were taken over by the present owner shortly before or during the study period and some changes during the process of conversion can be attributed to the take-over, rather than the conversion as such; even so it is difficult to separate the two. On two different farms, important personnel (the herdsman, farm manager) changed during the period of conversion. On one farm, a substantial arable enterprise went into set-aside during the conversion to organic farming. Two farms had high borrowing for the size of the farm, in one case related and partly attributed to other income from non-farming activities and, on the other farm, as a result of previous management.

Of the ten commercial farms in the study, for which whole-farm data could be obtained, three were tenant family farms, five farms were owner-occupied, one of them was run by a family partnership. Two farms were run by farm managers and employed farm staff.

Farm size and type

Ty Gwyn, with 67.4 ha (62.8 ha after the exclusion of field experiments), was smaller than the average ofthe commercial farms. The ten commercial farms in the sample had an average farm size of 162 ha UAA (Utilisable Agriculture Area), ranging from 45 to 459 ha. They fell into two categories, with seven farms under 90 ha UAA and four farms over 200 ha UAA. There were no farms between 90 ha and 200 ha UAA in the sample.

The total forage area was on average 75%, varying from 65% to 100% of the land area. Ty Gwyn was like two commercial farms, an all-forage farm with no cash crops grown. Eight of the ten commercial farms in the sample were growing some cereals or other crops before the beginning of conversion, ranging from 4% to 43% of the land area.

For all eleven farms (including Ty Gwyn) the standard gross margin and business size was calculated, following similar procedures as the Farm Business Survey-Wales. In their final conventional year the commercial farms had an average of 55.6 British Size Units. On the basis of the contribution to Standard Gross Margin (STGM) from the main enterprises the farms were classified into farm types. Before the conversion to organic farming started, eight farms including Ty Gwyn were specialised dairy farms (over two-thirds of STGM from dairy), two farms were mixed dairy farms (between 40% and 66% of STGM from dairy, 30% to 50% STGM from arable) and one farm was mainly arable (more than two-thirds of the STGM from arable).

Dairy and other grazing livestock

Ty Gwyn with 2 LU/ha (Table 4) was stocked relatively higher than the commercial farms (average stocking rate of 1.8 LU/ha) before conversion started. With 132 dairy cows before conversion started, Ty Gwyn had a greater herd size than the average for all the commercial farms in the study, reflecting the fact that no dairy herd replacements were being reared. Cow numbers on the commercial farms varied from 33 to 320 dairy cows; the farm with the lowest cow number was in the process of building up a dairy herd. In all cases, the dairy herd was the biggest grazing livestock enterprise, the dairy herd and dairy replacements representing 58% of all LU on one, and over 75% on all other farms.

The average milk yield at Ty Gwyn (5024 litres per cow) was just below the average for all the farms in the study and also below the average for dairy herds in Wales with over 80 cows (FBS, 1993). The dairy cows in the 10 herds had an average performance of 5150 litres of milk, ranging from 4500 to 5900 litres per cow. The farmers used between 550 and 2300 kg of concentrate per cow. All but one farm had Holstein Friesian (HF) or some combination of Friesian with HF cattle; the remaining farm had an Ayrshire herd.

Table 4 The eleven farms in the study

	Dairy farms								Mixed dairy		Arable	Mean[b]
Farm	*TG*	*12*	*11*	*4*	*10*	*9*	*2*	*3*	*1*	*7*	*5*	
Last conventional year	1991	1990	1989	1990	1989	1990	1989	1988	1988	1989	1990	
Organic symbol	1994	1993	1996	1992	1997	1995	1994	1992	1993	1993	1996	
Conversion steps	1	1	1	2	2	2	3	3	7	3	4	
Dairy STGM (%)[a]	100	100	75	95	80	75	90	85	40	65	20	**85**
BSU[a]	40	25	120	25	35	135	15	40	85	25	215	**55.6**
Stock rate (LU/ha)	2.0	1.8	1.6	1.4	2.5	1.5	1.7	2.0	2.3	1.9	1.7	**1.8**
Dairy cows (No)[a]	130	70	135	70	70	320	40	90	105	50	100	**113**
Dairy output (% total)	98	79	62	82	68	95	62	76	38	62	34	**75**
Milk yield (l/cow)[a]	5,000	5,500	4,800	4,500	5,200	5,400	5,000	6,000	5,000	5,400	4,800	**5,205**
Concentrate (kg/cow)[a]	1,220	2,015	550	770	690	1,325	1,115	1,705	1,435	605	2,340	**1,166**

[a] Numbers rounded to nearest 5; [b] Averages are based on original numbers; TG=Ty Gwyn.

2.3.3 Comparison with conventional data

To judge whether the farms in the sample were typical for dairy farms in the UK, comparison of a few selected parameters with conventional data from several sources was carried out. The farms in their last conventional year were individually compared with a group of conventional farms, selected from Farm Business Survey (FBS) data by cluster analysis (see Section 4 for details) and with the closest matching group from published FBS data (1992, 1993 and 1995) from the Universities of Aberystwyth, Exeter and Reading. Averages were calculated for these individual farm comparisons. In addition, the average for all the farms in the study were compared with the Genus Milkminder data (see Table 5).

The size of the farms in the sample was higher than the average for the published FBS. The stocking rate was considerably lower than the data for Genus Milkminder farms in 1989/90 (Thomas and Perry, 1991) but higher than for the published FBS data and higher than the average for the specially selected clusters. The average milk yield was lower than the average of Genus Milkminder for England and Wales but higher than for the published FBS data. From the greater farm size and lower milk yields per cow and the lower stocking rate compared to Genus Milkminder farms, it can be assumed that at least some of the farms in the sample were producing extensively before the conversion started. This was supported by some of the farm managers (or farmers) who expressed in the interviews that their farms were managed extensively before the conversion started. However, this conclusion is not justified for all farms, as some farms in the study were stocked higher and achieved milk yields higher than their conventional cluster before the conversion to organic management started.

Table 5 Comparison of the 11 farms with conventional data

Comparison with other data	Average 11 farms last conventional year	Average for clusters (see Sect. 4)	Average for published FBS data (Aberystwyth, Exeter & Reading)	Genus Milkminder 1989/90 (Thomas and Perry, 1991)
Size (ha)	153	148	110	N/A
Stocking rate (LU/ha)	1.83	1.66	1.74	2.25
Milk yield (litres/cow)	5,205	5610	4472	5601

2.4 Recording Methods

In this section the data collection methods for Ty Gwyn and the commercial farms are outlined briefly. A more detailed description of the methodology, together with the results and discussion, is given in Sections 3 and 4.

2.4.1 Ty Gwyn research farm

Starting in spring 1993, all grazed fields were sampled monthly, using exclosure cages, for dry-matter yield, digestibility and crude protein content. Every trailer load of grass cut for silage was weighed and the ensiled forage was analysed for quality.

Milk output and quality were recorded (based on monthly returns from the Milk Marketing Board), together with incidence and treatment of diseases, parasites and lameness, plus monthly changes in individual animal live weight and body condition. Incidence of mastitis was carefully monitored by: (a) weekly bulk sampling of milk, for total bacterial and cell counts; (b) monthly individual cow cell counts; (c) bacteriology of all clinical samples, both pre- and post-treatment.

Total volumes and mineral content of slurry produced were estimated, based on the number and content of trailer loads. Soil from all fields was sampled down to 20 cm each spring and analysed for pH and extractable P and K using conventional methods of analysis. Losses of nitrate by leaching during each winter were estimated in selected fields by: (a) measuring mineral-N in the soil profile at the end of the growing season, at 20 cm sampling depths down to 80 cm; (b) direct measurement of nitrate leaching using ceramic cup samplers for collecting soil water.

The botanical composition of all grass fields was measured, together with population densities of major weeds, e.g. docks (*Rumex obtusifolius*). Four hedges were planted to act as wildlife corridors between isolated woodlands. Bird numbers and species were recorded at appropriate times, using standard monitoring protocols.

The economic monitoring included farm costings and budgets for the last conventional year and the whole of the conversion period, was carried out by ADAS. The results were further evaluated and compared to the commercial farms and a conventional comparison group by UWA.

2.4.2 Commercial farms

Monitoring of crop and livestock performance was carried out less comprehensively than on Ty Gwyn farm. Nevertheless, 10 grass fields per farm were assessed for nutrient and weed status. On each farm, two high and two low yielding (as identified by the farmer) grass fields were selected, each split for either grazing or silage cutting management. As from April 1993, herbage on offer immediately prior to harvesting (using exclusion cages on frequently grazed fields) was sampled and analysed for nutritive value. For animal production, general information was collected on the breed, housing system, calving season and size of the herd. From the dairy costings, data on milk yield and concentrate used were obtained for the whole conversion period. The health status of the herd was monitored throughout the study period.

Further physical and financial information on individual enterprises was collected, based on the farm accounts, which were supplemented by additional information from dairy costings and invoices. All farms were able to supply at least financial records for previous years, back to the last conventional year before conversion started. For reasons outlined above, the sample of the commercial farms included farms that started their conversion in different years (further details in Section 4.2). Wherever results from different farms are compared Year 0 refers to the last conventional year, Year 1 to the first year of conversion and so on. In addition all farmers were interviewed in the final year of the study about their experiences with the conversion of the farm.

SECTION 3: PHYSICAL ASPECTS OF CONVERSION

After first reporting on changes in land use and farm management practices during conversion of the study farms (section 3.1), this section concentrates on the biophysical aspects of conversion, with special reference to changes in soil nutrients (3.2), forage yield and quality (3.3), biodiversity (3.4), animal production (3.5) and animal health (3.6).

3.1 Changes in land use and farm management during conversion

By S. Padel

3.1.1 Introduction

This introductory part of the report describes the process of conversion on the farms in the study, how the principles of the standards were followed on the farms, what major changes and innovations were implemented and what overall experiences occurred during the process of conversion.

3.1.2 Methodology

Two different approaches were used. Firstly, changes in cropping pattern and land use were obtained from the analysis of the financial accounts and dairy costings of the farms. The methods of analysis are described in more detail in Section 4. Secondly, all farmers were interviewed in the last summer of the study period. For the open interviews, a guideline was used covering the areas of: motivation to convert, experience with the conversion, major problems arising, and strategic changes in the management of the farm. The questions were kept open, encouraging the farmers to talk about the areas that were most important to them. All interviews were taped and transcribed in full and a computer package was used to assist with the analysis of unstructured data. Reference to these interviews will be made in the discussions which follow, concerning the physical and financial monitoring of the farms.

3.1.3 Results

Ty Gwyn

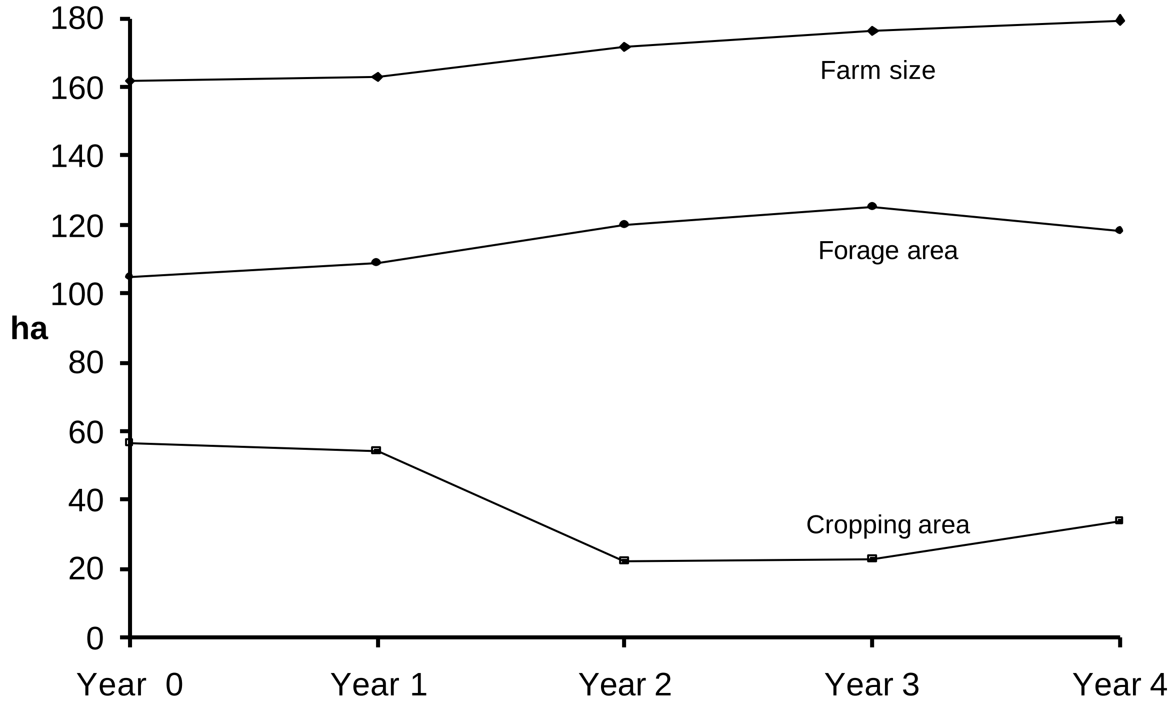
The research farm at Ty Gwyn had been taken over by IGER during the year before conversion started. The overall aim of the conversion was to establish an organically managed dairy farm (in accordance with UKROFS standards) as rapidly as possible. It was therefore decided to convert the whole farm at once and the last "non-permitted" fertiliser was applied in the summer of 1991. Further aims were to meet the herd needs as fully as practicable from on-farm resources and to maintain the size of the dairy enterprise, with special emphasis on milk quality in order to meet local market opportunities. Forage yields were anticipated to be at least 20% lower during the first year of the conversion and the overall farm size had to be reduced from 67.4 to 62.8 ha to accommodate separate EU research trials. The number of dairy cows was therefore initially reduced to 70, but herd replacements (16 followers) were subsequently kept on the farm. The aim was to increase cow numbers again, once the forage yields had improved. This was achieved after the second year of conversion. Production targets for the dairy herd included spring calving and a lactation yield of just under 5000 litres and using close to 0.5t DM of cereal concentrates. A crop rotation with 2 years of cereals, a medium-term ley (4 years of white clover/perennial ryegrass) and short-term ley (2 years red clover/Italian ryegrass) was set up on the 40 ha of cultivatable land. From the second year onwards much of the permanent grassland and long-term swards were slot-seeded with white clover seed, variety Menna. Because of the high rainfall and lack of grain drying facilities, plus the need to maximise forage supplies, the cereal crops were harvested as arable silage. Livestock breeding, culling, rearing and health policies were all in accordance with best practices, paying particular attention to animal welfare, longevity, life-time yield, milk quality, lameness and mastitis prevention. The aim of the manure policy was to collect, store and return all liquid and solid animal wastes to the short-term leys, in early spring and after the first silage cut, and to potassium-deficient permanent pasture. Further details of the conversion of Ty Gwyn can be found in the Conversion Plan, which is lodged in the IGER library.

Problems and experiences: No major problems were recorded at Ty Gwyn with the required changes from conventional to organic farming introduced progressively during the period. The main challenge was to increase the level of crop production by introducing a crop rotation and by the replacement of the old unproductive swards with white clover-based swards. Another change which took longer to implement was the replacement of a conventional concentrate cube feed with a number of separate ingredients acceptable for feeding to the organic dairy herd. Both the purchasing of regular supplies of these feeds and the lack of suitable on-farm storage facilities were additional problems encountered during the early part of the conversion period. The introduction of the use of alternative remedies and the withdrawal of the routine use of conventional medicines, including antibiotics, also took longer to introduce. This was due primarily to the cautious attitude of both the herdsman and the visiting veterinary surgeon in their approach to the introduction of alternative remedies for the treatment of specific ailments (see also Section 3.5).

Commercial farms

In contrast to the development at Ty Gwyn, the average farm size of all farms increased by 10% (see Fig. 2). This was caused by three farms increasing their size during the process of conversion, by between 10 and 75 %. The reminder stayed the same. The total forage area increased in the majority of cases (on average by 17%), as a result of increased farm size and reductions in the cropping area. Only on three farms did the cropping area increase; in two cases (Farms No 2 & 12) because cereals were introduced into the rotation of a previous all-forage farm and, in the case of Farm 1, a mixed farm, as a result of a substantial increase in farm size. Farms No 3 and 10 stopped growing cereals during the conversion process, in one case because the conventional small scale cereal growing was felt to be no longer viable. This helped to reduce the intensity of stocking on the forage land. The only mainly arable farm in the study (Farm 5) used three-year set-aside as a way to introduce organic agriculture.

Fig. 2 Changes in average farm size and land use



Motivation to convert: In the interviews farmers were asked why they were converting their farms to organic management. In two cases, where the decision to convert was taken by the owner and not the farm manager, the answers reflected the motivation of the farm manager to get involved in organic management. All farmers mentioned several reasons for converting, so the numbers in the following summary of the motivations come to more than the number of farms in the study. Financial motivations were mentioned by seven farmers, covering the desire to cut costs (five answers) as well as the perspective to be able to sell milk for a premium (three answers). Health problems with the cows were mentioned by one farmer, whereas contact with homeopathy or other alternative treatments (for people as well as for animals) was mentioned by four farmers. Four farmers stated that they had always preferred extensive systems and two farmers specifically mentioned their liking for clover-based farming. Three farmers cited general environmental concerns as a motivation to convert to organic farming.

Nine of the ten farmers in this project had received some advice during conversion, mostly from the Organic Advisory Service: nearly all reported that visiting other organic farmers was important before or during the conversion period. A joint seminar by Unigate and MMB had been attended by several farmers in Devon and was described as useful for the decision to convert. In two cases farmers had discouraging experiences with conventional advisors.

Conversion strategy: Of the eight specialised dairy farms in the sample, three converted the whole farm at once (Farms 11, 12 and Ty Gwyn) and five farms (Farms 2, 3, 4, 9 and 10) converted in stages. The reasons for an all-at-once conversion varied between the two other commercial farms. In one case, rapid conversion was chosen because of a potential market outlet for the milk. However, the conversion coincided with a drought and the feeding of the cows was a major problem in the first winter following the rapid conversion. In the other case, the farmer felt that the farm had initially been fairly extensive, so a rapid change would not affect the farm greatly. The farms that converted in stages used relatively few conversion steps (two steps: Farms 4, 9 and 10). In these cases the grazing land was converted before the silage ground because it was felt to be easier and, once some clover had been grown successfully, confidence in the new management system increased. This was also the case for the farmers that converted in three steps (Farm 2 and 3). One of these farmers indicated that after 10% of the land area went into conversion in the first year on a trial basis, the final decision to convert the whole farm was made a year later and all the land was brought in over the subsequent two years. All three mixed or arable farms (Farms 1, 5 and 7) converted in stages, and the period over which all the land was changed varied from three to more than seven years (see Table 4). Farm 1 was initially intending to only convert some cropping land. After the decision had been taken to include the livestock enterprises into the conversion as well, the land was then brought in with the fertility-building phase of the rotation. Farm 5 also converted in stages, but with the use of the set-aside scheme. As a result of the different conversion strategies the farms qualified for the symbol of the dairy herd in different years of the conversion (See Section 4.3).

Problems and experiences: Apart from the difficulties with forage production in the case of Farm 11 the overall experience from the farmers' point of view with the conversion was positive, even though some problems and uncertainties were encountered during the process. One farmer mentioned a serious problem with slugs destroying the clover on heavy clay soil, leading to a loss in production; eel worm was also a problem in the red clover fields. In another case the major pest threatening forage production were rabbits. Further problems with forage production included weed control in a lucerne crop and the separation of in-conversion and organic forage in the clamp. Animal health and treatment was also mentioned in several cases as an area of great uncertainty; specific problems included drying off, mastitis, control of parasites and trace elements (see Section 3.6). Marketing of organic milk proved a major problem in Devon, where none of the farms had access to a special outlet.

3.1.4 Discussion

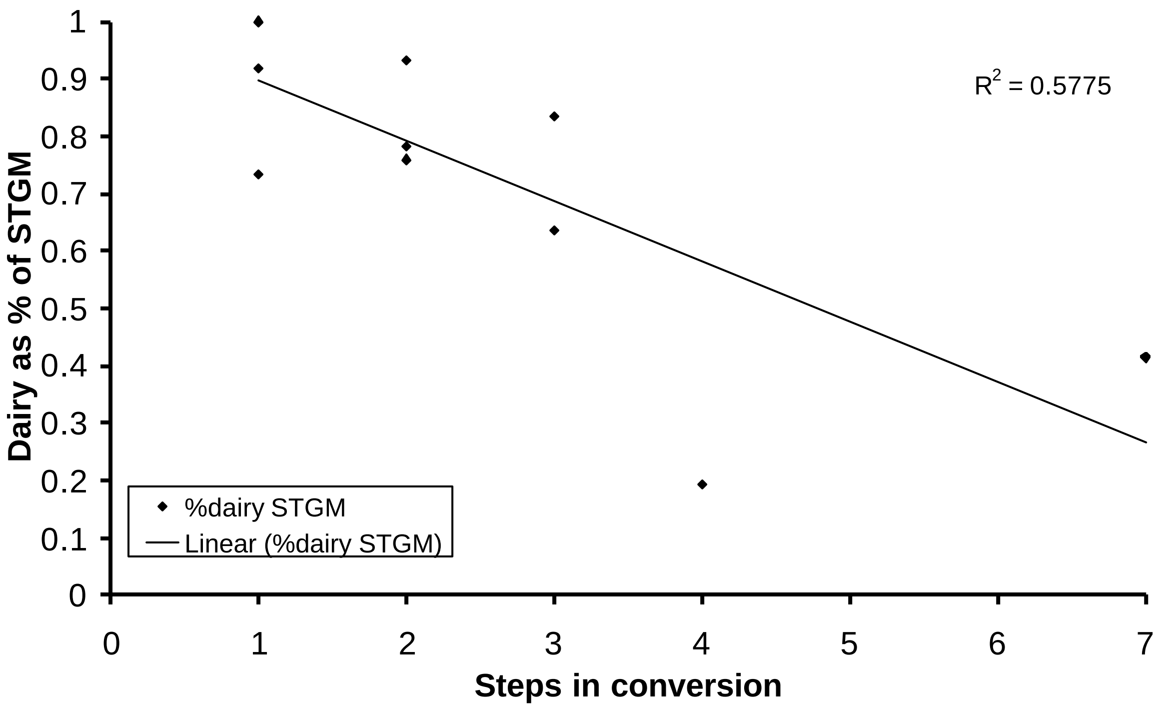
The tendency to increase *farm size* and forage area, as occurred on some of the commercial farms, has also been found in previous case studies of dairy farms converting to organic production (Lampkin, 1993) and two German studies (Rantzau *et al.*, 1990; Schulze Pals, 1994). Farms were found to increase their size to compensate for a loss in forage productivity or to increase the area for home grown cereals without losing forage area.

Changes in *land use* have been reported widely for arable and mixed farms in conversion to organic farming. They are commonly associated with the introduction of forage legumes and other fertility-building crops at the expense of cash crops in the rotation (Padel and Lampkin, 1994a). A case study of a specialist dairy farm found considerable changes in land use, particularly later in the conversion, but this was accompanied by the introduction of milk quotas and the need to restrict milk production (Lampkin, 1993). However, for most of the farms in this study, land use did not change greatly; reduced cropping on two farms was compensated by increases in cropping on others. The majority (eight of eleven) did not grow their own cereals for feeding. This can be explained by the difficulties associated with harvesting, storage and handling of small amounts of home grown cereals and the relatively good availability of appropriate concentrates, in most regions of the study.

Motivation: The range of motives mentioned by the farmers in this study was similar to those found in other studies. As also observed in other studies, financial motives are mentioned more frequently by farmers converting now than 10 or 15 years ago. Mac Rae (1990) related this to the general economic situation of farming in the developed world, but it can also be argued that it is related to the greater commercial orientation of the farmers that convert today, or to a greater financial attractiveness of organic farming where premium prices are available.

Conversion strategy: The majority of the commercial farmers (8 out of 10) opted for a staged conversion process, which allowed confidence in the system to increase gradually and spread the risk of reduced forage production over several years. The number of steps to include all land area in the conversion varied between farms from two to more than seven. It appears that the conversion process was shorter on the specialised dairy farms than on the mixed farms (see Fig. 3), which is reflecting the regulation in the organic standards for dairy cows under which premium can only be achieved if more than 50% of the diet is fully organic (SA, 1995).

Fig. 3 Farm type and steps in conversion



3.1.5 Conclusions

The predominantly positive impression reported by farmers about their experiences over the conversion period confirms that specialist dairy farms can be converted to organic management without too many difficulties. However, most of the commercial farmers that participated in this study either received specialist advice with planning or planned their conversion carefully. Whether or not advice of such kind will be available in the future for all farmers willing to convert is uncertain. The problems and uncertainties experienced by Ty Gwyn and the commercial farms in the area of forage yields, diet composition and animal health problems, discussed here and in following sections, highlight areas where further improvement of the process of managing conversion might be possible.

3.2 Soil nutrients

By S.P. Cuttle, E.L. Jones and P.J. Bowling

3.2.1 Sampling methods and calculation of nutrient balances

Nutrient content of soils, from Ty Gwyn and collaborating farms.

All fields at Ty Gwyn, plus ten fields on each collaborating farm, were sampled annually during 1993-95. The contract started in October 1992 and since all farms were identified by early 1993, soil sampling began in April 1993, thus allowing 3 years' data to be collected, analysed and interpreted during the course of the contract. Soils were sampled in the spring of each of the three years to assess changes in nutrient levels over the transition period. Although soil sampling at the end of the growing season could have provided a better indication of nutrient deficiencies and comparative data from individual fields, this would have meant that only two years' data would have been obtained during the course of the contract. Because it was anticipated that some fields would be ploughed during the transition period, soils were sampled to 20 cm to include the full depth of the plough layer, rather than sampling to 7.5 cm for grassland, or 15 cm for arable land, as normally recommended for advisory purposes (MAFF, 1985). (Elm Farm Research Centre recommends depths of 15 cm for routine sampling of grassland and 20 cm for arable fields.)

Soil samples were taken by auger at 10 random locations (on a grid basis) in each field. Samples were air dried, crushed and sieved and the less than 2mm fraction analysed using standard methods (MAFF, 1985). Phosphorus was extracted from soil with sodium bicarbonate solution at pH 8.5. Potassium was extracted with ammonium nitrate solution. Soil pH was measured in a freshly stirred suspension of soil in water, using a glass electrode.

Additional soil samples were collected from selected fields at Ty Gwyn in August 1994 to examine the extent to which the 20 cm sampling depth used in the current investigation influenced analysis values compared with the standard depth of 7.5 cm as used by ADAS for grassland. Soil cores were collected from 0-7.5 cm and 0-20 cm depths on five fields. Three of the fields (numbers 16, 18 and 19) had received slurry in the year of sampling, while Fields 3 and 20 had not. Three bulk samples were collected for each depth in each field, each bulk sample being composed of 10 individual cores. After air-drying and sieving, the samples were analysed by the methods described above.

Phosphorus and potassium contents of herbage samples were also determined as an indirect measure of soil nutrient status. At Ty Gwyn, herbage samples were collected from beneath exclusion cages on all grazing fields and from random points within silage fields prior to harvesting (see Section 3.3). On the collaborating farms, phosphorus and potassium contents were determined in herbage samples collected in July from two cut and two grazed fields on each farm (see Section 3.3) (only the grazed fields were sampled in 1993).

Nitrate leaching, Ty Gwyn.

Direct measurements of nitrate leaching.

Ceramic cup samplers were installed in Fields 2 and 19 in early December 1993. Ten samplers were installed in each field at a uniform sampling depth of 0.75 m. Samplers were arranged in pairs with a 2 m spacing between paired individuals and 25-40 m separation between pairs. Soil water samples were collected from January 1993 onwards, initially at weekly intervals but the frequency was reduced to fortnightly collections from autumn 1994. Concentrations of nitrate and ammonium-N were determined in all samples with additional analyses of total-N contents in selected samples. Drainage volumes were initially determined from the hydrological balance. Four monolith lysimeters were installed at Ty Gwyn in October 1994 and these were used to provide values for drainage volumes after this date.

Both fields were under permanent pasture with a moderately high proportion of white clover and were used for grazing. Soils in the areas of the fields where the samplers were installed are mapped as free-draining brown earths of the Rheidol series. During winter 1993/94, it was necessary to pump surface water from the farm slurry store to prevent the store from overflowing. Part of this "dirty water" was sprayed onto Field 2, at a rate of about 180 x 10^3 l per ha.

Measurements of mineral nitrogen contents in soil profiles

Soil cores were collected from eleven fields at Ty Gwyn between 20 October and 8 December 1994. These fields were selected to represent a range of soil types and managements. Twenty cores were collected from each field with sampling points evenly distributed in a W-shaped pattern. Where possible, soils were sampled to a depth of 0.8 m in 0.2 m increments. However, soils were frequently too shallow or too stony to allow sampling to the full depth, and in these cases, cores were taken from the maximum depth possible. After collection, soils were stored at 4^0C overnight before preparation and extraction the following day. All samples were analysed separately. The fresh soils were sieved and the <6 mm fraction weighed and mixed before subsampling for moisture determinations and extraction with 1M KCl solution (30 g fresh soil: 150 ml extractant). Aliquots of the centrifuged extracts were frozen and stored for subsequent determination of nitrate and ammonium-N contents. These values and corresponding soil weights were used to calculate the quantity of mineral-N (nitrate + ammonium-N) in each core section and in the full soil profile at each sampling point. Values were expressed as kg N/ha on the basis of the sectional area of the corer.

Between 20 March and 10 April 1995, a second series of cores was collected from six of the previously sampled fields in order to measure the residual content of mineral-N after winter. These fields were selected to avoid those that had been treated with slurry in the weeks immediately prior to sampling. Sampling and analytical procedures were the same as described above.

Nutrient balances, Ty Gwyn

Whole-farm balances of inputs and outputs of nitrogen, phosphorus, potassium and calcium were calculated for Ty Gwyn for the three years (April-March) 1992/3, 1993/4 and 1994/5. Estimates were derived from measured quantities where possible, supplemented by values from the literature where necessary. Individual inputs and outputs were calculated as follows:

(i) Inputs. Nitrogen fixation was calculated separately for each field from the total herbage yield and proportion of clover in the sward, assuming annual fixation rates of 40 kg N/ha per 1000 kg yield of red clover and 54 kg N/ha per 1000 kg of white clover (van der Werff *et al*., 1994). The input was determined for each field area and the sum of these values used as an estimate of the input by fixation to the farm as a whole.

Inputs of nutrients in purchased concentrates were calculated from farm records of the quantities of feed purchased and fed to cattle, combined with values of nutrient contents obtained from merchants' specifications, by measurement and from the literature (Preston and Linsner, 1985). Quantities of nutrients in straw purchased from outside the farm were calculated from farm records of the quantities of straw used and measured concentrations of nutrients in straw samples. Calcium inputs as lime were calculated from records of lime applications to individual fields, assuming a calcium content of 34%.

Nutrient inputs in rainfall were calculated assuming an annual input of 7 kg N/ha, annual rainfall of 1200 mm and contents of 0.003 mg P/l, 0.23 mg K/l and 0.7 mg Ca/l (Allen, 1989; Adams and Evans, 1990; Cuttle *et al*., 1992; Cuttle and James, 1995).

(ii) Outputs. Outputs of nutrients in milk were calculated from records of volume of milk produced and protein content, and values of phosphorus, potassium and calcium contents from the literature (Paul and Southgate, 1978; Agricultural Research Council, 1980). Quantities of nutrients exported from the farm as livestock were calculated from records of animals sold, approximate body weight and published values of composition (Agricultural Research Council, 1980).

3.2.2. Results

The farm at Ty Gwyn was monitored in greater detail than the other farms in the study and data are therefore presented for Ty Gwyn separately as well as in combination with those for collaborating farms. Where data are presented separately, and unless stated otherwise, they refer to all fields at Ty Gwyn. When Ty Gwyn is grouped with the collaborating farms, only 10 fields are included (selected on the same basis as those on the other farms) in order to avoid bias.

Phosphorus in soils and herbage

Ty Gwyn

The mean phosphorus content of soil from fields at Ty Gwyn was similar to the overall mean of all farms in the survey (Table 6). However, there were marked differences between values in the different sampling years. The mean phosphorus content of soils collected from Ty Gwyn in 1994 was almost double that measured in 1993 and then fell to an intermediate value in 1995 (Fig. 4). In the case of individual fields, phosphorus contents of soils collected in 1995 were greater than those in 1993 in 80% of the fields sampled. Contents were lower in 9% of fields and remained unchanged in 11% (n=35).

All farms

The overall mean calculated from the phosphorus content of soils from all fields on all farms in the study was considerably lower for samples collected in 1993 than for either of the following two years (Fig. 4). With the exception of Farm 5, means for individual farms were all lower in 1993 than in 1995. The relatively high mean for Farm 5 in 1993 was associated with a single, particularly high value of 163 mg P/l measured for one field in that year. Considering individual fields on all farms, measurements of extractable phosphorus in soils sampled in 1993 and 1995 indicated that contents had increased in 77% of fields. Contents had declined in 10% and remained unchanged in 13% of fields (n=104).

In none of the sampling years was there a consistent relationship between the phosphorus content of soils and the stage of conversion. Fig. 5 shows the extractable phosphorus content for individual fields sampled in 1995 and grouped according to the year in which the conversion process had started. There is no indication of a decline in phosphorus content with increasing period of organic management. Although the figure suggests a slight tendency for contents to increase in the initial years of conversion, no such trends were apparent in the data obtained in 1993 or 1994. It might be expected that any change in nutrient content would be greatest in the years immediately following the cessation of fertiliser use. If this were so, differences between soil phosphorus contents in 1993 and in 1995 would be greatest in those fields where the conversion process had started most recently; however, there was no relationship between the magnitude of any change and the year of conversion.

Table 6 Mean contents of extractable phosphorus and potassium and pH of soils for individual farms (means of values for soils sampled in 1993, 1994 and 1995)

Region	Farm name/no.	Extractable P (mg/l)	Extractable K (mg/l)	Soil pH
Dyfed	Ty Gwyn	20.8	124	5.8
	2	17.0	119	6.0
	7 [a]	(16.1)	(132)	(6.1)
	12 [a]	(14.3)	(153)	(6.2)
Devon	4	28.2	155	6.2
	10	19.8	140	5.9
	11 [a]	(25.7)	(137)	(6.1)
Somerset	3	21.7	208	6.8
	6 [b]	(9.6)	(197)	(6.7)
	9	19.8	207	7.3
Gloucester	1	16.1	160	6.9
	5	23.5	283	7.1
	8	24.7	200	6.9
	Mean	19.8	170	6.5

[a] *Means of data for 1994 and 1995 only.* [b] *Data for 1993 only.*

Fig. 4 **Contents of extractable phosphorus in soils sampled between 1993 and 1995: means of fields at Ty Gwyn and of all farms in the study**

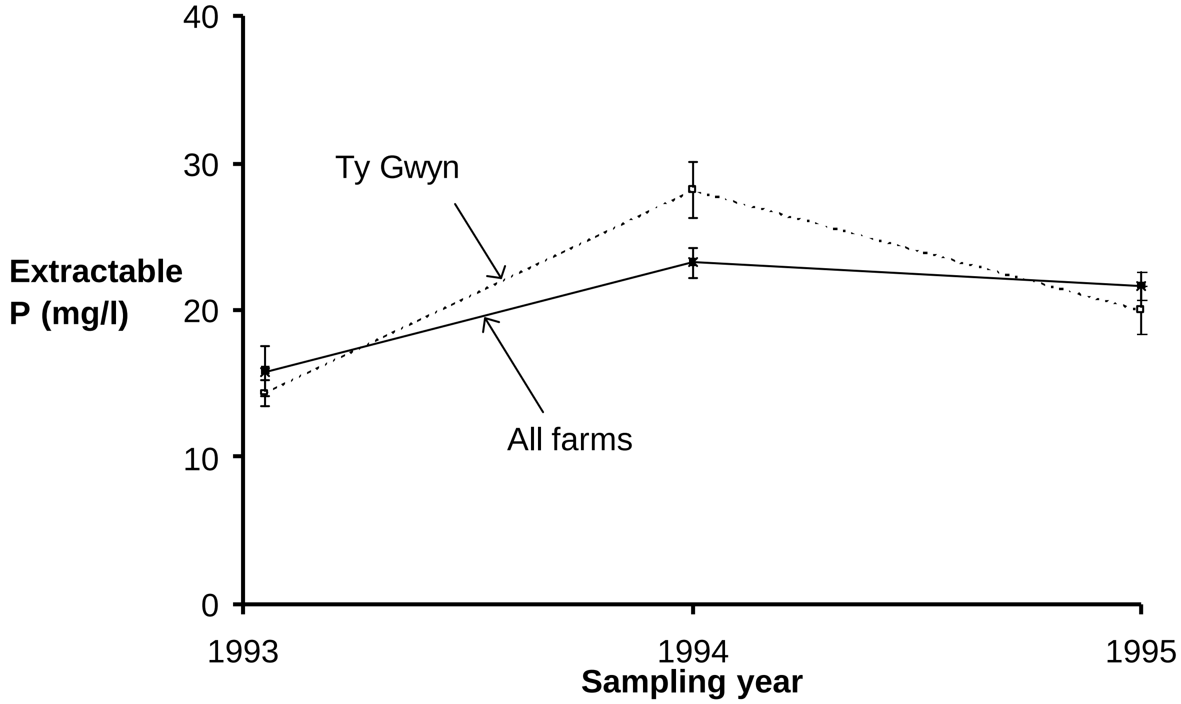
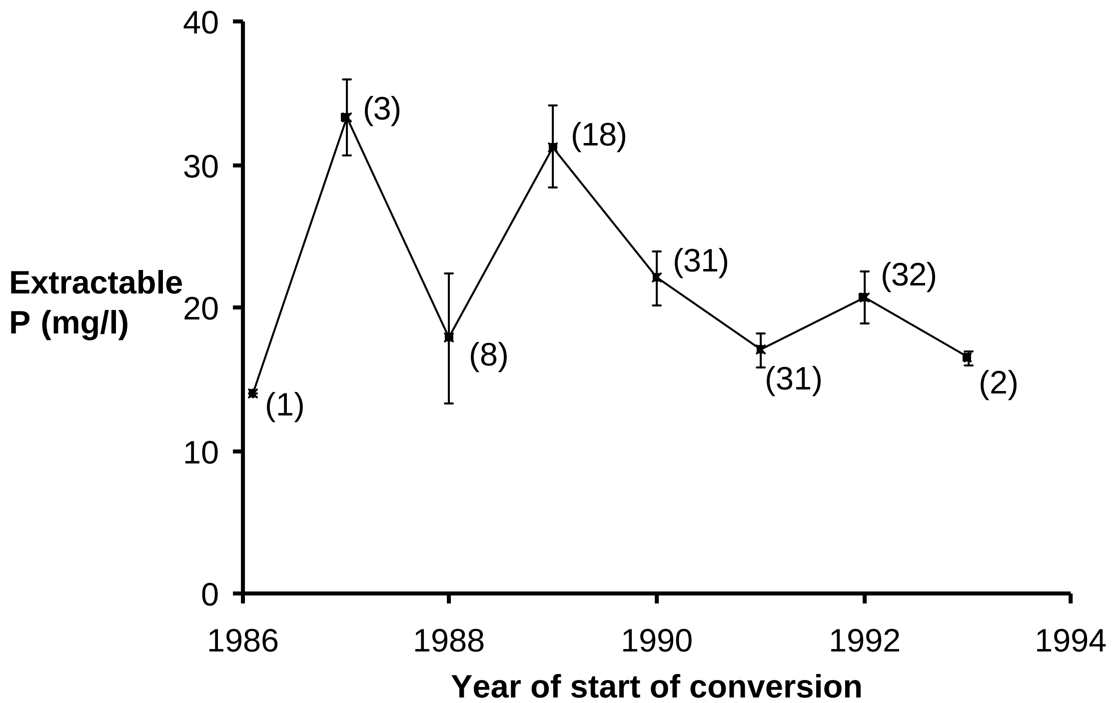


Fig. 5 **Contents of extractable phosphorus in soils from all fields in 1995, grouped according to the year in which conversion started (group means with bars denoting ± standard errors and with the number of fields in each category)**



There were no marked or consistent differences between the mean phosphorus contents of soils from fields that were cut for silage and those that were grazed (Table 7). In 1993, the mean content for cut fields was slightly less than that for grazed fields but this was reversed in the following two years. There was no relationship between the extractable phosphorus content for individual fields and either the age of grassland or the frequency of manure or slurry use.

The phosphorus content of herbage samples collected in different years varied less than the corresponding contents of extractable phosphorus in soil. In contrast to soil contents, which were appreciably lower for samples collected in 1993 than for those in later years, mean concentrations in herbage from grazed fields were similar in all three years (Table 7). Only in the case of samples collected in 1995 were these herbage contents significantly correlated with phosphorus contents in soil ($P<0.05$). The correlation was no longer significant when data for cut fields were included. The phosphorus content of herbage from cut fields was not significantly different from that from grazed fields.

Table 7 Mean content (±SE) of phosphorus in soil (mg/l) and herbage (% DM) samples from grazed fields or cut fields on collaborating farms during 3 years (n = number of fields in each category)

Material	Management	1993 (n=18)	1994 (n=24)	1995 (n=24)	Mean
Soil	Grazed	15.3 (1.87)	20.6 (1.55)	19.8 (1.98)	18.6
	Cut	13.0 (1.65)	22.5 (2.01)	21.0 (2.06)	18.8
	Mean	14.2	21.5	20.4	
Herbage	Grazed	0.34 (0.017)	0.33 (0.014)	0.34 (0.012)	0.34
	Cut	-	0.33 (0.013)	0.30 (0.014)	0.32
	Mean	-	0.33	0.32	

Potassium in soils and herbage

In 1993, extractable potassium contents of soils that were greater than 250 mg K/l were simply reported as >250 mg/l. Although all contents for subsequent years were expressed as actual values, this grouping of high concentrations for the 1993 data limits the comparisons that can be made between potassium contents in different years.

Ty Gwyn

Mean contents of extractable potassium in soils at Ty Gwyn were amongst the lowest of all farms surveyed (Table 6). In contrast to soil phosphorus contents, the mean potassium content for Ty Gwyn was appreciably lower for soils collected in 1994 than for those in 1993, then rose slightly in 1995 (Fig. 6). Excluding the one field where the content was reported as > 250 mg/l in 1993, 85% of fields at Ty Gwyn exhibited a lower content when sampled in 1995 than in 1993; contents for the remaining 15% all increased in this period (n=34).

All farms

In common with Ty Gwyn, soils from the other farms surveyed in Dyfed and those in Devon all contained less extractable potassium than soils from farms in Somerset and Gloucester. The overall mean of the potassium content for all farms was lower for samples collected in 1994 than in 1993 but in 1995 was similar to the initial value (Fig. 6). There were 24 fields, out of a total of 104, where the potassium content in 1993 was expressed as >250 mg/l. Hence the true mean would have been greater than that reported and the reduction in content between 1993 and 1994 would have been greater than that indicated. Excluding those fields with contents >250 mg/l in 1993, 66% of individual fields contained lower contents of potassium when sampled in 1995 than in 1993. Contents in 23% of fields increased in this period.

In no year was there a relationship between soil potassium contents in particular fields and the stage of conversion. Data for contents measured in 1995 are shown in Fig. 7 but there was a similar absence of any consistent trends in the data sets from other years. As with phosphorus, there was no indication that changes in potassium content of soils between 1993 and 1995 were any greater in fields where conversion had only recently started than in those at a later stage of conversion. Variations in extractable potassium content were not related to age of the grassland or to the frequency of manure and slurry applications.

Potassium contents of soils from cut fields were consistently less than those for grazed fields (Table 8) but the difference was only significant in 1995 ($P<0.05$). In all three years, the mean content for cut fields was less than that for what were selected as the "worst" grazing fields, which in turn contained less potassium than soils from the "best" grazing fields.

Concentrations of potassium in herbage varied in a similar manner to those in soils. Contents in herbage sampled from grazed fields in 1994 were lower than those in 1993 but increased again in 1995. In spite of this broad agreement, and as with phosphorus, correlations between herbage and soil contents for individual fields were only significant for samples collected in 1995 ($P<0.05$). In this case, inclusion of values for cut fields improved the closeness of the relationship ($P<0.01$).

Table 8 Mean content (±SE) of potassium in soil (mg/l) and herbage (% DM) samples from grazed fields or cut fields on collaborating farms during 3 years (n = number of fields in each category)

Material	Management	1993 (n=18)	1994 (n=24)	1995 (n=24)	Mean
Soil	Grazed	208 (11.7)	172 (19.2)	238 (33.4)	205
	Cut	171 (14.9)	124 (15.2)	140 (17.9)	145
	Mean	189	147	189	
Herbage	Grazed	2.53 (0.130)	2.41 (0.125)	2.61 (0.113)	2.52
	Cut	-	1.87 (0.109)	1.89 (0.077)	1.88
	Mean	-	2.14	2.25	

Fig. 6 Contents of extractable potassium in soils sampled between 1993 and 1995: means of fields at Ty Gwyn and of all farms in the study

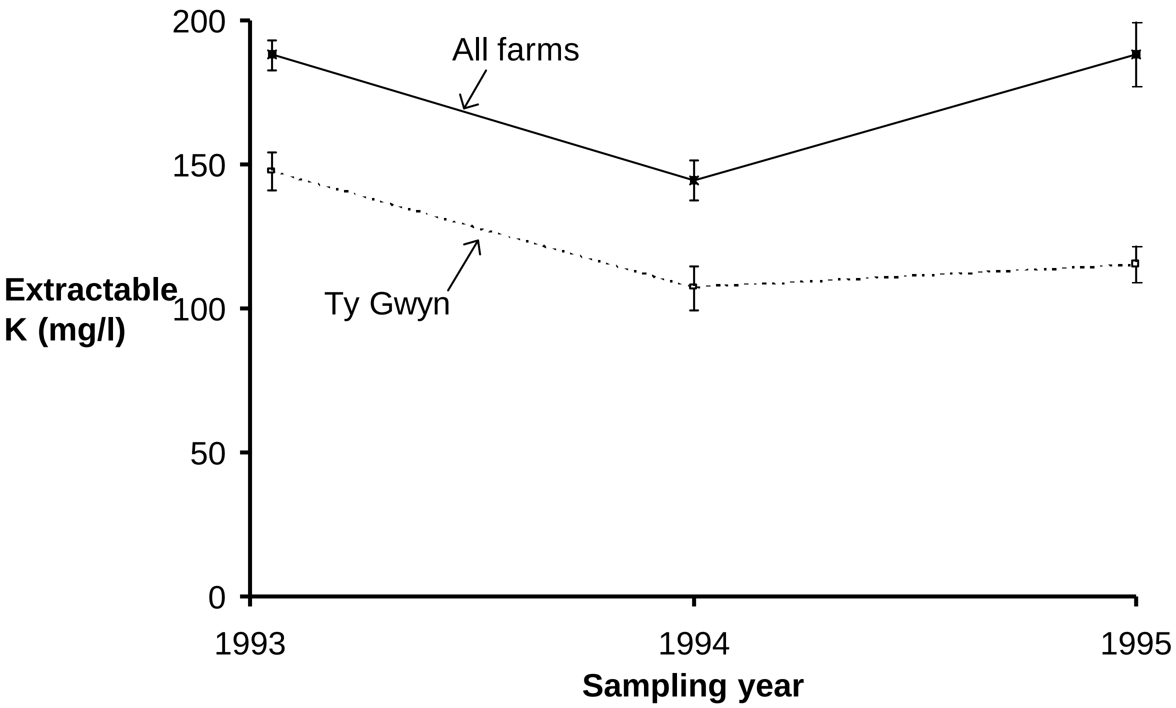
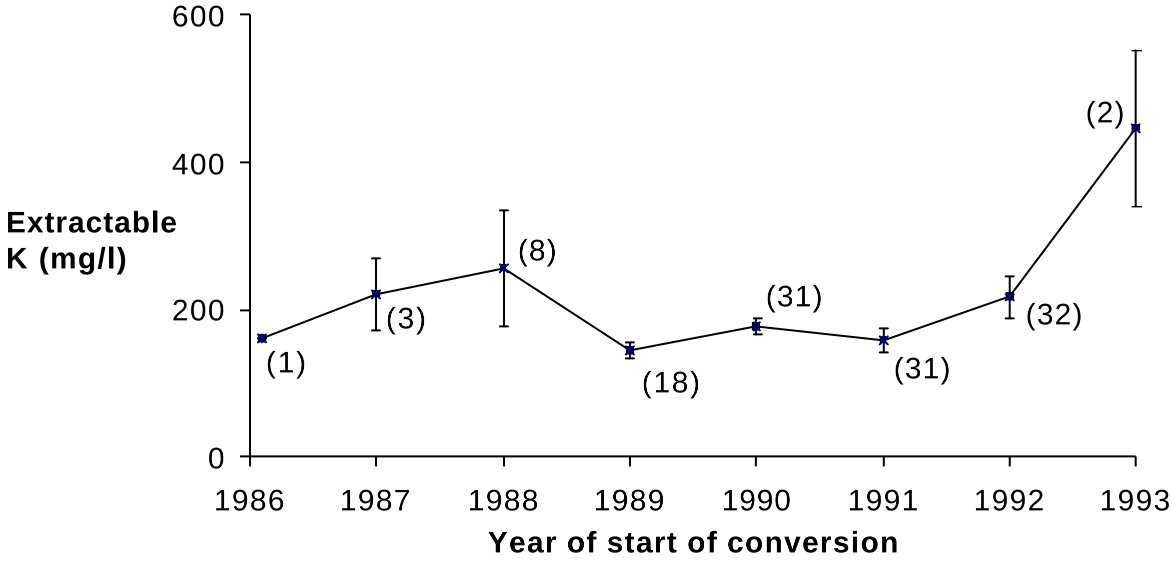


Fig. 7 Contents of extractable potassium in soils from all fields in 1995, grouped according to the year in which conversion started (group means with bars denoting ± standard errors and with the number of fields in each category)



Soil pH

Ty Gwyn

The mean pH of soils at Ty Gwyn was the lowest of all farms in the survey (Table 6). The mean for soils collected in 1995 was the same as that measured in 1993 but was slightly lower in 1994. Of the 35 fields monitored at Ty Gwyn, soils in 49% were more acidic when sampled in 1995 than in 1993; 31% were less acidic and 20% remained unchanged.

All farms

As with potassium contents, mean soil pH values for each of the surveyed farms in Dyfed and Devon were less than those for farms in Somerset and Gloucester (Table 6). The overall mean of all farms varied in a similar manner to that measured at Ty Gwyn. The mean pH of soils in 1995 was similar to that in 1993 and slightly lower in 1994 (Fig. 8). Mean values for individual farms either remained unchanged or fell slightly between 1993 and 1995. In only three cases did the change represent a reduction of greater than 0.1 pH units, and then did not exceed 0.3 units. The proportions of fields where pH increased or decreased between 1993 and 1995 were similar to those at Ty Gwyn with acidity increasing in 53% of fields, decreasing in 30% and remaining unchanged in 17%.

Again, there was no indication that soil pH was influenced by the stage of conversion. Mean pH values for fields grouped according to the year in which conversion started are shown in Fig. 9. Although the data refer to soils collected in 1995, corresponding graphs for 1993 and 1994 were of a similar form. In no year were the pH values of soils from grazed fields significantly different from those for fields that had been cut for silage (Table 9). In all three years, mean pH values for individual farms were significantly correlated with mean contents of extractable potassium ($P<0.01$).

Table 9 Mean pH (±SE) of soils from grazed fields and cut fields on collaborating farms during 3 years (n = number of fields in each category)

Management	1993 (n=16)	1994 (n=24)	1995 (n=24)	Mean
Cut	6.7 (0.11)	6.2 (0.10)	6.4 (0.12)	6.4
Grazed	6.7 (0.18)	6.1 (0.10)	6.4 (0.13)	6.4
Mean	6.7	6.2	6.4	

Fig. 8 pH of soils sampled between 1993 and 1995: means of fields at Ty Gwyn and of all farms in the study

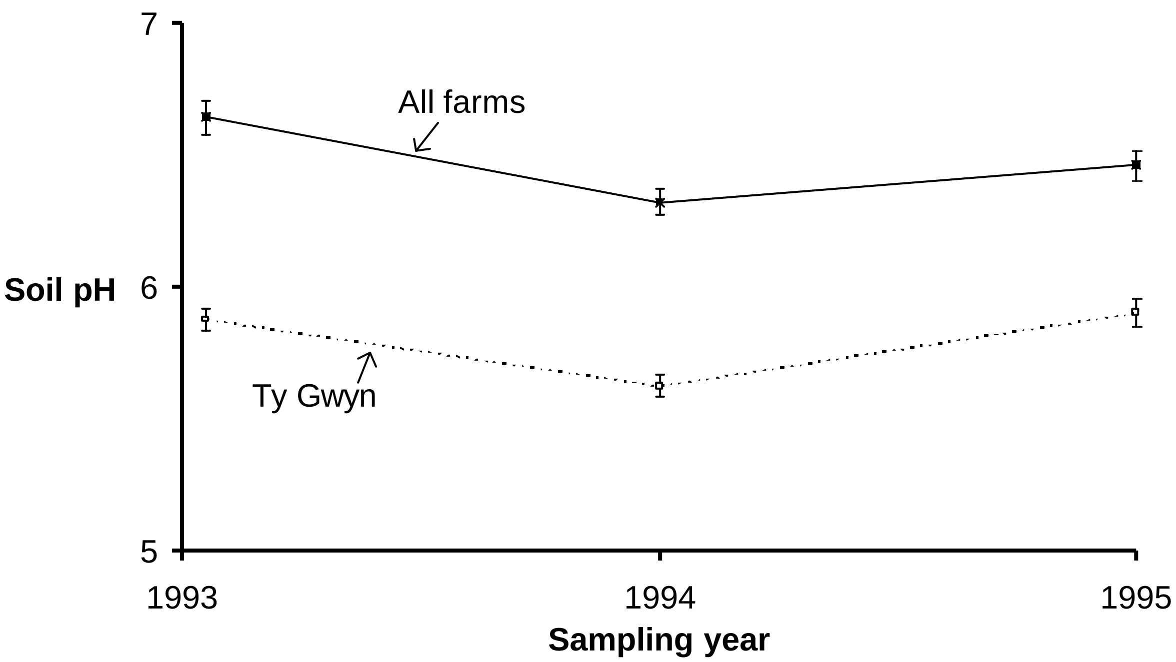
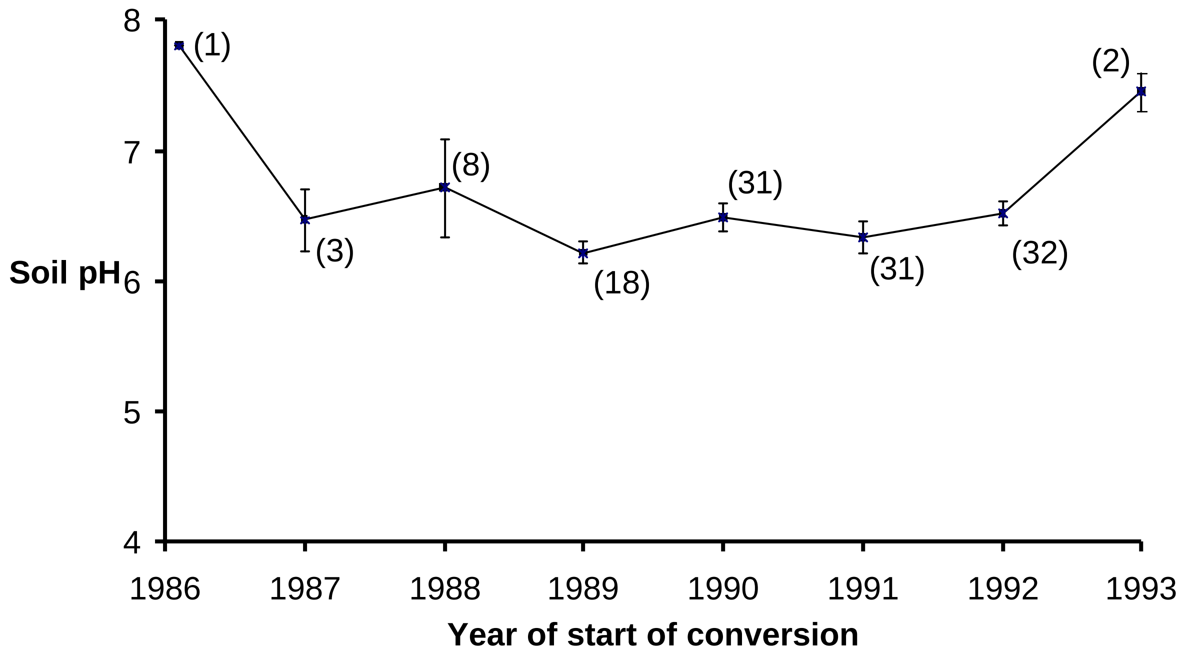


Fig. 9 Soil pH for all fields in 1995, grouped according to the year in which conversion started (group means with bars denoting ± standard error and with the number of fields in each category)



Effect of sampling depth on soil pH and extractable phosphorus and potassium

Soils were collected from 0-7.5 cm and 0-20 cm depths on five fields at Ty Gwyn to examine the extent to which the deeper sampling influenced pH and nutrient contents compared with the 7.5 cm depth commonly used for grassland.

The increased depth of sampling resulted in significantly higher pH values and lower values for the content of extractable phosphorus (Table 10). There was no significant effect on the contents of extractable potassium. In most cases, differences in pH and nutrient content in samples from different depths were small compared with the range of values observed in the main investigation and were insufficient to invalidate comparisons between these values and published data based on a 7.5 cm sampling depth.

Table 10 Efect of sampling depth (cm) on pH and extractable P and K contents of soil

Field number	pH		P (mg/l)		K (mg/l)	
	0-7.5	0-20	0-7.5	0-20	0-7.5	0-20
3	5.72	5.71	15.0	14.3	105	92
16	5.61	5.71	31.7	23.3	152	128
18	5.85	6.09	43.0	39.0	270	196
19	5.66	5.80	31.0	29.7	165	182
20	5.96	6.01	33.0	31.7	145	131
Mean	5.75	5.86	30.7	27.6	167	146
Difference	+0.11 (P<0.05)		-3.1 (P<0.05)			-21 (NS)

Nitrate leaching, Ty Gwyn

Direct measurements of nitrate leaching

Sampling of soil water from the porous cup samplers started in January 1994 and continued to June 1994 when the soil became too dry to allow extraction of further water. Sampling restarted when the soil rewetted in September 1994 and continued to late May 1995. Afterwards, the soil did not moisten sufficiently to provide further samples until early October.

Mean concentrations of nitrate-N in soil water samples collected from Fields 2 and 19 between January and June 1994 are shown in Fig. 10. Concentrations from Field 19 ranged from 0.8 to 4.0 mg N/l (mean 2.4 mg/l) with slightly greater concentrations during winter than from spring onwards. In contrast, concentrations in water from Field 2 were appreciably higher and ranged from 3.9 to 36.0 mg N/l (mean 13.2 mg/l) with peak concentrations in mid-March and again in mid-June. Mean concentrations between September 1994 and March 1995 are shown in Fig. 11. For most of the period, as in the previous winter, soil water from Field 2 contained greater concentrations of nitrate than samples from Field 19 with ranges of 1.7 - 15.4 and 0.5 - 3.9 mg N/l and means of 6.6 and 1.7 mg/l, respectively.

As in other studies of nitrate leaching from grazed pastures (White *et al.*, 1987; Cuttle *et al.*, 1992), there was considerable variation between the concentrations measured at different positions on any particular sampling occasion. As a consequence of this and the limited number of samplers, there were high standard errors associated with the calculated means. The highest individual nitrate concentration was 167 mg N/l, measured in a sample from Field 2. This contrasts with a minimum concentration of 0.4 mg N/l measured on the same date. It is probable that in a number of cases, the observed values would be most closely described, as in other studies, by a log-normal distribution. However, there were too few samplers to provide a clear indication of the form in which the data were distributed and for the present analyses, all mean values were calculated as simple arithmetic means, assuming a normal distribution.

Fig. 10 Mean concentrations of (a) nitrate-N and (b) ammonium-N in soil water samples from Fields 2 and 19 between January and June 1994. Concentrations of ammonium-N in samples from Field 19 remained <0.1 mg/l throughout the period

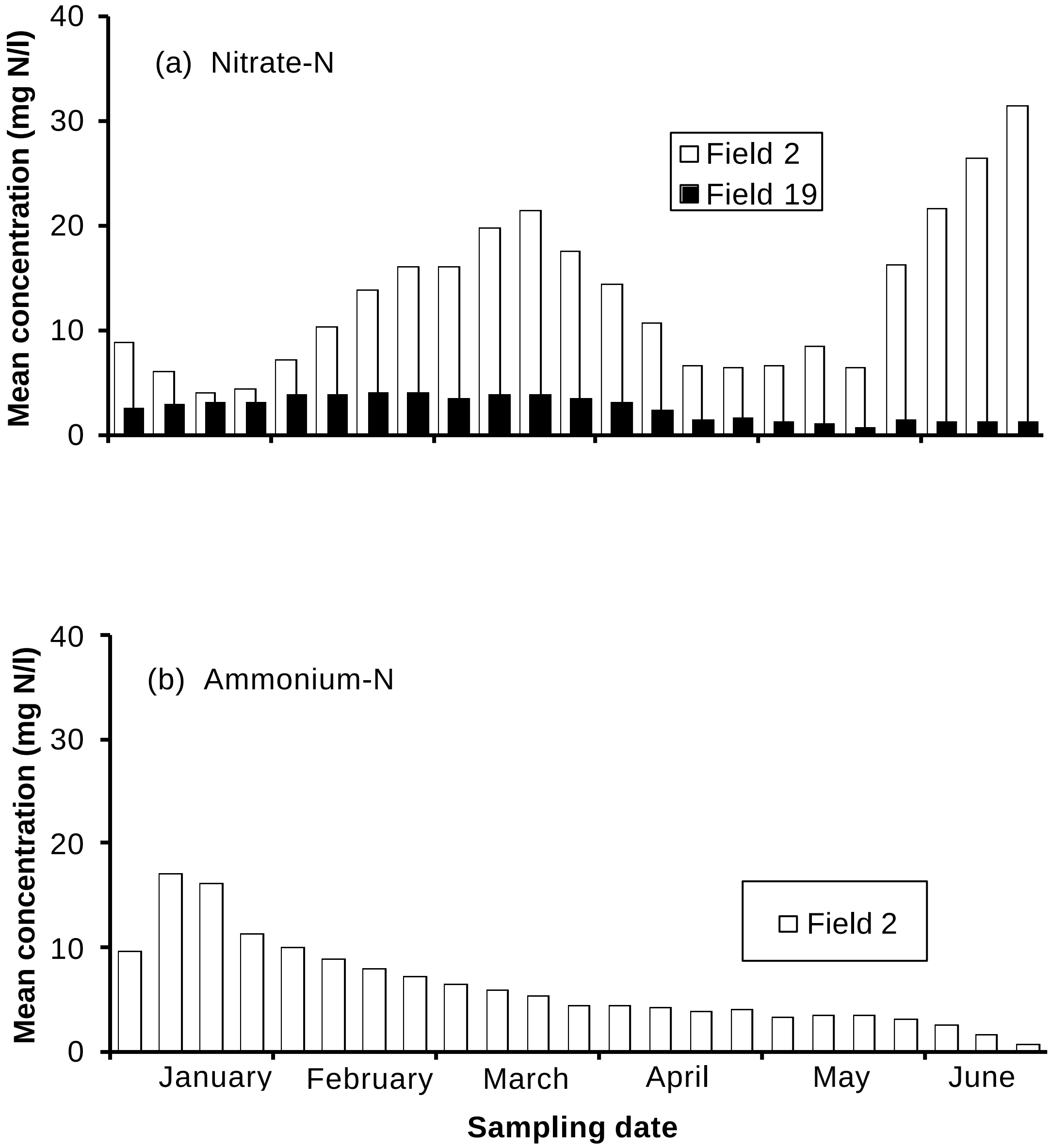
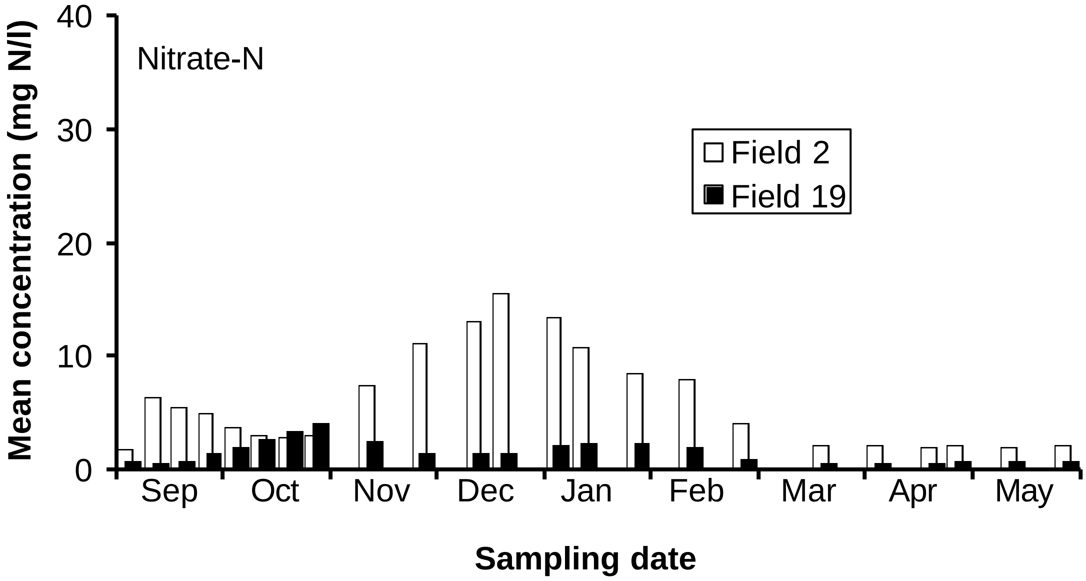


Fig. 11 Mean concentrations of nitrate-N in soil water samples from Fields 2 and 19 between September 1994 and May 1995



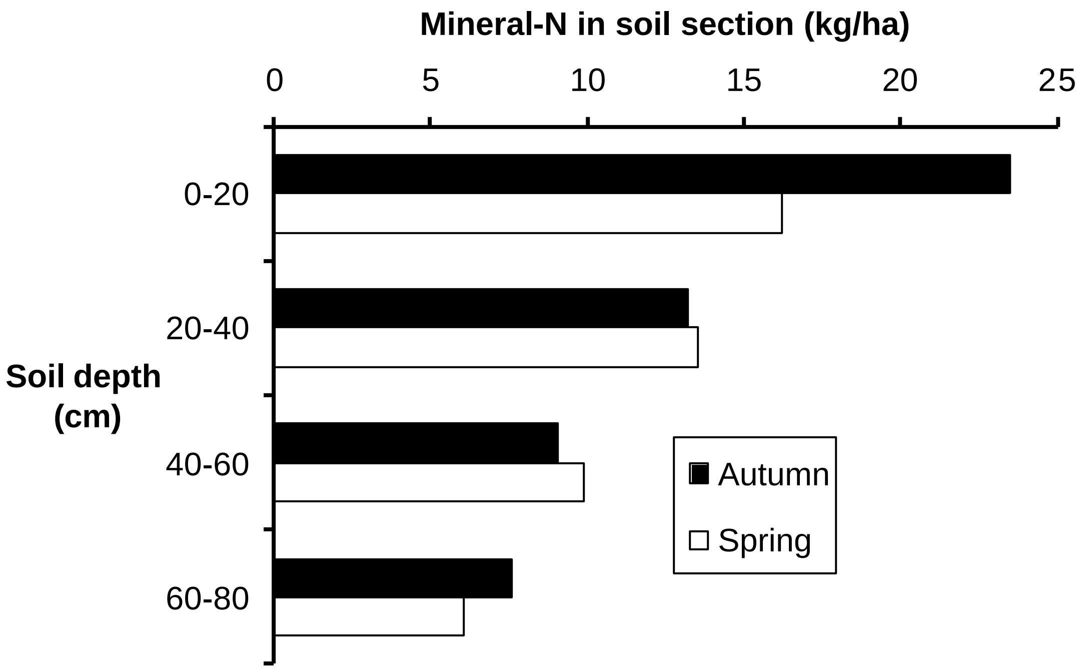
It is assumed that the greater concentrations of nitrate in water samples from Field 2 compared with Field 19 during the first winter were associated with the application of "dirty water" to the former. Although the routine water sampling started too late to provide information about the relative concentrations from the two fields prior to these applications, concentrations of ammonium and organic-N were also greater in water from Field 2 than from Field 19, supporting the belief that the high concentrations of nitrogen originated from a hydrologically mobile, organic source. Mean ammonium concentrations for the two fields between January and June 1994 are shown in Fig. 10. Whereas concentrations in samples from Field 19 did not exceed 0.2 mg N/l (mean 0.06 mg/l), those from Field 2 contained up to 17 mg /l (mean 5.1 mg/l). Concentrations were highest at the start of the sampling period and gradually declined. Concentrations of organic-N in samples from the treated field were also highest at the start of this period, ranging from 1 to 6 mg N/l. Little organic-N could be detected in water from Field 19. It is unlikely that significant drainage would have continued into June. The high concentrations of nitrate that were measured in water from Field 2 in June 1994 may have been a result of *in situ* mineralisation of organic matter previously transported to depth, rather than to active transport of dissolved nitrate through the sampling zone. Although the "dirty water" applications were not repeated in the following winter, nitrate concentrations in soil water were again greater for Field 2 than for Field 19 (Fig. 11) but in this instance, concentrations of ammonium-N and organic-N in water from both fields remained below 0.1 mg N/l.

These concentrations correspond to an estimated total loss of 64 kg N/ha from Field 2 between January and March 1994. Of this loss, 58% occurred as nitrate and 34% as ammonium-N. In the same period, 12 kg N/ha was leached from Field 19, predominantly as nitrate (92%). During the following autumn and winter (September 1994 - March 1995), losses from Fields 2 and 19 were equivalent to 61 and 14 kg N/ha, respectively.

Measurements of mineral nitrogen contents in soil profiles

Analysis of the results is complicated by the difficulties of comparing data from soil cores of different depths. The average sampling depth for individual fields ranged from 0.54 to 0.79 m with the number of cores that could be collected from the full 0.8 m-depth ranging from 3 to 19 per field (Table 11). The minimum sampling depth was 0.43 m and to allow inclusion of all sampling points in the data analysis, the main analyses were confined to comparisons of nitrogen contents in the upper 0.4 m of the soil profile. The variation in mineral-N content with depth for a typical field is shown in Fig. 12. Contents decreased with depth, with an increasing proportion of the nitrogen present as ammonium-N at the greater depths. At the time of the autumn sampling, mineral-N in the 0-0.4 m sections represented 71% of the content in the full 0.8 m depth. Mean profile nitrogen contents to 0.8 m-depth, calculated using the values that were available from full-depth cores, ranged from 19.7 to 54.4 kg/ha for individual fields, with an overall mean of 36.2 kg/ha.

Fig. 12 Variation in mineral-N content with soil depth at Ty Gwyn (Field 12) in autumn 1994 and spring 1995



Mean contents of mineral-N in the upper 0.4 m of the soil profile in individual fields sampled in autumn 1994 are shown in Table 3.2.6. Values ranged from 14.6 to 36.7 kg N/ha with an overall mean of 25.7 kg N/ha. Mineral-N contents for individual sampling points were between 7 and 203 kg/ha.

Table 11 Quantities of mineral-N measured in soil profiles (0.4 m depth) in fields at Ty Gwyn in autumn 1994 and spring 1995, together with details of soil type, mean sampling depth, management, most recent slurry application in 1994 and year of reseeding (PP = permanent pasture; * only part of field 9 was reseeded in 1994)

Field no.	Main soil type(s)	Mean core depth (m)	Management	Most recent slurry application	Reseed year	Mineral-N in soil profile (kg/ha) (SE)	
						Autumn 1994	Spring 1995
9	Brown earth & gley	0.54	Cut & grazed	None	1994*	14.6 (1.12)	
4	Brown earth	0.65	Cut & grazed	July	1993	17.7 (1.04)	20.8 (1.97)
19	Brown earth	0.62	Grazed	None	PP	18.1 (0.94)	13.1 (0.57)
18	Gley & brown earth	0.71	Cut & grazed	November	PP	22.5 (1.52)	
2	Brown earth	0.58	Grazed	January	PP	23.0 (1.11)	20.7 (1.39)
13	Gley & brown earth	0.71	Cut & grazed	November	1994	28.7 (2.49)	
16	Gley	0.79	Cut & grazed	July	1994	28.7 (2.71)	
5	Brown earth	0.63	Cut & grazed	July	1992	29.2 (2.44)	
14	Gley & brown earth	0.54	Grazed	None	PP	31.1 (6.22)	16.7 (0.65)
6	Brown earth	0.64	Cut & grazed	November	1983	32.0 (9.06)	15.6 (0.94)
12	Gley & brown earth	0.71	Cut & grazed	November	1993	36.7 (3.20)	29.7 (4.33)

The mean nitrogen contents measured in autumn were compared with the corresponding values for those fields that were resampled in spring 1995. With the exception of Field 4, all the spring values were lower than those determined at the start of winter. The overall mean nitrogen content for these six fields in autumn was 26.4 kg N/ha, compared with 19.4 kg/ha in spring.

Nutrient balances

General aspects of farm performance influenced the flows of materials and nutrients into and out of Ty Gwyn farm. For example, greater quantities of concentrates were used in 1992/3 and 1994/5 than in the intervening year and these differences are reflected in the estimates of nutrient inputs. Variations in outputs were largely a result of differences in annual milk production; the volume was greatest in 1992/3 and least in 1994/5. There were also fewer animals sold from the farm in 1994/5 than in the preceding years.

Inputs and outputs of nitrogen, phosphorus, potassium and calcium for the Ty Gwyn unit are summarised in Table 12. In the case of nitrogen, the two main inputs were by fixation and as bought-in feed. The estimates indicate that in 1992/3, similar quantities of nitrogen were supplied by fixation and as bought-in concentrates but that the quantity of nitrogen supplied by fixation increased during the three years examined, with the result that concentrates provided a smaller proportion of the total input in later years. Inputs of nitrogen in straw and rainfall were of relatively minor importance. The main output of nitrogen was in the form of milk with only minor quantities leaving the farm in sold livestock. In all years, the total output in products was appreciably less than the input to the farm (and was less than either of the separate inputs by fixation or as concentrates). Averaged over the three years, 25% of the total nitrogen input was recovered in products from the farm.

The only significant input of phosphorus was that present in bought-in concentrates. Nevertheless, in all years the input from this source was greater than the quantity leaving the farm in agricultural products. This recovery averaged 61% of the total phosphorus input. Similarly, the main input of potassium was in purchased feed; although in this case inputs in straw and rain were also of significance relative to the quantities exported from the farm in agricultural output. Once again, the total input exceeded outputs, the recovery in products averaging 35% of the input of potassium to the farm.

In the case of calcium, the output in milk and livestock was approximately balanced by the inputs in rain and purchased straw. Including the additional input of calcium in feed, the recovery in products averaged 28% of the input. A limited number of fields each year received a dressing of lime and even when averaged over the whole farm area, this input was appreciably greater than other forms of calcium input to the farm. When lime was included in the balance calculations, the recovery of calcium in products was reduced to 5% of the total input.

Table 12(a) Estimated inputs and outputs of nitrogen and phosphorus for Ty Gwyn farm (excluding losses), expressed as kg/ha averaged over the whole farm area

	1992/93	1993/94	1994/95	Mean
Nitrogen				
Inputs (kg/ha)				
N fixation	46	78	90	71
Concentrates	50	33	44	42
Straw	2	2	2	2
Rain	7	7	7	7
Total input	105	120	144	123
Outputs (kg/ha)				
Milk	31	28	27	29
Cattle	2	2	1	2
Total output	34	30	27	30
Input - output	72	90	117	93
Phosphorus				
Inputs (kg/ha)				
Concentrates	11.2	7.5	10.0	9.6
Straw	0.3	0.3	0.4	0.3
Rain	0.03	0.03	0.03	0.03
Total input	11.6	7.8	10.4	9.9
Outputs (kg/ha)				
Milk	5.8	5.2	5.0	5.4
Cattle	0.8	0.8	0.1	0.6
Total output	6.7	6.0	5.2	5.9
Input - output	4.9	1.8	5.3	4.0

Table 12(b) Estimated inputs and outputs of potassium and calcium for Ty Gwyn farm (excluding losses), expressed as kg/ha averaged over the whole farm area

	1992/93	1993/94	1994/95	Mean
Potassium				
Inputs (kg/ha)				
Concentrates	21	14	18	18
Straw	4	4	5	4
Rain	3	3	3	3
Total input	28	21	26	25
Outputs (kg/ha)				
Milk	9	8	8	8
Cattle	0.2	0.2	0.1	0.1
Total output	9	8	8	9
Input - output	18	12	18	16
Calcium				
Inputs (kg/ha)				
Concentrates	22	15	20	19
Straw	0.7	0.7	0.7	0.7
Rain	8	8	8	8
Lime	78	180	374	211
Total input	110	204	404	239
Outputs (kg/ha)				
Milk	7	7	6	7
Cattle	1.4	1.3	0.3	1.0
Total output	9	8	7	8
Input - output	101	196	397	231
(excluding lime)	23	16	23	21

3.2.3 Discussion

Changes in soil pH and nutrient contents

Comparison of analytical results for soils sampled in the three years of the investigation provided no evidence of a marked change in the overall pH or nutrient content of soils on the farms being monitored. However, there was greater variation for individual fields. Whereas contents of extractable phosphorus were greater in 1995 than in 1993 in over three quarters of fields, potassium contents in the majority of fields declined in this period and about half of the fields increased in acidity. There would therefore appear to be a greater potential for potassium contents to decline during the conversion period. These results should be treated with caution as the monitoring period only allowed changes to be assessed over two cropping seasons which may be too short a time to separate true changes in nutrient status from the effects of seasonal and sampling variations. Results may also have been biased by farmers directing manures and slurries onto those particular fields that the soil analyses had indicated to be deficient in nutrients. In the case of phosphorus, extractable contents for almost all fields in the study were appreciably lower in 1993 than in 1994. It is unlikely that the nutrient status of such a wide range of fields with differing managements would change in such a uniform manner, suggesting that changes were due to a sampling or seasonal effect. Because of the initial need to select suitable farms, the majority of soil samples were not collected until late April in the first year of the study, compared with early February in subsequent years. The later sampling date would provide greater opportunity for uptake of phosphorus by the growing sward which may have contributed to the lower contents measured in the soil in 1993. The offtake of phosphorus in a typical first-cut silage crop may remove the equivalent of about 10 mg P/l from the soil. If much of this herbage growth occurred during April, the greater uptake of phosphorus in 1993 would have been sufficient to account for much of the difference between soil contents measured in 1993 and 1994.

The difficulties of measuring changes over a relatively short time period limit the information that can be obtained from direct comparisons of data from individual years of the study. An alternative indicator of possible changes in nutrient supply during the initial years of conversion may be provided from comparisons of nutrient contents of soils at different stages of conversion. Any tendency for nutrient status to fall would result in lower contents in soils from those fields that had been farmed organically for the longest period. However, the results of the soil analyses provided no evidence that either soil pH or contents of extractable phosphorus or potassium declined with increasing number of years under organic management.

Although the study provided little evidence of marked changes in the nutrient status of soils during the conversion period, it is equally important to consider the absolute values of soil pH and nutrient content and their adequacy for maintaining production. For advisory purposes, the results of soil analyses of extractable phosphorus and potassium contents are customarily grouped into ranges and expressed as nutrient indices (MAFF, 1985). Index 0 represents a low nutrient status where deficiencies are likely to occur, whilst Index 2 represents a satisfactory level for most cropping rotations, requiring only maintenance dressings of fertiliser. Indices of 1-2 may be sufficient for continuous grassland. A pH of 6.5 is normally recommended for most arable crops and at least pH 6.0 for grassland, particularly where a high proportion of clover is required. These indices refer to analytical values obtained using the same laboratory procedures as those used in the present investigation. Although indices for grassland generally refer to soils sampled to 7.5 cm depth, rather than 20 cm as adopted for this study, the comparisons for soils at Ty Gwyn (Table 10) indicated that differences in sampling depth had relatively little effect on the analytical values obtained.

The proportion of fields in the present study falling into each index category is shown in Table 13 (means of 3 years). Only a small percentage of fields had a potassium index of 0 and would be expected to be deficient in this nutrient. More than two thirds were at Index 2 or above, requiring only maintenance applications of potassium. Concentrations of potassium in herbage from grazing fields (Table 8) were generally above the range of 1.8-2.0% at which responses to fertiliser would be expected to occur (Clement and Hopper, 1968; Prins *et al.*, 1985) but concentrations for cut fields were in this marginal range. Although a slightly greater proportion of fields were deficient in phosphorus (Index 0), the majority of fields were at an index considered satisfactory for grassland. However, the mean contents of phosphorus in herbage from cut and grazed fields (Table 7) were slightly below the concentration of 0.35% necessary to satisfy the dietary requirement of dairy cows (Dampney and Unwin, 1992). The pH of about half of the fields in the study were below the value recommended for arable cropping and marginal for grass/clover swards.

In Table 13, the proportions of fields with different nutrient indices were compared with equivalent percentages for grass fields on non-organic farms obtained from the Representative Soil Sampling Scheme in England and Wales (Skinner *et al*., 1992). Soils in this study are sampled to a depth of 15 cm and the results of the analyses are therefore expected to be directly comparable with those in the present study. Percentages of organic fields falling into each of the index categories and pH ranges are broadly similar to those for non-organic fields. However, more detailed comparisons should take account of differences between sampling regions as the organic farms are confined to Wales and south-west England whereas the data for non-organic farms refer to a representative sample for all of England and Wales. The fact that there may be similar proportions of fields on non-organic farms where nutrient indices and pH are less than recommended has no direct relevance to the sustainability of organic systems other than to provide information about the possible nutrient status of soils at the start of the conversion period and to indicate that deficiencies that occur on organically farmed fields may have been inherited from the previous management.

Measurements of nitrate leaching at Ty Gwyn

The measurements of mineral-N in the soil profile in autumn 1994 provide an indication of the nitrogen available for leaching over the following winter. The overall mean content was equivalent to 36 kg N/ha for cores to 0.8 m depth or 26 kg N/ha to 0.4 m depth. These values are similar to quantities determined in other studies on organically farmed or moderately fertilised grassland (e.g. Titchen and Scholefield, 1992; Younie and Watson, 1992). Assuming 700 mm over-winter drainage and complete leaching of mineral-N, the content of 39 kgN/ha to 0.8 m would be equivalent to a mean concentration in drainage water of about 5 mg N/l, well below the European Union limit of 11.3 mg N/l for nitrate in drinking water supplies. Actual differences in profile nitrogen contents between autumn and the following spring indicated a much lower net loss of 7 kg N/ha. In practice, the differences that are measured are determined by the net balance between leaching and denitrification and the release of mineral-N from mineralisation of soil organic matter during winter.

Table 13 Percentages of fields at Ty Gwyn and collaborating farms with different nutrient indices and in different pH ranges (means of 3 years), compared with published values of percentages for grassland on non-organic farms (Skinner *et al*., 1992)

	Phosphorus index				
Index	0	1	2	3	4+
(mg P/l)	(0-9)	(10-15)	(16-25)	(26-45)	(>45)
Organic fields	15	25	40	17	4
Non-organic fields[a]	17	23	30	22	8
	Potassium index				
Index	0	1	2	3	4+
(mg K/l)	(0-60)	(61-120)	(121-240)	(241-400)	(>400)
Organic fields	3	26	51	17	2
Non-organic fields[a]	7	41	41	9	1
	Soil pH				
	<5.5	5.5-6.0	6.0-6.5	6.5-7.0	>7.0
Organic fields	2	23	28	23	25
Non-organic fields[a]	13	32	31	13	11

[a] *Grass fields from Representative Soil Sampling Scheme in England and Wales for years 1983-88.*

Measurements of profile nitrogen contents provide a poor indication of leaching losses from poorly drained soils where much of the loss may be by denitrification and if winter temperatures are sufficiently mild to allow significant mineralisation to occur. In these cases, profile nitrogen contents in autumn are best regarded as a measure of the excess nitrogen that has accumulated during the growing season and is potentially available for loss during the winter. If leaching was the dominant process responsible for changes in concentration between winter and spring, it would be expected that maximum nitrate concentrations would migrate down the profile during the winter and that an increasing proportion of the remaining nitrogen would be present in the spring as the mobile, ammonium form. Neither of these features was particularly pronounced in the profiles examined in the present investigation, suggesting that processes other than leaching had contributed to the changes in nitrogen content between autumn and winter.

Mean nitrogen contents for individual fields sampled in autumn (0.4 m depth) varied from 15 to 37 kg N/ha. No single management variable, for example, year of reseeding, cutting or grazing or rate of slurry application, adequately explained the variation in nitrogen content between fields. Two of the highest contents were associated with fields that had received an application of slurry about two weeks before sampling but equally high contents were also found in fields that had either received no slurry or none since early summer. The greatest risk of nitrate leaching in ley/arable rotations is associated with the cultivation of grassland and presence of bare soil in autumn following an arable crop. In the present rotation at Ty Gwyn, barley crops are undersown with a grass/clover mixture and cut for whole-crop silage in mid-summer. This allows the undersown sward to develop an effective rooting system and utilise mineralised nitrogen in the soil before the start of winter. Thus the rotation would not be expected to significantly increase the risk of nitrate leaching. The results of the profile-N determinations provided no indication that nitrogen contents were appreciably greater in recently cultivated fields than in longer established pastures.

In the case of the two fields in which porous cups had been installed, there was poor agreement between the profile nitrogen content and directly measured estimates of nitrate leaching. To some extent this may be a result of the large errors associated with both measurements and demonstrates the unreliability of estimates based on a limited number of sampling points. Mineral-N contents (0.4 m depth) in Fields 19 and 2 in autumn 1994 were 18 and 23 kg N/ha, respectively, compared with porous cup estimates of 14 and 61 kg/ha leached between September 1994 and March 1995. Although both fields were grazed rather than cut, which would tend to increase leaching, neither had received slurry other than the applications of "dirty water" to Field 2 in January 1994. The porous cup measurements during the previous winter indicated a loss of 64 kg N/ha following these applications. Although this indicates a relatively high rate of nitrogen loss during this 3-month period between January and March and the risk of increased leaching associated with spreading dilute slurries at this time of the year, only two fields were treated in this way so that the overall impact on leaching from the farm as a whole would have been less marked.

Nutrient balances at Ty Gwyn

In the case of all nutrients, there was a positive balance between the total estimated input and the export of nutrients in agricultural products, indicating the potential for accumulation or loss of nutrients from the system. The results demonstrate the importance of bought-in feed as a source of nutrient inputs to the farm which in all cases exceeded the export in milk and livestock. The magnitude of these inputs also demonstrates that the sustainability of the existing farming system at Ty Gwyn, which is still dependent on external inputs, cannot be assessed in isolation but should also take account of the other farmed areas that contribute materials to the system.

The difference between inputs of nitrogen and the quantity recovered in farm products was equivalent to 93 kg N/ha averaged over the whole farm area. This is an indication of the quantity of nitrogen available for loss by leaching, denitrification or volatilisation or for immobilisation in soil organic matter. For a model of a conventional dairy farm, Jarvis (1993) estimated that losses of nitrogen could be apportioned between leaching, denitrification and volatilisation in the proportions 36, 35 and 29%, respectively. Assuming a similar division for losses from the less intensively farmed system at Ty Gwyn and 700 mm annual drainage, the nitrogen surplus would correspond to an annual leaching loss of 33 kg N/ha, equivalent to an average concentration in drainage water of 4.8 mg N/l. Balances for other nutrients indicate that corresponding concentrations of phosphorus, potassium and calcium in drainage, assuming all surpluses to be lost by leaching, would be 0.6, 2.3 and 33 mg/l, respectively. In comparison, concentrations of nutrients measured in the main stream running through the Ty Gwyn unit were 0.1 - 4 mg N/l, 0.01-0.03 mg P/l, 1 - 3 mg K/l and 5 - 8 mg Ca/l. Although concentrations will have been influenced by nutrient inputs upstream of the farm, they did not change appreciably between the inflow and outflow from Ty Gwyn indicating that these stream concentrations were similar to those in drainage from the farm. Comparisons between these concentrations and the surpluses determined from the nutrient balance calculations suggest that under the present management, contents of nitrogen and potassium within the farm may be approximately static whereas phosphorus and calcium pools may be increasing. Although apparently static, the balance for nitrogen does include significant losses of this nutrient to the wider environment.

This demonstrates the difficulty of balancing different nutrient budgets on organic farms. At Ty Gwyn, where the main agricultural output is in the form of milk, relatively small quantities of nutrients are exported which helps maintain a positive balance for phosphorus and potassium. In the case of nitrogen, however, the limited export of this nutrient and the additional input by fixation result in a surplus which contributes to greater losses. Any changes to the cropping pattern to increase the proportion of nitrogen exported in agricultural products would also increase the export of phosphorus and potassium and move the system towards a negative balance for these elements.

Nitrogen and phosphorus balances at Ty Gwyn were similar to those reported by van der Werff *et al*. (1995) for three ecological, mixed dairy farms in the Netherlands. Potassium surpluses in this study were greater than those at Ty Gwyn, largely because of greater inputs in purchased concentrates. This study also demonstrated the much greater surpluses of nitrogen and phosphorus associated with conventional dairy farms. Positive balances for nitrogen, phosphorus and potassium were also found for two organic dairy farms in the UK examined by Fowler *et al*. (1993), provided that an allowance for the input of nitrogen by fixation was included in the calculation. Clover appeared to make a relatively small contribution to the productivity of one of these farms, where the major input of nutrients was in the form of large quantities of purchased manure. Assuming little nitrogen was supplied by fixation, the annual nitrogen surplus on this farm was similar to that at Ty Gwyn. Unlike fixation, however, manures supply other nutrients in addition to nitrogen and surpluses of phosphorus and potassium were appreciably higher than at Ty Gwyn, in spite of additional export of nutrients in grain as well as in milk.

The major component of the nitrogen balance at Ty Gwyn is the input through symbiotic fixation. Unlike the other nutrients, this large input of nitrogen adds to that supplied in bought-in feed and increases the potential for loss from the system. In the present investigation, nitrogen fixation was not a measured quantity and is thus particularly subject to the risk of error. If, as has been suggested (Becana and Sprent, 1987), fixation activity declines in soils of higher nitrogen status, the system may exert a degree of self-regulation so that the quantity of nitrogen fixed may diminish as the size of the soil and slurry nitrogen pools increases and thus limit surpluses. This regulation would not be taken into account by the current method of calculation unless it acted by controlling the proportion of clover in the sward.

3.3 Forage yields and quality during conversion

By E.L. Jones, P.J. Bowling and R.J. Haggar

3.3.1 Sampling methods

Herbage yields, grazed fields

At Ty Gwyn, all grazing fields were monitored for herbage accumulation under exclusion cages, each measuring 1.5 x 0.9 x 0.4m high. Five such cages were used per field. At the start of each recording period, a sample area measuring 1.25 x 0.4m was cut with a reciprocating hand mower to 50mm in the centre of the caged area. A repeat sample was taken 4 weeks later. A 200g sample was separated into grass and clover components. All fresh material was weighed and dried for 12h at 80°C in an Unitherm oven for dry-matter (DM) determinations. Cages were resited randomly for each grazing period.

On the collaborating farms this procedure was carried out on two grazing fields per farm (one selected by the farmer as the "best" field and the other the "worst" field).

Herbage yields, silage fields

At Ty Gwyn, yield of herbage from all silage fields was measured immediately prior to cutting for silage from 6 random areas per field, each measuring 0.46 x 2m, with a reciprocating hand mower, as in 3.3.1 above.

On the collaborating farms, first-cut silage yields was assessed on two fields by measuring herbage at two dates (about 25-28 and 3-5 days prior to harvesting) in order to calculate growth rates in kg DM/ha/day, and hence estimate herbage yields on the day of cutting.

Herbage quality

Quality of herbage harvested in the field from both grazed and cut fields at Ty Gwyn was measured in terms of per cent dry-matter, protein content and in vitro (two-stage) digestibility. Quality of silage was measured in terms of crude protein, ammonia-N, pH and metabolisable energy using standard ADAS methods.

Herbage ensiled.

At Ty Gwyn every trailer load of grass cut for silage was weighed and sampled for dry-matter content. On the collaborating farms the total amount of herbage ensiled was calculated by measuring the volume of silage about 6 weeks after ensiling and multiplying the silage volume by a density factor depending on dry-matter content of silage (e.g. 0.165 for a silage dry matter of 20-25%), in the second and the third year of the study.

3.3.2 Results

Herbage production, Ty Gwyn

In the two years prior to the cessation of nitrogen applications in 1991, the average yield of herbage harvested from 5 fields was calculated to be 9.2t DM/ha. No herbage yields were recorded during 1991. Mean yields from 22 fields for the period 1992-1995 (8 grazed, 14 cut for silage) are shown in Table 14.

Table 14 Average annual herbage harvested per field, Ty Gwyn (t DM/ha)

Field management	1992	1993	1994	1995
Grazed only	6.81	7.18	7.28	6.71
Mainly cut	8.43	8.93	9.19	8.60
Mean	7.84	8.37	8.61	7.86

The mean yield of 7.84t DM/ha harvested in 1992 represented a 15% reduction compared with the pre-conversion yield. In the case of the silage fields the reduction was less than 9%.

As the conversion proceeded, herbage yields increased steadily until the exceptionally dry year of 1995 (Table 14); the drought proved particularly damaging to herbage growth in the grazed fields (Table 15).

The total amount of silage produced at Ty Gwyn increased steadily during the conversion period (Table 15), whereas total herbage produced from the grazed area peaked in 1993 and was considerably reduced in 1995.

Table 15 Total herbage produced at Ty Gwyn, t DM

Year	Grazed fields	Silage fields	Total
1992	217	272	489
1993	261	278	539
1994	252	290	542
1995	211	291	502

The white clover content of the herbage dry matter harvested rose from less than 5% (estimated in 1989/90 from 5 fields) to 14.9% in 1992 (mean of 18 fields), 17.6% in 1993 (16 fields) and 33.7 in 1994 (7 fields). Corresponding values for red clover were 18.5, 37.8 and 37.5% respectively.

The digestibility of the herbage on offer on the grazed swards did not vary greatly between years (Table 16). However, during the first year of conversion the quality of the first-cut silage from the white clover/perennial ryegrass area was rather low.

Table 16 Quality of herbage harvested at Ty Gwyn (% DOMD)

Field management	1992	1993	1994
Grazed only	76.3	76.6	74.2
1st cut white clover/PRG	57.3	62.3	61.4
1st cut red clover/IRG	56.8	57.9	69.9

During the first two years of conversion the digestibility of the red clover mixture at the time of cutting for silage was slightly lower than that of the white clover-based silage. The higher quality of the red clover mixture in 1994 was because it was cut 14 days earlier than the white clover mixture during that year.

Silage quality, as indicated by crude protein levels in Table 17, also increased during the course of conversion, notably in the case of the second cut.

Table 17 Quality of silage produced, Ty Gwyn

	Cut 1				Cut 2			
	CP % DM	pH	ME	AmN*	CP % DM	pH	ME	AmN*
(a) White clover/perennial ryegrass								
1992	10.5	4.05	10.0	5.68	10.5	3.95	10.4	8.58
1993	13.1	4.10	10.7	3.35	16.0	4.00	10.6	4.10
1994	13.8	4.10	11.0	5.76	17.2	4.31	10.4	7.22
(b) Red clover/Italian ryegrass								
1992	12.8[x]	4.18	10.9	3.75	10.6	3.83	9.9	6.68
1993	11.4	4.10	10.2	5.80	14.5[†]	5.11	9.8	13.84
1994	13.6	4.01	11.4	2.89	19.4	4.47	10.4	6.03

* Ammonia- N (as % of total N) [x] Arable silage, undersown [†] Big bale silage

Silage yields were substantially higher from the red clover/Italian ryegrass swards (Table 18), compared with the white clover/perennial ryegrass swards.

Table 18 Mean yields and quality from clover-based sward, Ty Gwyn

	Yield in field)	Quality* (clamp silage)	
Clover/ryegrass	(DM t/ha)	CP %	ME
Red/Italian	14	14.0	10.5
White/perennial	9	13.5	10.5

* Mean of 2 cuts, 1992-94

Herbage production on the collaborating farms

Average amounts of herbage (mean of 10 farms) harvested on the collaborating farms during the 3 years of monitoring are shown in Table 19.

Table 19 Herbage harvested on collaborating farms, t DM/ha

Management	1993	1994	1995
Grazed, "best"	7.73	9.58	6.43
Grazed, "worst"	6.21	7.60	5.46
Mean	6.99	8.59	5.94
Range	2.6-11.6	4.1-12.9	3.9-9.5
Silage (1st cut only)	4.02	4.53	3.73

There was a 20% difference between the "best" and the "worst" fields in 1993 and 1994, falling to 15% in the dry year of 1995. It was interesting to note (Table 20) that the soils on the "worst" fields were lower in potassium and phosphorous (especially in 1993) compared with the "best" fields; similar differences were detected in the herbage.

Table 20 Levels of potassium and phosphorus in herbage (% DM) and soil samples (mg/l) from collaborating farms

		Potassium			Phosphorus		
Sample	Fields	1993	1994	1995	1993	1994	1995
Herbage	"Best"	2.82	2.54	2.68	0.36	0.34	0.34
	"Worst"	2.29	2.28	2.54	0.31	0.32	0.33
Soil	"Best"	216	177	240	20.0	22.4	21.8
	"Worst"	199	166	236	11.1	18.7	17.8

The mean yield from the "best" grazed fields during the period 1993-95 was 7.91t DM/ha, compared with 7.05 t DM/ha for the grazed fields at Ty Gwyn during the same 3 years, indicating that yields at Ty Gwyn equated well to the "best" fields of the collaborating farms (see also Fig. 13). Because of the large differences between the 3 years, plus the fact that the fields were at various stages of conversion, it is not possible to use the data in Table 19 to determine the effect of stage of conversion on herbage productivity. However, by placing the yield recorded from each field into its respective conversion year (i.e. number of year(s) since the cessation of fertiliser application in that field) it was possible to calculate the average yield for a range of conversion years (Table 21).

Table 21 Influence of stage of conversion on herbage harvested from grazed and cut fields on collaborating farms, t DM/ha

	Years from start of conversion				
Management	1	2	3	4	>5
Grazed, "best"	6.95	8.79	8.03	8.56	7.15
Grazed, "worst"	5.42	6.82	6.85	7.83	5.34
Mean	6.18	7.95	7.41	8.22	6.14
Silage (1st cut)	4.46	4.42	4.03	4.05	4.16

The data indicate that yields on the "best" fields in conversion years 2 to 4 were about 15 per cent higher than in the first year of conversion, which is consistent with the finding at Ty Gwyn that yield is reduced by about this amount during the first year of conversion. Unfortunately, it was not possible to obtain data on herbage yields prior to conversion on the collaborating farms.

To overcome the large between-year variations, and particularly the possible bias of the low yields caused by the 1995 drought occurring at the end of the monitoring period, data for that year were increased by 20% (difference in mean annual yield between 1995 and 1993) whilst data from 1994 was reduced by 19% (difference in yield between 1994 and 1993). The revised data, plotted against stage of conversion (Fig. 13) confirms an upward trend in amounts of herbage harvested during the first two or three years of conversion, followed by a consistent decline on the "worst" fields, in contrast to a long-term increase in the "best" fields.

At the start of the monitoring exercise, there were large differences in clover content between the "best" selected field and the "worst" (see Fig. 14, in which individual field data collected in 1993, 1994 and 1995 has been allocated to the relevant year of conversion). These differences in clover content subsequently narrowed, especially in year 2, although there were signs of further divergence after year 4, in line with divergences in herbage yields (Fig 13).

Fig. 13 Influence of stage of conversion on herbage yields from 'best' and 'worst' grazed fields of collaborating farms, compared also with Ty Gwyn

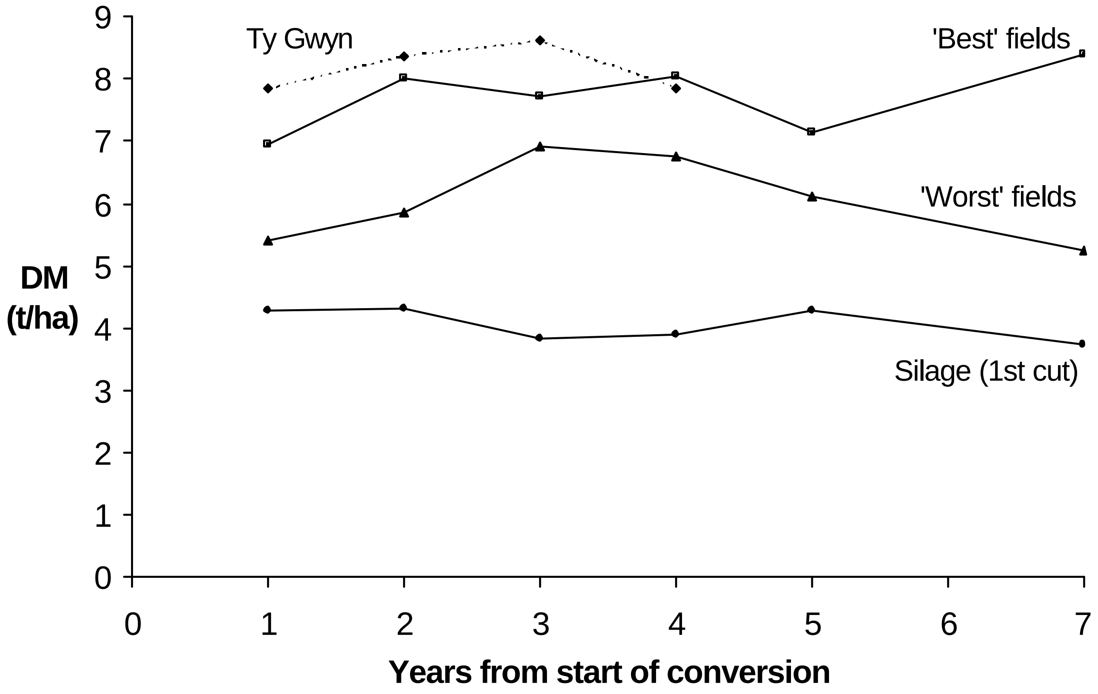
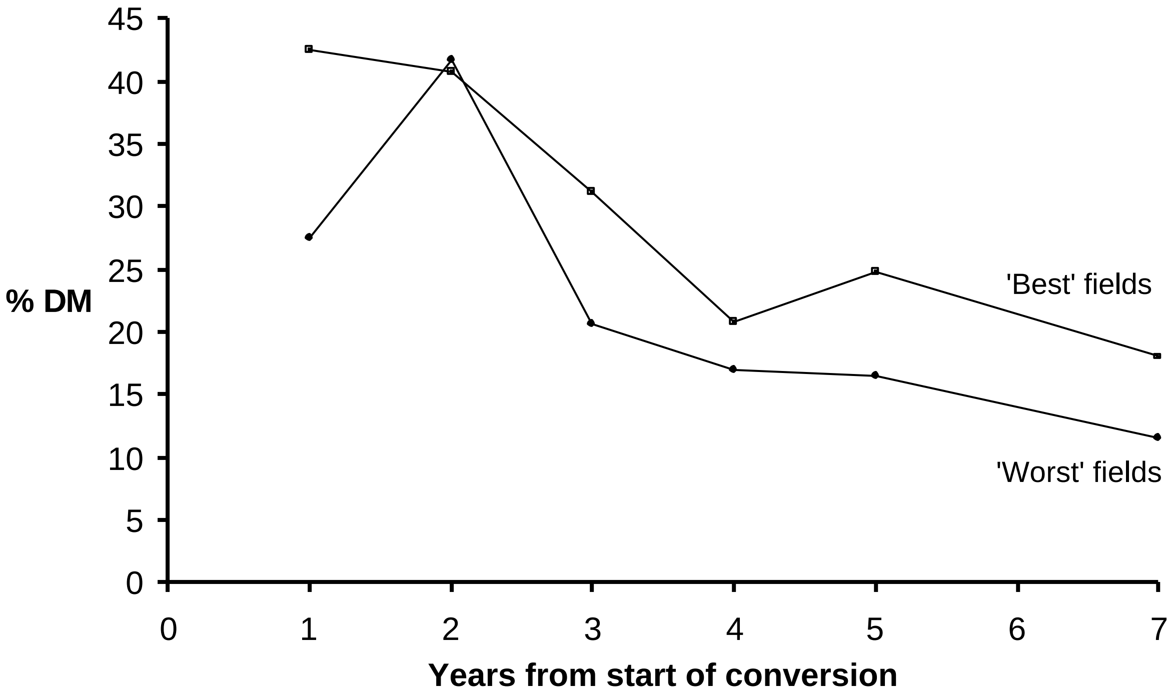


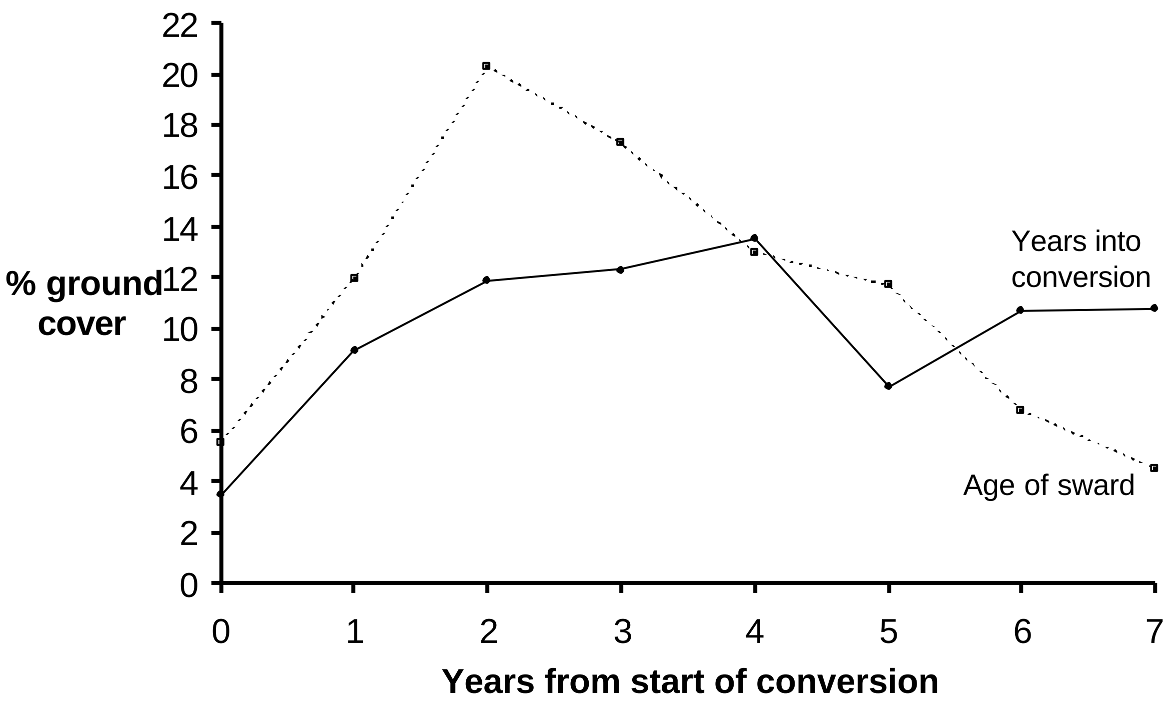
Fig. 14 Influence of stage of conversion on white clover content of herbage from 'best' and 'worst' fields of collaborating farms



There was a general decline over time in clover content, such that by year 4, clover contents were less about half the starting values.

A more precise relationship between stage of conversion and clover content can be obtained from a grassland survey of all fields of all collaborating farms carried out in May of 1993 and 1994.(A report of this survey by P.J. Bowling is lodged in the IGER library. See also 3.4.1). For instance, data on clover ground cover (343 fields) plotted against stage of conversion, shown in Fig. 15, indicates that clover ground cover reached an average mean value of 12 per cent in the second year of conversion, rising to 13.5 per cent in year 4 and falling thereafter. However, it should be noted that much of this decline was accounted for by sward age, which showed a peak in clover ground cover of 20.3 per cent in year 2, falling to below 5 per cent in year 7.

Fig. 15 Influence of stage of conversion and sward age on white clover ground cover (all farms)



Comparisons with herbage production on non-organic farms

Mean yields of about 8t DM/ha from Ty Gwyn, and from the "best" fields of the 10 collaborating farms, equated well with conventionally managed grass/clover fields receiving about 240 kg N/ha of fertiliser nitrogen per annum (Holmes, 1989). Hence, it can be concluded that organically managed swards containing more than 20 per cent white clover in year 2 are capable of producing yields equivalent to heavily fertilised swards, at least for up to 5 years from the start of conversion. Thereafter, falling clover contents might well prejudice long-term productivity of such organically managed swards.

3.3.3. Discussion

At Ty Gwyn, the abrupt cessation of nitrogen applications in 1991 meant that the ryegrass-dominant swards looked nitrogen deficient in the spring of 1992, even where they had been treated with liquid slurry. The grass also appeared to be less leafy. In consequence, it was not surprising that grass yields fell by 15% during the first year of conversion, whilst herbage quality was also suspect (certainly by comparison with subsequent years). However, with the gradual build-up of white clover, plus the continued judicious use of slurry, mean yields of herbage had recovered by year three to 93 per cent of their starting values. The actual mean value of 8.6t DM/ha equates well with the estimated production of 7.5tDM/ha/annum from a well managed grass/white clover sward receiving no fertiliser nitrogen (Thomas and Young, 1991).

Following the first year of conversion at Ty Gwyn, total herbage produced on a whole-farm basis continued to rise, reflecting at least in part, the expansion of the red clover/Italian ryegrass area and a build up of white clover. This increased total production meant that increasingly more herbage could be ensiled as the conversion proceeded. Moreover, the quality of this herbage also tended to increase during this time period.

Mean yields of herbage produced at Ty Gwyn closely matched the average yields from the "best" fields on the collaborating farms, although there was a wide variation between farms. Even on fields that the collaborating farmers considered to be "poor" performers, the levels of herbage produced (6.4t DM/ha) were only slightly lower than those reported (Newton and Stopes, 1995) from non-organic grass/clover swards (7-8t DM/ha) and much higher than all-grass swards receiving no fertiliser nitrogen (4-6t DM/ha).

This illustrates the high level of grassland productivity achievable from organic grassland systems, containing high levels of white clover. During the first 3 years of conversion most of the "best" fields on the collaborating farms had an average clover content in excess of the 30% found in the survey of 82 organic fields by Newton *et al*. (1995); even the "worst" fields had a mean clover content in excess of 20 per cent during the first two years of conversion (Fig. 14).

It was possible to classify fields into site classes (according to soil type, soil depth, number of grass-growing days (Down *et al*., 1981) and altitude, using criteria outlined by Newton and Stopes, 1995), with site class 1 being the best and 5 the worst. The mean yields for each site class are given in Table 22.

There were significant differences ($P<0.01$) between the three site classes and the general relationship between site class and herbage yields was similar to that reported by Newton and Stopes (1995), albeit at a lower level, due to the lower sampling height (to ground level) used by these authors.

Table 22 Mean herbage yield from fields in different site classes

	Yield, t DM/ha		Number of fields	
Site class	1993	1994	1993	1994
2	9.07 (0.51)	10.11 (0.61)	4	5
3	6.66 (0.23)	9.05 (0.23)	12	14
4	4.90 (0.53)	5.74 (0.43)	3	4

(   ) Standard error.

3.3.4 Conclusions

- The cessation of nitrogen fertiliser application leads to a shorter-term loss in herbage availability (about 15%) and quality but, once white clover levels have built up, herbage yields recover and stabilise at levels equal to yields from conventionally managed grass/clover swards.
- Most of the collaborating farms were successful in establishing high levels (30%) of white clover in their swards. However, there was a marked trend for clover contents to fall as swards aged.
- Herbage yields were closely related to site class and level of available phosphate in the soil.
- Red clover-based swards proved particularly helpful in maintaining herbage yields and providing good quality silage during the transition phase at Ty Gwyn.
- Total forage (including herbage from red clover-based swards and whole-crop cereals) produced on a whole-farm basis at Ty Gwyn showed a gradual increase during the course of conversion, thereby allowing additional silage to be made.

3.4 Changes in biodiversity during conversion.

3.4.1 Botanical composition

By P.J. Bowling and R.J. Haggar

Methodology.

During 1993 a base line inventory of the botanical composition of 10 fields on each of 10 collaborating farms (and all fields at Ty Gwyn) was carried out by eye estimation. This involved recording all plant species, including weed infestations, noted during a standard walk across each field. The contribution to vegetation cover (0-9 ranking) by the main components was recorded, together with relevant field data, e.g. soil characteristics, field size, sward age, management regime (grazing, livestock, hay/silage, drainage, manuring etc.). In 1994 this survey was extended to all fields on each of the collaborating farms. Measuring changes in botanical composition during conversion would ideally have required this survey to have been repeated at a later date. However, estimated time trends in botanical composition were calculated by placing the percentage ground cover of a particular species in each field (343 in total) against the stage of conversion of that field.

Results

Perennial ryegrass.

The ground cover of perennial ryegrass in newly sown leys rose quickly, to over 60 per cent, during the first year of conversion (Fig. 16), fell slightly in year 2 and remained at about 60% from year 4 onwards. On the other hand, the ryegrass content of older swards, although starting at 50%, fell sharply to just over 20% by the end of year 2, recovering to about 40 by year 4.

White clover.

The ground cover of white clover in newly sown leys peaked in year 2 (Fig. 17) and showed a gradual decline thereafter. The clover content of long-term swards increased substantially within one year of the start of conversion and stabilised thereafter, albeit at a level lower compared with the leys.

Broad-leaved species.

During the early stages of conversion, the ground cover of broad-leaved species increased substantially in long-term swards (Fig. 18) but declined in younger leys, the latter decline reflecting the demise of various arable-type weeds, e.g. *Stellaria media* (common chickweed) and *Chenopodium album* (fat-hen). Thereafter, the young swards tended to become more botanically diverse but their total number of species continued to remain substantially lower than in the long-term swards.

Fig. 16 Comparison of stage of conversion and ryegrass ground cover

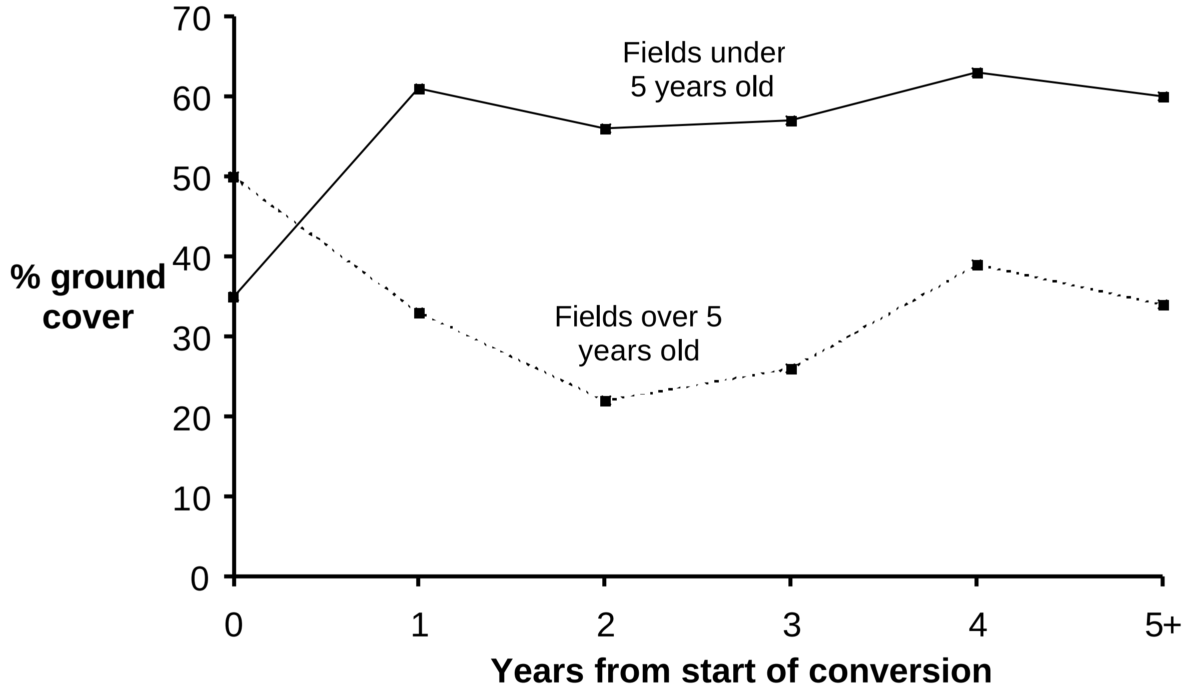


Fig. 17 Comparison of stage of conversion and clover content

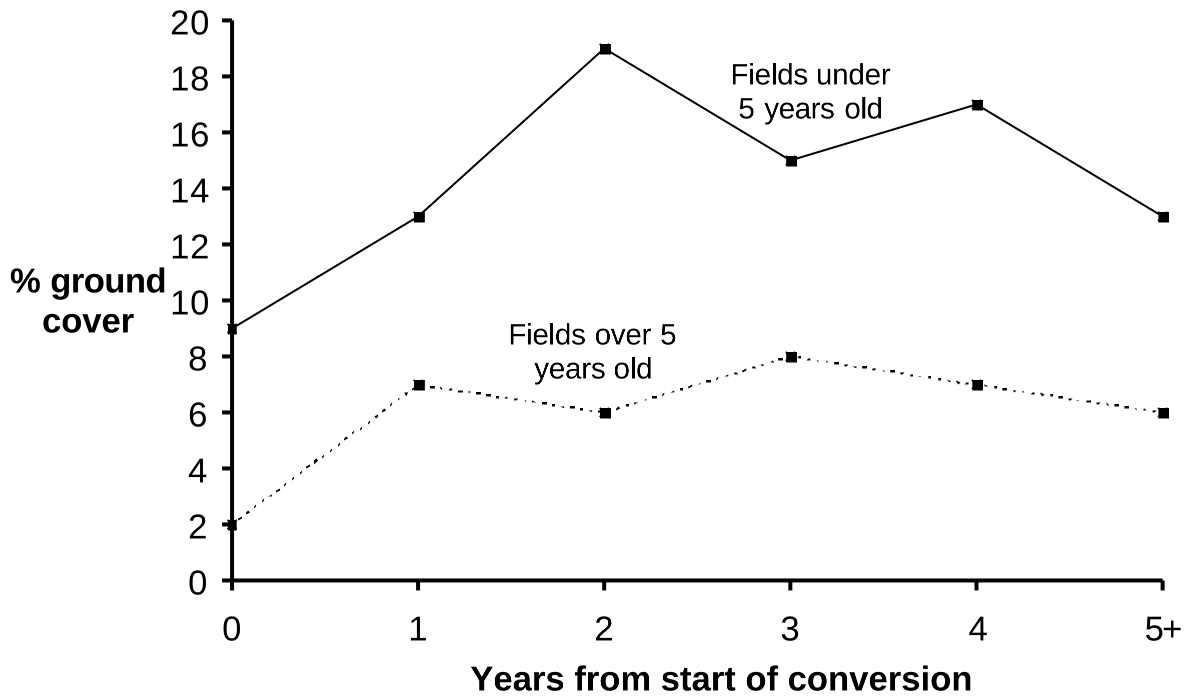
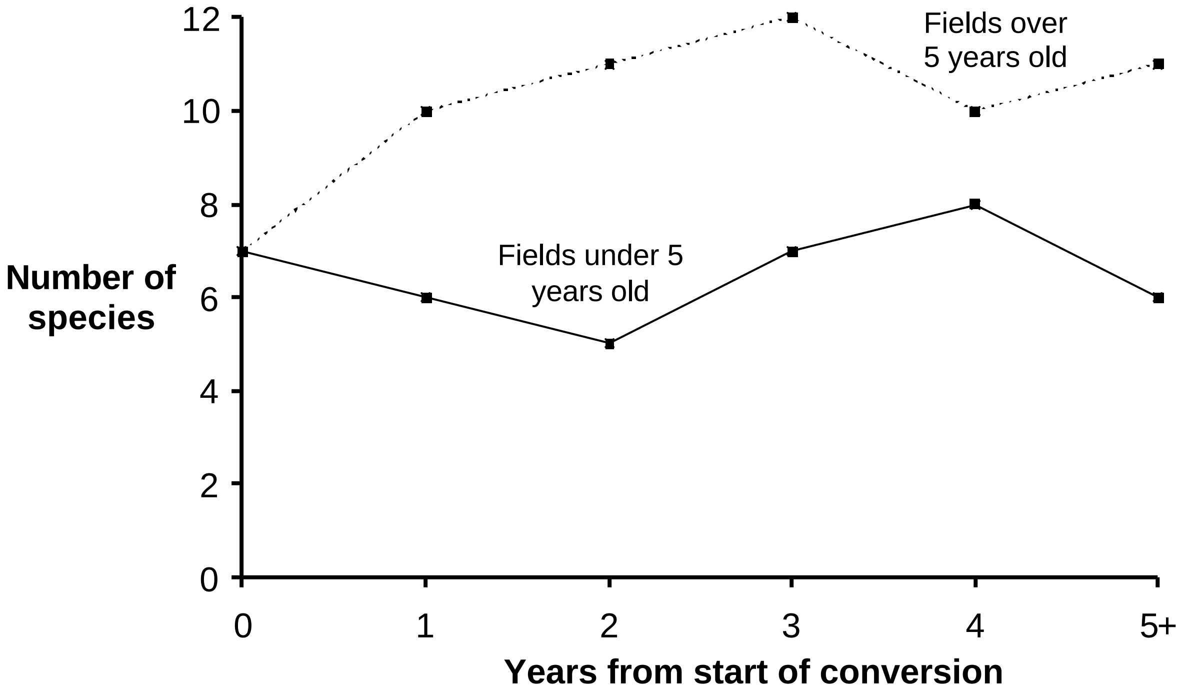


Fig. 18 Comparison of stage of conversion and number of broad-leaved species



Docks.

Although docks became increasingly more visible in young swards undergoing conversion (Fig. 19), reaching a plateau presence of 40% in year 2, they were only considered to be "becoming a problem" (i.e. evenly distributed) in 20% of these swards. The number of swards having an *actual* dock problem (more than 5% ground cover) increased steadily during the later stages of conversion reaching about 10 per cent of all young swards by the fifth year. In long-term pastures, docks were considered to constitute a problem on 20% of swards at the start of conversion (Fig. 20) but by year 4 this figure had fallen to less than 5%.

Buttercups.

Apart from the first year of conversion, there was a general increase in ground cover of buttercups in short-term swards (Fig. 21) as conversion proceeded, whereas the reverse appeared to happen in long-term pastures although there were large variations between years.

Nettles.

In short-term leys nettles increased to a peak in year 2 (Fig. 22), whereas in permanent swards, where nettles were relatively more frequent, they tended to increase beyond year 2.

Fig. 19 Comparison of stage of conversion and docks (swards under 5 years old)

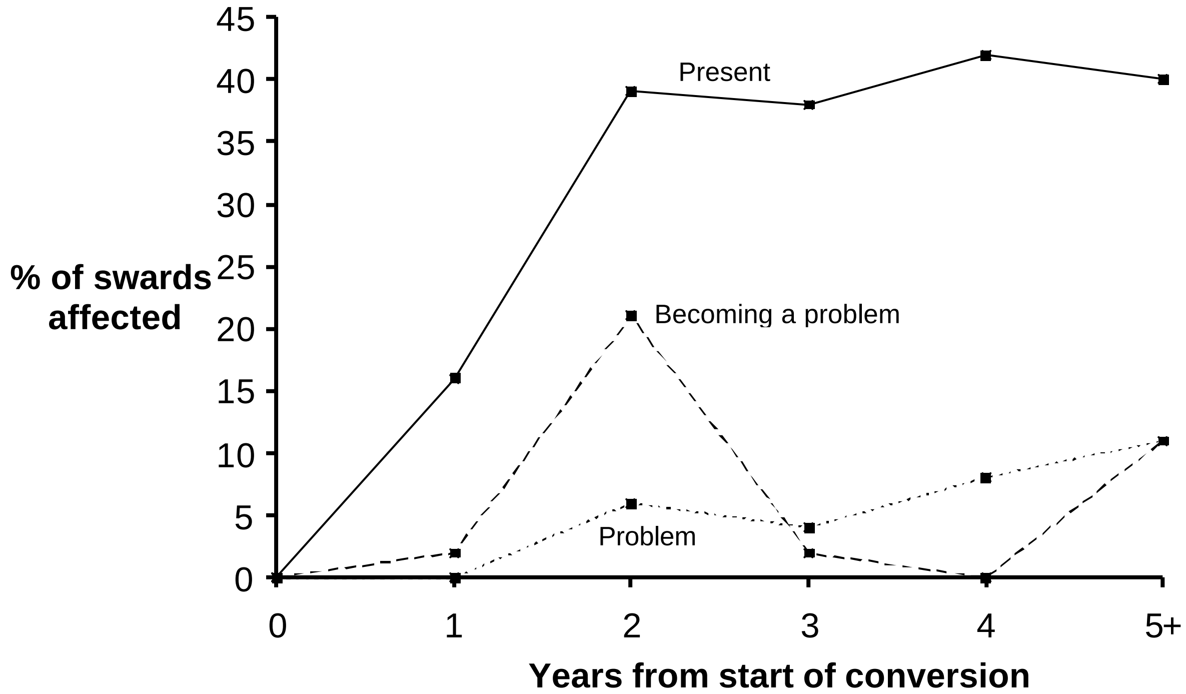


Fig. 20 Comparison of stage of conversion and docks (swards over 5 years old)

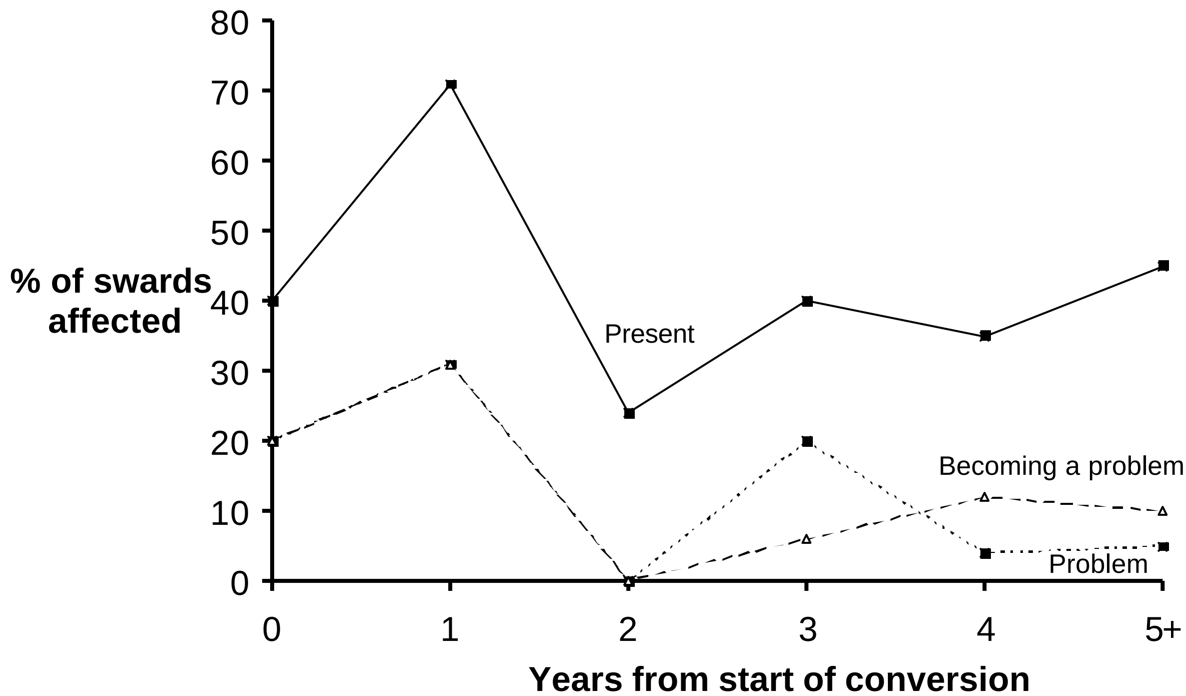


Fig. 21 Comparison of stage of conversion and presence of buttercups

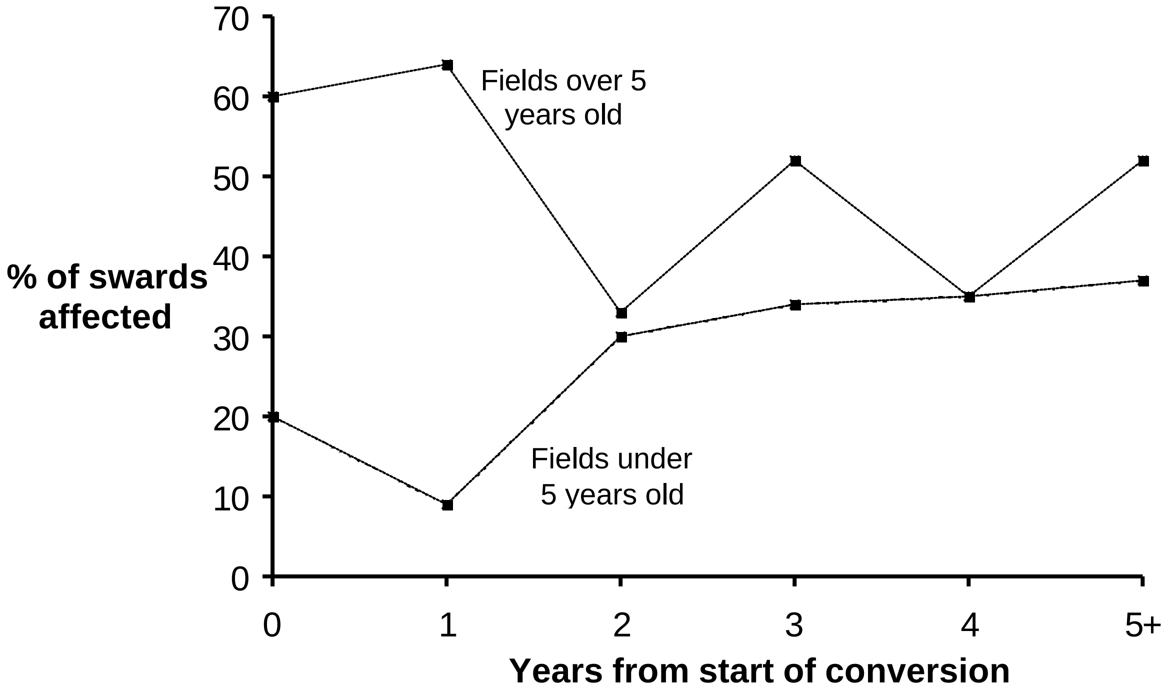
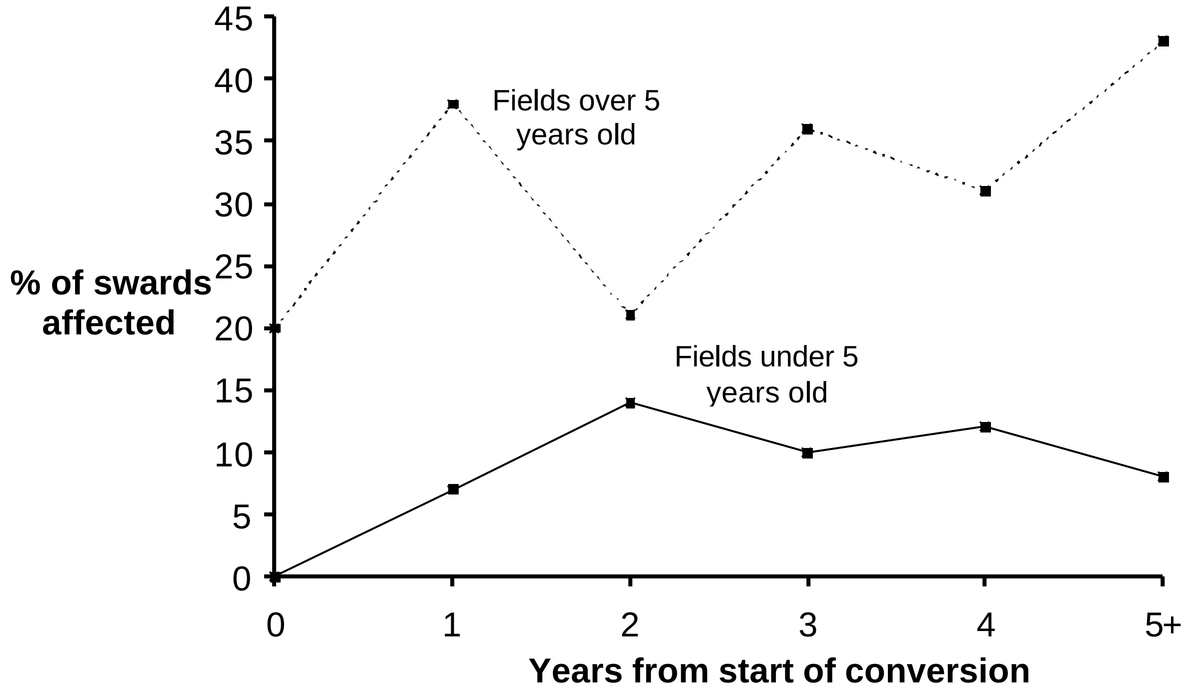


Fig. 22 Comparison of stage of conversion and presence of nettles

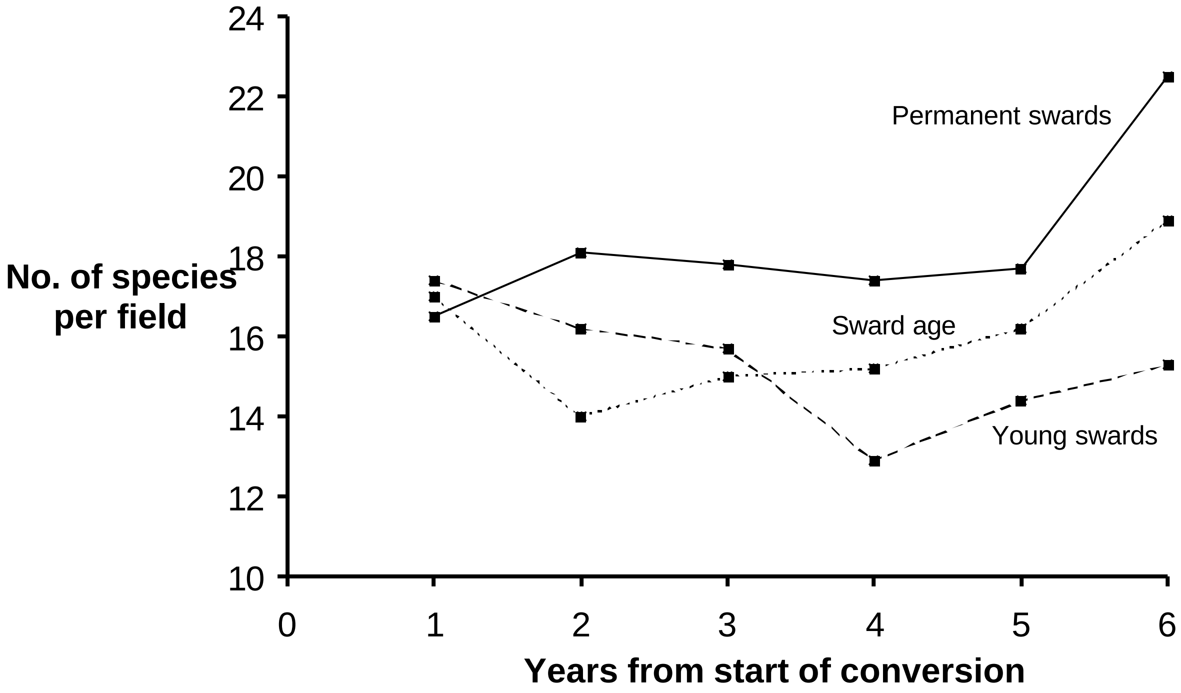


Discussion

To get a true measure of the botanical consequences of changing from a conventional to an organic system of management would have required (a) all swards being assessed at the start of conversion, (b) these swards being re-assessed at the end of the conversion phase, and (c) the starting date of conversion be phased over years (to avoid atypical seasonal or annual events). As this was clearly not possible in a 3-year contract, the present approach of grouping swards into different years of conversion proved the only feasible way forward, albeit accepting that the findings need to be interpreted with extreme caution, noting especially that factors other than stage of conversion are likely to play a more dominant role in determining botanical change. This can be illustrated by reference to dandelions. Although they were present in 83% of the swards surveyed (and even more in permanent swards) there was no significant correlation between stage of conversion and their presence. However, there was a significant correlation (r = 0.263 at P=0.001) between sward age and the presence of dandelions. Management factors also influenced buttercup presence, e.g. more swards were affected (93%) when grazed with horses compared with cattle (83%) or sheep (66%). Soil factors, too, influence buttercup presence, e.g. swards on steep gradients of over 13° were more affected (91%) than those on flatter land (78%).

Using all 343 fields in the survey (each of known age and stage of conversion) and plotting total number of species per field against years into conversion, it can be seen (Fig. 23) that botanical diversity actually decreased in young swards undergoing conversion until about year 4. On the other hand, swards over 5 years (and including permanent pastures) showed no such reductions and eventually ended up containing a large number of species. However, as with buttercups, this increase in species-richness was closely related to sward age (see Fig. 23)

Fig. 23 Influence of stage of conversion and sward age on botanical diversity



It must be emphasised that the above calculated trends in botanical composition are provisional and require further and more rigorous statistical analysis, plus confirmation by resurveying in two or three years' time. On the basis of the above evidence it can be tentatively concluded that converting to organic management: increases docks in short-term swards but decreases docks in long-term swards. Suprisingly, however, conversion does not appear to lead to an immediate increase in total numbers of species, particularly in young swards; even in more species-rich older swards, conversion needs to proceed for some considerable time before any substantial increase in biodiversity can be expected.

3.4.2. Changes in dock populations in fields undergoing conversion

By P.J. Bowling

Methodology.

At Ty Gwyn, infestations of docks on four silage fields and three grazing fields were recorded in 1993. Within each field, fourteen 2.5 metre quadrats, divided into 100 small squares were located at random in areas of high dock populations. The number of dock plants in each square were counted and recorded on a chart. In subsequent years (1994 and 1995) the quadrat was repositioned in the same place and further counts were made.

On 8 of the collaborating farms, plus Ty Gwyn, a single field heavily infested with docks was selected and closely monitored in July of each year during a 3-4 week regrowth period following first-cut silage, using the same method as described above.

Results and discussion

Population changes in high-infestation patches within fields during conversion (all farms).

Because of unforeseen interruptions in field management during the 3-year monitoring period, only data from 6 of the 10 field patches are included in Table 23.

Table 23 Changes in dock numbers (plants per m^2, mean of 4 quadrats)

Management	District	1992	1993	1994	Mean	
Silage	Dyfed		15	22	29	
Silage	Devon		5	9	15	
		Mean	10.0	15.5	22.0	15.8
Silage/grazing	Dyfed		21	28	14	
Silage/grazing	Somerset		5	3	7	
		Mean	13.0	15.5	10.5	13.0
Grazing	Somerset		10	8	7	
Grazing	Gloucester		1	1	<1	
		Mean	5.5	4.5	2.6	4.5

Table 23 shows that densities increase during conversion on fields cut for silage but decreased during conversion on grazed fields, indicating that grazing reduces dock numbers compared with cutting.

Table 24 Influence of sward management on dock numbers (plants per m^2 mean of 16 quadrats) during conversion, Ty Gwyn

Management	Field		1993	1994	1995
Silage	Palu Bach A		0.3	1.3	1.7
Silage	Mansion A		5.4	3.3	7.3
Silage	Mansion B		3.5	0.9	2.9
		Mean	3.0	1.8	4.0
Grazing	Ty Gwyn 2		0.3	0.4	0.3
Grazing	Birdfield C		0.1	0.1	0.1
		Mean	0.2	0.2	0.2

Population changes during conversion on whole-field basis, Ty Gwyn.

Complete records from 5 fields (out of an initial 7) are presented in Table 24. This confirms the trends in the previous table, namely (i) there were substantially more docks on silage fields than grazed fields, (ii) that docks showed signs of increasing on cut swards during the later stages, and (iii) docks did not increase during conversion on grazed fields.

Docks survey: impact of management factors (all farms)

The number of fields seriously infested with docks rose rapidly as sward age increased, stabilising at around 30 per cent, before dropping to 12 per cent in permanent pastures (Table 25).

Table 25 Total number and % of swards infested with docks in relation to age of sward

Sward age	Total number of swards	Infestation % incipient*	Infestation % serious**
1 year	39	10	5
2 years	45	15	9
3 years	25	24	32
4 years	21	24	24
4 to 8 years	30	33	27
9 to 20 years	53	24	29
over 20 years	68	12	12

* evenly distributed

** more than 5% of ground cover

3.4.3. Changes in small mammals during conversion at Ty Gwyn

By N. Sharpe**.**

Methodology

Introduction and objectives. Trapping of small mammals at Ty Gwyn started in March 1993. The methodology closely followed that used in the ADAS National Survey of Small Mammals in hedgerows which ran from 1983 to 1992. One of the sites included in this National Survey was a length of hedge at Lodge Farm, Trawsgoed, adjacent to Ty Gwyn.

Trapping was confined to four newly planted (autumn 1992) hedges, two of which contained only hawthorn while the other two were made up of a mixture of various hardwood species. The rooted samplings were planted through polythene sheeting (for weed control). Each hedge was double fenced. The hedges connected isolated clumps of woodland.

Small mammals in hedgerows were chosen as environmental indicators for three main reasons:

- Hedges are one of the most important wildlife habitats on farms and are especially valuable where agriculture is intensive.
- Small mammals such as voles and mice play a key role in the ecology of farmland since they form a major part of the diet of predators such as owls, kestrels and weasels.
- The planting of four new hedges provided an opportunity to follow the development of a wildlife habitat from scratch.

The objectives were:

- To measure the ecological value of developing hedgerows by monitoring the populations of small mammals which colonise them.
- To record the effects of hedgerow management and adjacent land use on small mammal populations.

Trapping sites. Each of the new hedges was given a 100m trapping line starting from the track which ran alongside the woodland. All 4 lines were also extended into the woodland for a short distance to asses the small mammal population in this habitat which was assumed to be the primary source for colonisation of the hedges.

Pairs of Longworth traps were put down at 10m intervals in the base of the hedge. An additional 3 pairs of traps were laid in the woodland. This gave a total of 28 traps per line (22 in the hedge, 6 in the woodland) and thus 112 in all.

Trapping timetable. Populations of small mammals fluctuate during the year so that trapping was carried out at intervals of two months.

A minimum of two nights trapping was involved, the traps being checked twice a day so that animals were not held captive for 24 hours.

Traps were lined with dry hay as bedding and were provided with about 30 grams of porridge oats and 15 grams of blow fly pupae as food for the captures. The latter was needed to keep shrews alive whereas the oats were provided for the rodents. Neither food sources were intended as baits, they were primarily for preventing death from starvation. Captured animals were released into a large polythene bag and then gently held by the scruff of the neck to enable identification and marking. Each one was given a unique fur-clip mark. This allowed the marking of 126 individuals (63 males, 63 females). After marking the animals were weighed using a small spring balance and their sex, age and breeding condition was noted. They were then released at the point of capture. The individual code of the trap was recorded alongside the details of the animal so that a case history could be built up.

Weather records. For each trapping session information on weather such as wind, rain and snow was recorded since factors such as these can have a significant effect on capture rate.

Data input and handling. All field information was recorded on a standard form. Data were then inputted onto microcomputer using Supercalc 5. Subsequently all data were copied into Minitab to facilitate handling.

Results

Table 26 shows the overall results for both the hedges and the woodland. The figures for all four hedges have been added together because there was no difference in the capture rate between them as shown in Table 27. One might have expected the two species-rich hedges to provide a more suitable habitat than the species-poor ones but they were too close together to observe differences; also all four hedges were early in their stage of development. Wood mice can travel quite long distances in a single night (for example up to 2.4km for males) and can therefore quite easily visit more than one hedge whilst out foraging. A contingency table for Woodmice caught along the hedges was set out and the value of x^2 calculated as 2.48 with 6 degrees of freedom. This indicated that there was no real differences in captures between the hedges. Due to small values the winter/spring catches (November to March) were combined and figures for hedge A were added to hedge D. Contingency tables for the two other species have not been constructed due to the small numbers caught but Table 27 indicates that again the captures did not show a difference between hedges.

Table 26 shows that small mammals were captured in the new hedgerows from the outset. This was expected since the adjacent woodland was a reservoir of Woodmice and Bank voles. The number of Wood mice caught fell off dramatically away from the woods. There was a similar fall off in numbers of Bank voles caught though the effect was much less marked. The reverse was true for Common shrews; they were caught in the hedges rather than the wood. Wood mice range widely and would be expected to occur along the new hedge lines at an early stage. No shrews at all were trapped along the hedges until more than a year had elapsed since planting. This reflects the unsuitability of new hedges as a habitat for shrews until a well-structured ground flora has developed. Thus a mixture of grasses and herbs provides shelter and invertebrate food. Bank voles were also caught in low numbers along the new hedges as expected since this is a species that requires older, well established hedgerows.

Table 26 Total numbers of small mammals caught per session, Ty Gwyn

		1993					1994						1995			
	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep
Wood																
A. sylvaticus	19	11	8	11	8	16	22	15	5	13	13	6	10	14	9	15
C. glareolus	0	2	4	7	1	1	2	0	0	1	1	1	1	0	1	1
S. araneus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
M. agrestis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hedges																
A.sylvaticus	3	18	11	8	1	0	0	3	10	12	11	5	1	1	7	0
C. glareolus	0	0	2	0	1	2	0	0	0	1	1	0	0	0	0	0
S. araeus 0	0	0	0	0	0	0	3	3	5	1	1	1	1	10	6	
M. agrestis 0	0	0	1	0	0	2	2	0	0	1	4	0	2	2	1	

Table 27 Total numbers of small mammals caught in four hedges at Ty Gwyn.

Species/hedges		March	May	July	Sep.	Nov.	Jan.
A. sylvaticus							
Hedge	A	1	2	5	3	1	0
	B	0	6	5	5	3	1
	C	1	9	11	8	7	3
	D	1	5	7	4	1	1
C. glareolus							
Hedge	A	0	0	0	1	0	0
	B	0	0	0	0	0	2
	C	0	0	0	0	2	0
	D	0	2	0	0	0	0
S. araneus							
Hedge	A	0	0	2	1	0	0
	B	0	0	4	6	0	0
	C	0	0	3	3	1	1
	D	1	6	4	1	0	0
M. agrestis							
Hedge	A	0	0	0	0	1	1
	B	2	4	0	0	0	0
	C	0	0	1	1	0	3
	D	0	0	2	1	0	0

It can be seen from the tables that the population of Wood mice in both the hedges and woodland was about the same in 1993 as it was in 1994. Variations occurred within seasons with highest numbers caught in May to September for the hedges but rather earlier (March to May) for the adjacent woodland. In the longer term it is expected that Wood mouse captures along the 4 hedges would approach the figures for nearby Lodge farm.

Common shrews were not trapped at all at Ty Gwyn until March 1994 when one was caught in the wood. This species was caught in the hedges in every session since May 1994, with the highest numbers recorded during the summer (May to September). Numbers themselves were not high enough to carry out a chi-squared test but there was no doubt that this species had colonised from the nearby wood. Bank vole numbers caught in both the wood and the hedges (Table 26) were relatively low though it must be remembered that only small numbers of traps were set in the woodland (24 in total). The small numbers mean that seasonal variations were difficult to ascertain but generally there were more captures in late summer and autumn and lower numbers in the spring and early summer. Looking at the figures for the hedges (Table 26) there is no clear change in numbers caught between 1993 and 1994 (totals of 5 and 2 respectively). This is not unexpected since this species favours older well established hedgerows. As with Wood mouse, a gradual increase would be expected in the longer term as the hedges develop a greater structural diversity. Two seasons is a relatively short period of time in the development of a hedge. In future, factors such as management and the variety of berry-bearing shrubs are likely to play an important role.

Discussion

A number of studies on small mammals in hedgerows have been carried out over the years, the 9½ year ADAS National Survey standing out as the largest. Much is now known about their biology and population fluctuations within and between seasons, but it is difficult to relate captures to characteristics of hedgerows and adjacent land use. Poulton and Langton (1993) concluded that few formal relationships could be found between capture rates and environmental variables in their very large and complex dataset for the National Survey when a parametric analysis was used. However, a non-parametric analysis produced some more interesting results. It was found that Wood mouse captures could not be predicted with any confidence using hedgerow variables in either spring or autumn whereas capture rates of both voles and shrews could be predicted by such variables with a high degree of confidence. Generally vole captures were more closely related to structural variables (such as hedge height and base width) whereas shrew captures were most often related to ground flora variables such as nettles and grasses.

Poulton and Langton (1994) found that adjacent crops had an important influence on either the behaviour of small mammals or their population size, or both. In particular the presence of a narrow strip of unmanaged grass immediately adjacent to the hedge appeared to favour small mammals generally.

It would be interesting to see how the population of small mammals in the four Ty Gwyn hedges change as they begin to be managed in subsequent years. Certainly factors such as the frequency of trimming and the presence or absence of standard trees would be expected to influence numbers. The two species-rich hedges will begin to differ more and more markedly as they develop, particularly if a range of shrubs and trees are allowed to grow on to maturity. Several of these species produce fruits so they would be expected to provide an important food source for Bank voles and Wood mice during the winter. However, Poulton and Langton (1993) could not find a clear relationship between small mammal numbers and the abundance of berry-bearing shrubs.

It follows that several more years of small mammal trapping are needed at Ty Gwyn to pick up changes as they relate to the development of the hedgerows in the longer term. Trapping at two-monthly intervals quickly gave a good indication of population fluctuations within seasons, but it is too early to detect much more gradual increases that might be expected for Wood mice and Bank voles. Common shrews did not appear in the hedges until a year into the project so again it would be interesting to see how their numbers alter over a few more years.

Adjacent land use is another factor that warrants further investigation but the continuity of improved grassland adjacent to the hedges at Ty Gwyn has not allowed any comparisons to be made.

There are four main questions that need to be answered with the results from the Ty Gwyn trapping:

(a) Has there been an increase in number of species and number of individuals of each species over the first two and a half years since the new hedges were planted?

The number of species of small mammals caught along the four new hedges increased from 3 to 4 over the first 2 years of the project. The extra species that colonised was the Common shrew. Of the remaining 3 species, Wood mouse and Bank vole were present in the adjacent woodland from the outset so that it is likely that those caught in the hedges were coming from the wood. The other species captured, the Field vole was not caught in the wood but as its name suggests its habitat is permanent grassland rather than hedgerow. Turning to numbers of individuals there is no doubt that shrews increased though the figures are too small to test statistically. This increase in shrews is a response to the development of the ground flora at the base of the hedge. Poulton and Langton (1993) found that shrew captures were related to ground flora variables, particularly nettles and grasses. It follows that farming practice can have a considerable effect on the small mammal population, e.g. applications of fertilisers or herbicides to the base of the hedge.

Numbers of Wood mice and Bank voles caught along the hedges did not increase during the project. Numbers of Wood mice were stable in the adjacent woodland with very similar catches for 1993 and 1994 (totals of 73 and 74 respectively) . There was a similar picture for the hedges with totals of 39 and 42 for the corresponding two years.

Bank vole numbers were consistently low in both hedges and the wood apart from some slightly higher catches in summer/autumn 1993. It cannot therefore be concluded that Bank vole numbers in the hedges are increasing.

(b) Is there any difference in captures of small mammals (of any species) between the species-rich and species-poor hedges?

Two of the hedges were planted with Hawthorn only and the other two were given a variety of shrubs in addition to Hawthorn as the main component. In the long term one would expect the latter to provide a much richer habitat for wildlife in general, including small mammals. However the present study showed no difference in numbers caught between the hedges for any of the three main species. However this was only tested statistically for Wood mice due to the low numbers for the other two species. Some of the figures were amalgamated to make expected values large enough to enable chi-squared to be calculated.

These results can be accounted for in terms of the home-range size of the small mammals and the fact that it will take several years for the hedges to develop a rich diversity of habitats. As explained above, a male Wood mouse can wander up to 2.4km in one night which would comfortably include all four hedgerows at Ty Gwyn. The latter are therefore too close together to be considered separate units for comparison.

(c) How do the results for Ty Gwyn compare with data for two other hedges for which there are nine and a half years of data?

General comparisons can be made between the Ty Gwyn data and the figures provided by the National Survey for nearby Lodge farm and Penglanowen near Aberystwyth (albeit that the hedges at Ty Gwyn were younger). The figures do not relate directly as slightly different trap groupings and spacings were used in the National Survey. Such differences were partly resolved by calculating a capture index per unit length of hedge, but there are still differences in the overall quantity of hedgerow trapped which cannot be overcome.

The captures of Wood mice per unit length were a lot higher at Penglanowen than the other two sites, but the differences between Lodge farm and Ty Gwyn were not so marked. However, the captures at the former do appear to be slightly higher on average despite one or two poor seasons in the late 1980's.

The picture for Bank voles is broadly similar with markedly higher catches at Penglanowen than the other two sites. However the differences between Ty Gwyn and Lodge farm are less obvious so that no firm conclusions can be drawn.

Shrew captures at Lodge farm and Penglanowen are broadly comparable. Though the figures are lower for Ty Gwyn there is overlap and it appears that numbers are increasing.

(d) How do the hedge results for Ty Gwyn relate to its organic status?

In order to make definite statements about the effect of organic status on the small mammal population a proper control is needed. In the absence of such a control it is still possible to make some inferences about the results. It is already established that agricultural practices have major effects on the structure and composition of farm hedges which in turn affects their populations of small mammals. Hedgerow establishment and management is likely to be similar in many respects. Thus planting, double-fencing and subsequent trimming at intervals coupled with occasional renovation (i.e. laying or coppicing) will be the same. The main difference is likely to be the use of inorganic fertilisers and pesticides (particularly herbicides) along the field margin and base of the hedge (usually unintentionally). Such chemicals would have a major effect on the flora at the base of the hedge, changing both the structure and species composition. This would be expected to have a particularly noticeable effect on shrews which need good thick cover near ground level coupled with a rich supply of invertebrate food. It can therefore be concluded that shrews will fare better under an organic regime as compared with a non-organic situation where the presence of inorganic fertilisers, herbicides or insecticides would have a deleterious effect on the hedgerow flora. However it is unlikely that such pesticides would be used in significant amounts outside arable areas.

3.4.4 Changes in bird populations at Ty Gwyn

By D. Jones

Methodology.

Prior to setting up the organic farm at Ty Gwyn, an inventory of bird species found at Trawsgoed was undertaken in the spring, summer and autumn of 1991 using a point-count method of bird census (Lack, 1992). A similar census had been carried out in 1956.

Beginning in winter 1992, counts of birds were made on Ty Gwyn, plus a comparable area (in terms of size, shape, crop type) on the adjacent, conventionally managed Lodge Farm, using guidelines set up by the British Trust for Ornithology, namely:

- Mapping the distribution of birds during the breeding season, 15 April to 15 July, using similar methodology to the Common Bird Census, with all data recorded on 1:2500 base maps.
- Completing a habitat/field boundary map, to include tracks, streams, woodlands and hedges. Additionally a broad botanical survey of the main species of trees, shrubs and herbs in each field was carried out in the spring of 1992.
- Counting the number of birds using the areas for the remainder of the year at monthly intervals.
- Completing an annual farm practice questionnaire covering previous cropping, farmyard manure inputs, cultivation and sowing techniques.

Results

During the 1991 census a total of 56 species of birds were recorded at Trawsgoed (Ty Gwyn and Lodge Farm). These are listed in Table 28. This compares with a total of 76 recorded in 1956. In other words, bird species declined by 20 over a 35-year period. Among the main casualties were Skylark, Yellow Hammer, various tits, Whitethroat and other species requiring particular breeding habitats, e.g. rough pastures, hedges and broad-leaved woods.

During 1992-94, a further two species were "lost" on Lodge Farm whereas 5 species reappeared on Ty Gwyn, viz. Barn and Little Owls, Yellow Hammer, Redstart and Brambling.

Discussion

These observations, suggesting a reversal of the decline in bird species at Ty Gwyn, are consistent with interim results from the British Trust for Ornithology survey comparison of paired organic and conventional farms (Wilson, 1993), of which the two farms at Trawsgoed form a part. It was interesting to note the increased activities of owls foraging along the newly established hedges at Ty Gwyn.

Similar findings have been reported in Denmark (Lack, 1992), showing that land farmed organically held considerably more birds, and more species, than land which was farmed conventionally.

[Data from the current bird survey at Ty Gwyn, including the habitat maps and field managements, are being analysed by BTO.]

Table 28 Systematic list of bird species recorded at Trawsgoed

Unit	1991 Whole-farm census (conventional)	Organic Farming Project (1992-94) Lodge (conventional)	Organic Farming Project (1992-94) Ty Gwyn (organic)
1. Breeding residents			
GROUP 1 (regularly detected)			
Buzzard* (*Buteo buteo*)	●	●	●
Rook* (*Corvus frugilegus*)	●	●	●
Carrion crow* (*Corvus corone*)	●	●	●
Jackdaw* (*Corvus monedula*)	●	●	●
Magpie* (*Pica pica*)	●	●	●
Jay* (*Garrulus glandarius*)	●	●	●
Woodpigeon* (*Columba palumbus*)	●	●	●
Pheasant* (*Phasianus colchicus*)	●	●	●
Mistle Thrush* (*Turdus viscivorus*)	●	●	●
Song Thrush* (*Turdus philomelos*)	●	●	●
Blackbird* (*Turdus merula*)	●	●	●
Starling* (*Strunus vulgaris*)	●	●	●
Robin* (*Erithacus rubecula*)	●	●	●
Dunnock* (*Prunella modularis*)	●	●	●
Pied Wagtail* (*Motacilla alba*)	●	●	●
Meadow Pipit* (*Anthus pratensis*)	●	●	●
House Sparrow* (*Passer domesticus*)	●	●	●
Chaffinch* (*Fringilla coelebs*)	●	●	●
Nuthatch* (*Sitta europaea*)	●	●	●
Treecreeper* (*Certhia familiaris*)	●	●	●
Great Tit* (*Parus major*)	●	●	●
Blue Tit* (*Parus caeruleus*)	●	●	●
Coal Tit* (*Parus ater*)	●	●	●
Long-tailed Tit (*Aegithalos caudatus*)	●	●	●
Wren* (*Troglodytes troglodytes*)	●	●	●
Goldcrest (*Regulus regulus*)	●	●	●
GROUP 2 (occasionally detected)			
Raven (*Corvus corax*)	●	●	●
Red Kite (*Milvus milvus*)	●	●	●
Kestrel (*Falco tinnunculus*)	●	●	●
Sparrowhawk (*Accipiter nisus*)	●	●	●
Tawny Owl (*Strix aluco*)	●		●
Barn Owl (*Tyto alba*)			●
Little Owl (*Athene noctua*)			●

Table 28 cont.

Unit	1991 Whole-farm census (conventional)	Organic Farming Project (1992-94) Lodge (conventional)	Ty Gwyn (organic)
Woodcock (*Scolopax rusticola*)	●	●	●
Black-headed Gull (*Larus ridibundus*)	●	●	●
Lapwing (*Vanellus vanellus*)	●	●	●
Grey Heron (*Ardea cinerea*)	●	●	●
Mallard (*Anas platyrthynchos*)	●	●	●
Feral pigeon* (*Columbia livia*)	●	●	●
Collared Dove (*Streptopelia decaota*)	●	●	●
G. Sptd Woodpecker (*Dendrocopos major*)	●	●	●
Green Woodpecker (*Picus viridus*)	●		●
Grey Wagtail (*Motacilla cinerea*)	●	●	●
Bullfinch* (*Pyrrhula pyrrhula*)	●	●	●
Goldfinch* (*Carduelis carduelis*)	●	●	●
Greenfinch* (*Carduelis chloris*)	●	●	●
Yellow Hammer (*Emberiza citrinella*)			●
2. Summer breeding visitors			
Spotted Flycatcher* (*Muscicapa striata*)	●	●	●
Chiffchaff* (*Phylloscopus collybita*)	●	●	●
Redstart (*Phoenicurus phoenicurus*)			●
Whitethroat* (*Sylvia communis*)		●	●
Willow Warbler* (*Phylloscopus trochilus*)	●	●	●
Garden Warbler (*Sylvia borin*)	●	●	●
Blackcap* (*Sylvia atricapilla*)	●	●	●
Tree Pipit (*Anthus trivialis*)	●	●	●
Swift (*Apus apus*)	●	●	●
Swallow* (*Hirundo rustica*)	●	●	●
House Martin (*Delichon urbica*)	●	●	●
3. Winter visitors			
Redwing (*Turdus iliacus*)	●	●	●
Fieldfare (*Turdus pilaris*)	●	●	●
Brambling (*Fringilla montifringilla*)	●		●
Total	**56 SPECIES**	**54 SPECIES**	**61 SPECIES**

* known to have bred

3.5 Animal production during conversion

by R.F. Weller, A. Cooper and S. Padel

3.5.1 Introduction and data collection

Ty Gwyn

The main objective was to monitor the changes in production of the Holstein-Friesian dairy herd during the conversion period, including changes in stocking rate, milk production, milk composition, body condition and concentrate inputs for the 3-year period from April 1992 to March 1995. At the start of the study cow numbers were reduced, not only due to the change from conventional to organic farming, but also to the management change from maintaining a flying herd to the establishment of a permanent herd supported by home-reared replacements. The herd was managed according to the standards defined by the United Kingdom Register of Organic Food Standards (UKROFS, 1993). In July 1994 the dairy herd at Ty Gwyn gained full organic status (UKROFS Standards) and organic milk was sold at a premium from 10 August, 1994.

Milk yield, milk composition, concentrate inputs and animal numbers were recorded monthly by Genus National Milk Records to provide both monthly and annual rolling average reports. From the start of the 1993 calving season all lactating cows were weighed and body condition scored (Mulvany, 1977) every month. During the grazing season the spring-calving herd of Holstein-Friesian cows were grazed on mixed grass and clover swards prior to being housed from October to early May. The winter forage requirements were achieved by the feeding of mixed grass (predominantly perennial ryegrass) and white clover silages in 1992/93, with additional silage in 1993/94 and 1994/95 conserved from swards of Italian ryegrass/red clover and whole-crop cereals. A biological additive (Ecosyl) was used for conserving the herbage, replacing the acid additives used prior to the conversion period. After February 1994 the concentrate feeding was changed to meet UKROFS requirements.

No major changes were made to either the milking parlour or housing areas, including the straw-bedded cubicles. However, the milking parlour was checked at 6-monthly intervals to ensure the milking plant was operating correctly to the required hygiene standards. Parlour hygiene was maintained using normal practices including the use of hypochlorite for cleaning the milking equipment and chlorhexidine gluconate and glycerine for the teat dipping of the cows. In September 1994 concrete grooving (7.6 x 7.6 cm) was carried out on a large proportion of the concrete floors in the housed area to reduce the risk of injury to animals on the over-smooth floors.

The system of rearing calves was changed during the conversion period from the previous practice of rearing replacements off site on a diet based on milk powder, to the home rearing of calves on colostrum and fresh milk for ten weeks after birth, supplemented with organic cereal grains (e.g. oats) and acceptable protein supplements, including full-fat soya beans and maize gluten meal.

To compare the performance of Ty Gwyn with that of conventional farms, the published gross margins for the dairy cow for herds with over 80 cows on specialised dairy farms in Wales have been used (FBS, 1992; 1993; 1995)

Collaborating farms

All the farms that participated in the study, including Ty Gwyn, were able to supply dairy costings. Some financial details of the enterprise physical parameters were recorded. However, the systems used, and hence information obtained, varied slightly between the farms. In the following section, changes in some of these parameters of the dairy production are presented. In all the figures related to the dairy cows' performance, farms were sorted according to their milk yield at the beginning of conversion, with the lowest farms at the left and the higher yielding farms at the right of the chart. Where available, data from Farm 8 was also included.

General information was also collected from each farm on breed of cows, type of calving pattern, type of winter housing facilities and size of the individual herds. Data on fat and protein contents of milk was collected every three months, when health data was also being collected (see Section 3.6).The objective was to monitor any changes in milk composition of the individual herds during the period from April 1993 to March 1995.

3.5.2 Results

Ty Gwyn

At the start of the conversion period the white clover content of many of the existing swards was low. These poorer swards were used for conservation as silage for feeding to the cows during late-lactation and the dry period. This allowed the dairy cows, during the period of peak milk production, to graze swards in 1992, 1993 and 1994 with mean white clover contents of 29.3, 29.5 and 33.0%, respectively. Mixed grass/white clover silages conserved in 1992 provided all the forage requirements for the 1992/93 winter period. With the establishment of the crop rotation at Ty Gwyn, additional silage was available in the 1993/94 and 1994/95 winter periods from whole-crop cereal silage (fed during late lactation and in the dry period) and Italian ryegrass/red clover silage, the latter providing 50% of the silage fed in the 1994/95 winter. Throughout the period well fermented silage was made with minimal wastage on either the top or sides of the clamps.

The total quantity of concentrates fed to the cows was 1.30, 1.14 and 1.45 tonnes/cow in 1992/93, 1993/94 and 1994/95. From April 1992 to February 1994 cows were fed individually, twice per day, in the parlour during milking, with a conventional concentrate cube fed as the sole concentrate supplement. From the start of the calving season in February 1994 concentrate supplementation of the forage diets was changed to out-of-parlour feeding on a group basis, with individual ingredients including organic cereal grains, winter beans, full-fat soya beans, peas, sugar beet pulp, maize gluten meal and wheatfeed. The concentrate feeds were fed at levels to provide diets containing at least 80% organic feeds, 60% forage and a minimum crude protein content of 18%. Changing from a conventional concentrate fed in the parlour to the group feeding of organically acceptable feeds led to problems in both feed storage and animal performance. The poor keeping quality of both winter beans and full-fat soya beans in 1994 resulted in the feeding of some unpalatable feed during early lactation and intense competition between cows when the concentrates were fed on a group basis. Although good quality silage (ME 11.2-11.5 MJ/kg DM) was offered *ad libitum* during early lactation in 1994 changing the type of concentrate fed and method of feeding resulted in total dry-matter intakes of less than 16 kg/cow/day, mean milk yields of 25.6 kg/day and milk protein levels of less than 3%. The purchase and feeding of the individual concentrate feeds was based on regular availability, price and the capacity of commercial suppliers to provide a suitable mix of the required ingredients. From 1994 all potential rations were evaluated using a computerised ruminant nutrition program RUMNUT (Chamberlain, 1994). Prior to the conversion, mineral supplementation for the dairy herd was supplied by allowing free access to minerals and also including them in the concentrate using a conventional mixture expressed on a % basis: calcium 16.0, phosphorus 13.0, sodium 8.2 and magnesium 4.0; on a mg/kg basis: manganese 8,000, zinc 5,000, copper 1,500, cobalt 200, iodine 500 and selenium 18. During the conversion period mineral supplementation was changed to allowing free access to seaweed meal: % - calcium 2.70, phosphorus 0.07, sodium 2.57, magnesium 0.17 and sulphur 1.47; mg/kg - manganese 105, zinc 62.8, copper 9.0, cobalt 6.0, iodine 390, selenium 0.45, molybdenum 0.9, chromium 3.0, nickel 5.6, lead 0.4, iron 3,880, boron 110 and cadmium 0.7.

The number of cows at Ty Gwyn were reduced from 135 (pre-conversion) to 71 during 1992/93. As shown in Table 29 only small changes were recorded during the 3-year period in the mean annual stocking rates, with the main effect being the decline in cows as the number of home-reared replacements increased. In both 1993/94 and 1994/95 there was a disproportionate ratio of cows to young stock due to the rearing of extra replacements to increase the size of the milking herd.

Table 29 Animal numbers and stocking rates at Ty Gwyn

Animal type	Livestock unit (LSU/ha)	Year			
		pre-1991	1992/93	1993/94	1994/95
Adult cows	1.0	132	90	68	75
Heifers 12-24 months	0.65	n\a	n\a	26	30
Calves 0-12 months	0.34	n\a	17	22	15
Stocking rates (LSU/ha)		2.0	1.5	1.5	1.6

The level of milk production and changes in the composition of the milk have been included with the data from the collaborating farms in Section 3.5.3.

Both the body weight and body condition score of the cows increased from 1993/94 to 1994/95, with body weight increasing from 576 to 609 kg and body condition score from 2.4 to 2.5. The increase in body weight of the cows in the herd in 1994/95 was attributed to both the increasing size of the animals within the herd, due to the increasing influence of the Holstein genetics, and also to the improved condition of the cows, as shown by the small increase in the body condition score.

The breeding policy for the dairy herd was based on maintaining the Holstein-Friesian breed and the selection of Holstein bulls from the Netherlands and North America with the genetic potential to improve both the conformation of the animals and also the milk protein content. In 1992 all cows were inseminated with Holstein semen, while in 1993 and 1994 the early-calving cows were inseminated with Holstein semen to ensure sufficient herd replacements were born; a beef bull (Limousin or Simmental) was used to serve late-calving cows. The annual mean parity of the herd during the 3-year period was 3.8, 3.9 and 3.8.

Visual observation showed that the grooving of the over-smooth concrete floors in the housed areas in September 1994 improved the confidence of animals moving over the floors and reduced the number of animals slipping and falling.

Collaborating farms

General information collected on the differences between the individual farms, including the breed of cows, calving season, type of housing and herd size, have been included in Table 30. With the exception of one herd of Ayrshire cows the main breed was the Holstein-Friesian. In four herds some of the Holstein-Friesian cows had been bred to Brown Swiss, Meuse Rhine Issel or Normande bulls, with the primary aim of improving the protein content of the milk and also the conformation of the animals. The majority of herds had an all-the-year round calving pattern, with straw-bedded cubicles the main type of housing for the winter period. Two farms changed from cubicles to loose housing during conversion and, on several other farms, small changes to the housing were introduced to improve the welfare of the animals. There were large differences between farms in the number of cows in the herd, ranging from an average of 42 up to 303.

Table 30 General herd information from the collaborating farms

				Cows in milk	
Farm	Breed of cow	Calving season	Type of housing	93/94	94/95
1	Ayrshire	All the year	Loose	125	127
2	HF	Spring	Cubicles	45	39
3	HF	All the year	Cubicles	82	89
4	HF	Spring/Summer	Loose	72	75
5	HF	All the year	Loose	125	114
7	HF/N	All the year	Loose	48	44
8	HF	All the year	Cubicles	62	50
9	HF	All the year	Cubicles	313	293
10	HF/M/B	Autumn	Cubicles	57	51
11	HF/M/B/N	All the year	Cubicles	202	200
12	HF/M/B	All the year	Loose	-	51
Ty Gwyn	HF	Spring/Summer	Cubicle	58	61

Key: HF=Holstein-Friesian M=Meuse Rhine Issel N=Normande B=Brown Swiss

Stocking rates at Ty Gwyn decreased, as a result of reduced stock numbers and farm size, by 20% from 2.0 to 1.6 LU/ha in the first two years and then increased again in Year 3 by 5%. The stocking rate was reduced on most farms at some stage during the process of conversion (see Fig. 24). In Year 4, the fourth year of conversion, the stocking rate was reduced by about 10% on average, to 1.7 LU/ha. On five out of the 10 commercial farms the stocking rate was still lower in Year 4 of conversion than it had been before the conversion started.

Fig. 24 Stocking rate (GLU/ha)

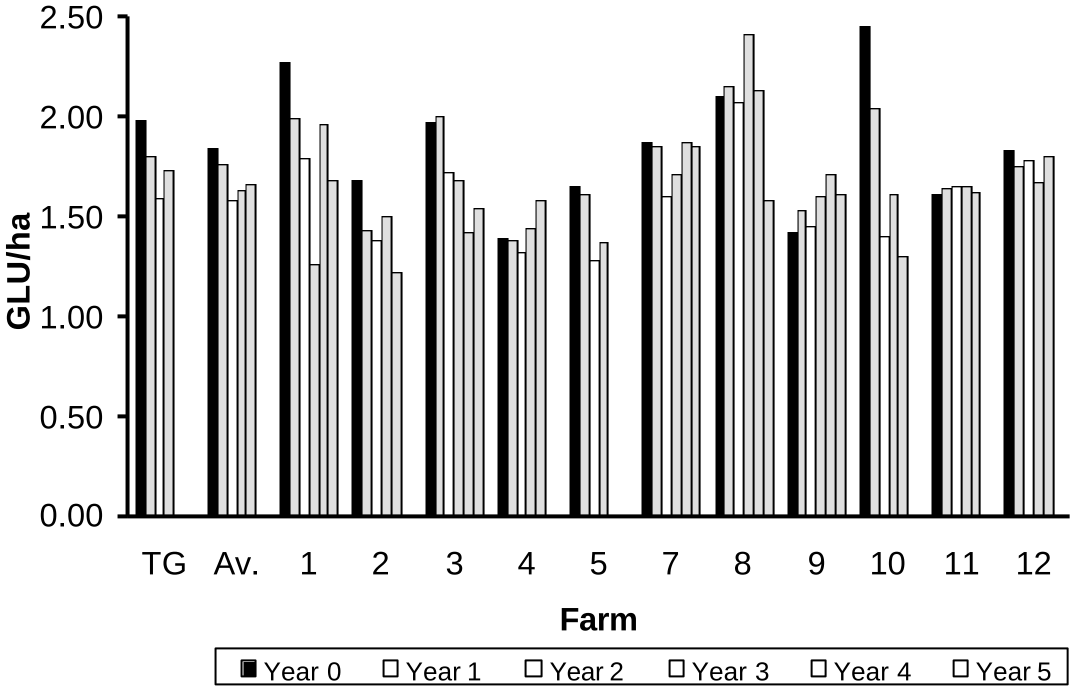
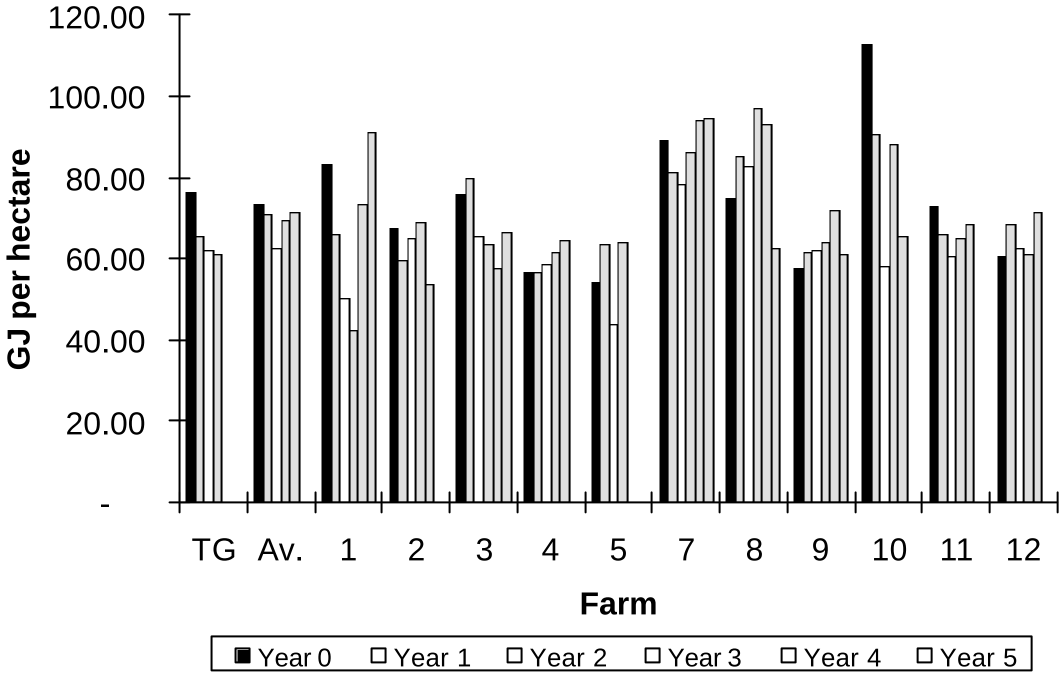


Fig. 25 Utilisable Metabolisable Energy (GJ/ha)



Three farms (Farms 7,11 and 12) were stocked at the same level as before conversion; Farms 7 and 12 reduced their stocking rates prior to conversion, whereas Farm 11 was stocked at a comparatively low rate all the time. Two farms (Farms 4 and 9) increased their stocking rates during conversion. It appears that reductions in stocking rate were more likely on those farms which were more densely stocked before starting conversion, whereas the lower stocked farms maintained or even increased their stocking rate.

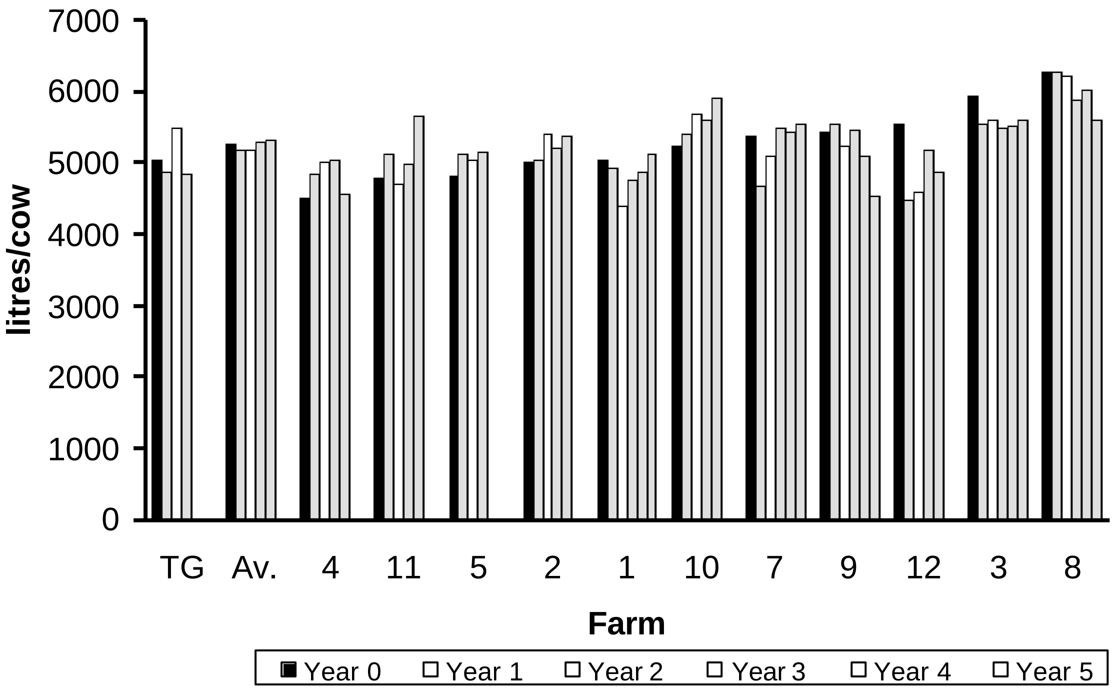
Measured forage yield (t DM/ha) was reduced in Year 1 by about 16% but achieved 95% of the prior conventional management production in Year 2. One possible explanation for these differences appears to be the change in forage quality, but a better understanding of the different methods of forage yield assessment and effects of differences in weather conditions from year to year is needed to explain these differences.

Utilisable Metabolisable Energy (UME) was calculated on the basis of the energy needed for milk production, minus the energy supplied by concentrates and other purchased feedstuff. It has been used as an on-farm measure of forage productivity for dairy farms (Thomas and Perry, 1991).

A similar trend to the stocking rate was seen in the UME figures for all collaborating farms. The average reduced by 15% in Year 2 and increased again in Years 3 and 4, resulting in a final average reduction of 2%. This reduction was smaller than the reduction in stocking rate and the trend for both measures was not similar on all farms. Both measures of forage productivity were likely to be influenced as much by the climate as by the conversion.

Milk yield before conversion of Ty Gwyn was 5024 litres per cow, about 7% lower than the FBS. It was reduced further in Year 1 of conversion, increased 9% above Year 0 (pre-conversion - 1991) in Year 2 and fell back to the Year 1 level in Year 3, which was about 3-4% below Year 0. The average milk yield for Ty Gwyn was below the average of 5125 litres for all the commercial farms (see Fig. 26). The average milk yield for all farms increased despite the conversion; however, the variation between the farms was considerable. Five farms (left in Fig.26) were able to improve milk yields during the process of conversion, four of these having started with yields below the average in Year 0. All farms which started with a higher-than-average milk yield in Year 0 (right in figure), plus Farm 1 and Ty Gwyn, experienced reductions in milk yield of up to 10% during the process of conversion. Farms 1, 7 and 12, where initial reduction occurred, were able to improve milk yield again later. The initial milk yield reductions of over 10% on farms 7 and 12 were potentially also related to drought conditions.

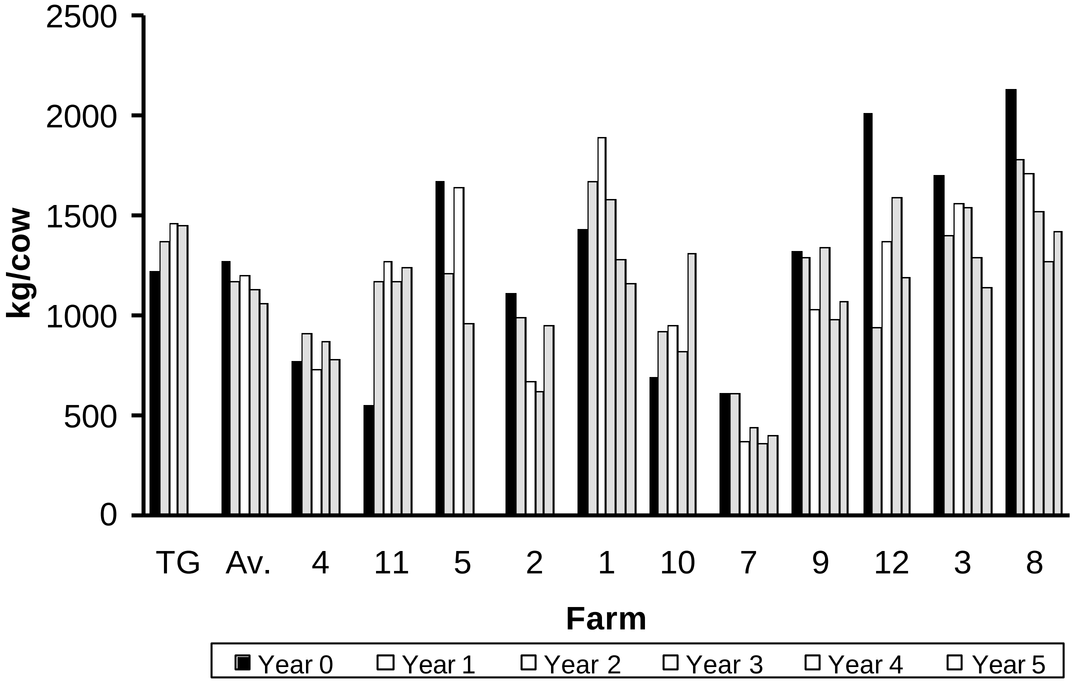
Fig. 26 Milk yield (litres/cow)



Concentrate use; like Ty Gwyn the majority of the commercial farms in the sample (seven of eleven) used only purchased concentrate for feeding. The concentrate use at Ty Gwyn was 1.2 t/cow, just below the average for commercial farms in Year 0. It increased during the conversion by about 20%. The variation for the commercial farms was considerable before and during conversion. All farms with high milk yields reduced concentrate use during conversion, but otherwise no clear relationship between milk yield and concentrate use was seen (see Fig. 27). The concentrate use in Year 4 was on average reduced by 17% compared to Year 0.

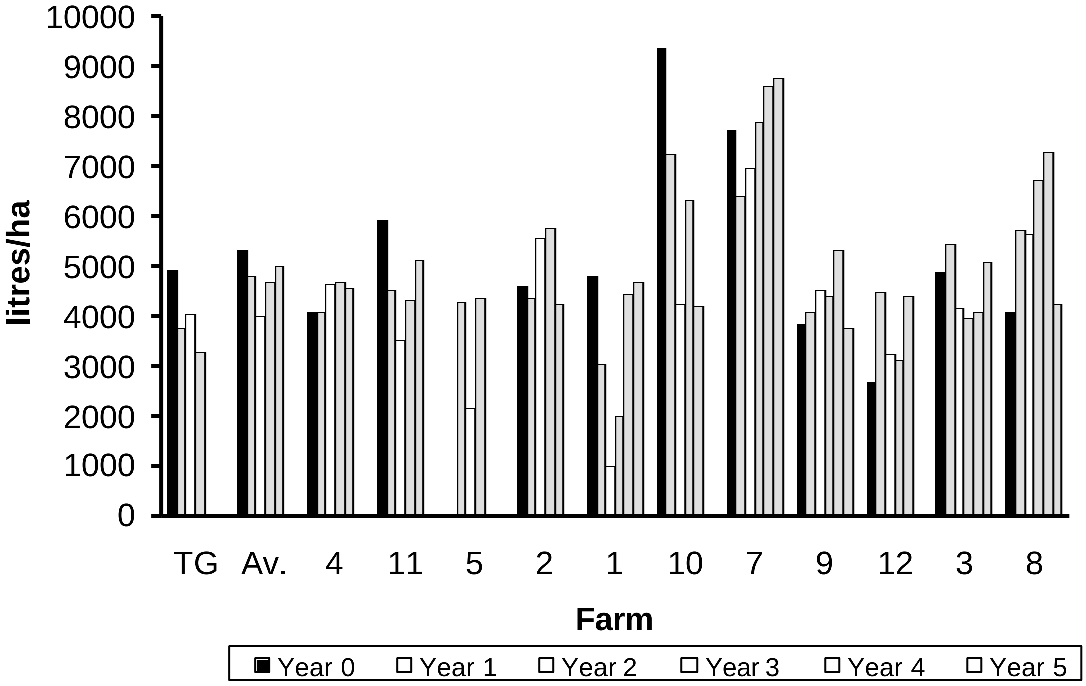
Only two of the eleven commercial farms (No 10 and 11) had higher levels of concentrate use in Year 4 compared to Year 0. Farm 10 had a comparably low level of concentrate use prior to conversion and their milk yield increased with higher concentrate use. Farm 11 was, according to information from the farmer, faced with serious feed shortages as a result of the "all at once" conversion of the whole farm; increased concentrate was used to compensate for this.

Fig. 27 Changes in concentrate use (kg/cow)



Milk from forage was calculated by combining the two parameters, milk yield and concentrate use. [An important aim of organic production is to increase milk produced from the farms' own resources, which should lead to an increase in milk from forage production]. Ty Gwyn, with 2500 litres of milk from forage, was below the average for the eleven commercial farms. The average milk from forage per cow for the commercial farms increased almost continuously, rising 13% by Year 4. However, no clear trend was apparent on most farms on a year-to-year basis, with some farms increasing the milk from forage initially and then decreasing (e.g. No's 4 and 2) whereas others decreased in the first years and then increased later (No's 1 and 11). The highest milk production from forage in any one year was achieved by farms 2,10 and 7. Those farms were, in Year 0, all placed around the average in their milk production. Because of the reduction in stocking rate, the milk produced from forage per hectare showed a reduction of about 20% in Year 2 and then increased back to its original level (see Fig. 28).

Fig. 28 Milk from forage (litres/ha)



Milk quality. Table 31 shows the mean annual milk composition for the collaborating farms. As the monitoring on Farm 12 did not commence until 1994 two sets of means and standard error of the means are presented for 1993/94 to allow both the inclusion of data from Farm 12 and comparisons between 1993/94 and 1994/95 for data from the other farms. At Ty Gwyn both the fat and protein contents of the milk were consistently higher during the conversion period, by 0.07 and 0.06% respectively, when compared to pre-conversion figures. Although a wide range of values were recorded between farms in milk fat (3.81 - 4.14%), milk protein (3.12 - 3.38%) and the level of milk production , there was no significant correlation between the level of milk production and either milk fat % (r=0.36) or milk protein (r=0.15). On most of the farms there was little variation between years in either the fat or protein content of the milk.

3.5.3 Discussion

Ty Gwyn

The main change during the conversion period was the reduction in animal numbers from 2.0 to 1.5-1.6 livestock units/ha, reflecting the change from a system based on the input of 380 kg/ha of nitrogen fertiliser to one based on clover and slurry as the main sources of N. The stocking rate at Ty Gwyn in 1994/95 of 1.6 LSU/ha was similar or lower than the stocking density of 1.6-1.8 recorded on other organic dairy farms (Houghton and Poole, 1990; Redman, 1991) and lower than the stocking rate of 2.33 recorded on conventional farms (Genus, 1994).

Table 31 Milk composition data from the farms

Farm	Milk fat % 1993/94	Milk fat % 1994/95	Milk protein % 1993/94	Milk protein % 1994/95
Ty Gwyn	4.00	4.08	3.22	3.20
1	3.80	3.90	3.29	3.32
2	4.13	4.14	3.38	3.29
3	4.09	3.92	3.34	3.30
4	3.91	3.94	3.15	3.12
5	3.95	3.99	3.23	3.24
7	4.02	4.10	3.35	3.28
8	4.11	4.09	3.29	3.28
9	4.14	4.07	3.32	3.16
10	4.00	4.13	3.25	3.17
11	3.93	3.96	3.17	3.20
Mean	4.02	4.04	3.28	3.24
sem	0.032	0.028	0.021	0.019
12	4.25		3.27	
Mean	4.04		3.28	
sem	0.035		0.019	

The management decision to maintain a reserve clamp of silage at the farm was achieved by the conservation of cereals as whole-crop silage and the inclusion of straw in the diet of dry cows during the 1994/95 winter. This policy ensured that adequate forage supplies were available throughout the 3-year period.

The fat and protein contents of the milk were slightly higher during the conversion period when compared with the pre-conversion figures and were similar to the national average for conventional Holstein-Friesian herds (Genus, 1994). The option of changing the breed from the Holstein-Friesian to a breed with genetically higher milk protein (e.g. Brown Swiss, Normande, MRI, Channel Island) was rejected as the current breed is representative of the majority of dairy herds in the UK.

As reported in Section 3.5.1 no major changes were made to the animal housing areas. The option of changing from cubicle housing to straw-bedded yards was considered and rejected for a number of reasons including the relatively low incidence of lameness within the herd, the high capital expenditure required to modify the existing building, the increased requirement of straw for bedding and the need to provide extra housing to compensate for the reduced stocking density.

Following the problems of the poor keeping quality of some of the purchased bulk concentrate feeds, the difficulty was partially rectified by the regular purchase of small quantities of feeds in bags, rather than in bulk, and also the purchase of some ingredients pre-mixed prior to delivery. The performance of the herd suggested that feeding concentrates on a group-fed basis out of the parlour, rather than individually in the parlour, had an adverse effect on both intake and performance as competition between animals is markedly increased. Visual observation showed large differences in palatability between individual concentrate ingredients and cows showed a general indifference to maize gluten meal.

Collaborating farms

The average *milk yield per cow* for all commercial farms remained almost unchanged during the study period. Farms with a milk yield above average in Year 0 decreased their milk yield at some stage during conversion, whereas farms with yields lower than average in Year 0 in many cases increased their yields. A similar result was found in a German study of 57 dairy farms in conversion, although an average reduction in milk yield of 2.7% was reported. (Schulze Pals, 1994). In earlier English case studies, milk yields declined by 10% on one farm and remained constant on the other (Lampkin, 1993). The different responses in milk yield to the change to organic management have been explained by Schulze Pals (1994) as being due to a higher reduction in concentrate use on higher yielding farms. Likewise all farms in our sample with milk yields above average before conversion reduced the amount of concentrate during conversion, resulting in most cases, in increased *milk from forage*. The interviews indicate that some of the reductions in concentrate use were strategic rather than due to forage quality and quantity. In the group with milk yields below average in Year 0 some farms reduced, whereas others increased the concentrate feeding. On some farms, concentrate feeding was increased to compensate for lack of forage. The maintenance of average milk yields, despite a reduction in concentrate feeding of about 15%, indicated the concentrate feeding before conversion was suppressing forage utilisation, at least on some farms. It also led to an average increase in milk from forage per cow. On the other hand, initial analysis of the interviews revealed that feed shortages in the first year of conversion, apart from the desire to improve milk yield, were one reason for increased concentrate input during the period of conversion.

The average milk yield (5332 litres) and the average concentrate feeding (1.1 t/cow) in Year 4 were higher than the results from Houghton and Poole (1990) and Lampkin (1993), reported in Section 2.1, and the yields reported for 253 organic farms with dairy cows in Germany, where an average milk yield of 4953 kg with an input of 0.58 tonnes of concentrate per cow was found (Krutzinna *et al*., 1995). The current results are almost identical to the results reported by Redman (1991). However, the almost unchanged milk yield for the average of the commercial farms in this study does not correspond with other studies, where organic milk yields were found to be 10% lower than for conventional dairy herds (see Section 2.1). This might be a result of the high proportion of specialised dairy farms in the study.

Differences between herds in the fat and protein contents of the milk suggest that, irrespective of breed, there were large variations between herds in the type of diets that were being fed, including the quantity and type of concentrates and quality of the forage, as well as the genetic base of the cows within the individual herds. The mean figures for both the fat and protein contents of the milk were similar to the national figures for conventional herds recorded by the Milkminder recording scheme (Genus, 1994).

As already outlined, there were difficulties in identifying ten commercial farms that were starting their conversion at the same time as the project; on many of the farms a substantial part of the conversion period had occurred before the study period started. Hence, for the years prior to the study start it is only indirect measures of forage productivity (e.g. stocking rate or forage area per cow) that can be calculated, using the basis of the available account figures. The average reduction in *stocking rate* (GLU per forage hectare) in the third or fourth year of conversion was about 10% for the commercial farms and Ty Gwyn and, as Fig. 24 shows, the reduction was more marked on those farms that had a high stocking rate at the beginning of conversion. The average reduction was not as high as has been reported from other studies, where reductions of up to 20% were found (Lampkin, 1993). This might be related to the soil and climatic conditions on some of the study farms being more favourable than in other studies. Schulze Pals (1994) found that reductions in stocking rate appear to be higher on poorer soils than on better soils; Newton (1994) established a relationship between soil site classes and forage productivity on organic farms.

The stocking rate (and similarly forage area per cow) is an inaccurate measure of forage productivity, especially for the process of conversion to organic farming, because grazing livestock on the farm are also supported by concentrates and purchased forage. Both are likely to change during the process of conversion. Purchases of feedstuff to compensate for reduced forage productivity, as reported by Farm 11, would result in smaller changes in the stocking rate. Similarly, a reduction in concentrate feeding would lead to reductions in stocking rate, where forage productivity was maintained. Therefore, *Utilisable Metabolisable Energy per hectare (UME)* has been calculated, using standard values as suggested by Thomas and Perry, (1991), because accurate data for purchased bulk feed and varying energy content of different concentrates was not available.

The reduction in the average UME figure was 2 %, much smaller than the reduction in stocking rate of about 10% in the same period. As Figs. 24 and 25 show, the trend for the two measures varied on some farms, but in most cases the reductions in stocking rates were larger than for the UME figure. Similar results were found in earlier case studies (Lampkin, 1993). Initial reductions in forage productivity during conversion were likely to be caused by an increase in the area under reseeding and/or through the withdrawal of fertiliser before clover became established. The observed changes in stocking rate were also likely to be influenced by changes in diet (concentrate feeding) and forage quality, which lead to a greater demand for forage on the farm. Because the conversion period was studied on most commercial farms on the basis of historic data, such changes could not be identified clearly throughout the period of conversion. A comparison between the actual forage yields as measured by IGER in this study period and indirect measures like stocking rate and UME figures will be possible in the next period of the study, when the farm account data for those years where forage has already been measured have been analysed.

3.5.4 Conclusions

The conversion plan for Ty Gwyn (available in the IGER library) provided essential information to guide the management of the herd, particularly in relation to the calculation of herbage production and the effect on animal numbers, feeding policy for the dairy herd and approach to the treatment of health problems within the herd. Defining broad targets in the conversion plan proved useful, particularly in the early stages of conversion when staff were planning the management of the unit.

Throughout the conversion period the recorded stocking rates were slightly lower than predicted, and the quantity of concentrates fed per cow higher, reflecting the need for organic dairy farmers to build up and maintain a reserve stock of forage as an insurance against an extended winter feeding period, or requirement for buffer feeding due to adverse weather conditions.

Changing from a conventional concentrate cube, regularly delivered in bulk, to the feeding of organically-acceptable diets, has highlighted a number of difficulties. These include the requirement for a regular supply of suitable feeds, the increased cost of concentrates for the organic dairy herd and the need to produce high quality forages for the dairy herd, preferably supplemented with some home-grown concentrate feed which will reduce the importation of nutrients on to the farm. The adverse effects of the group feeding of concentrates, due to the increased competition between animals at feeding time, could be reduced, either by the installation of individual feeding yokes, tombstone barriers, or the commercial production of a balanced organic concentrate cube that can be fed in the parlour.

The experience at Ty Gwyn supports the conclusions of Houghton and Poole (1990) that the major production priority for the organic dairy farm is to produce adequate quantities of high quality forage (both fresh and conserved) to meet the requirement for diets with more than 60% forage, achieve satisfactory stocking rates and reduce the quantity of imported concentrates required to balance the rations. Adequate forage supplies for the Ty Gwyn dairy herd were achieved by the decision to establish a crop rotation which included highly productive Italian ryegrass/red clover swards and also the decision to ensile cereal crops as whole-crop silage rather than combining them for grain.

Whilst the Holstein-Friesian breed of cattle were being kept at Ty Gwyn and also on the majority of collaborating farms, changing to a breed with a higher milk protein would increase the milk price per litre and, providing current milk yields per cow are maintained, also increase total milk income. The results from the collaborating farms show that the mean performance from the farms in terms of milk composition was similar to the performance of conventional herds (Genus, 1994). The use of semen from breeds with higher milk protein has not yet had an influence on the mean protein content of those herds.

Converting from conventional to organic dairy farming resulted in the marketing of organic milk and the payment of an additional premium both at Ty Gwyn and on many of the collaborating farms. As the total number of organic dairy herds is still small, the availability of a regular supply of milk is essential for dairies producing organic products, as well as the maintenance of milk quality throughout the year. For many organic dairy farmers changing to an all-the-year round calving pattern, rather than seasonal calving, may be necessary when a processing dairy requires a regular supply of milk from a relatively small group of producers.

3.6. Animal health

By R.F. Weller, A. Cooper and R. Wilkinson

3.6.1 Introduction and data collection

Ty Gwyn

The main objectives were to monitor the health and reproductive performance of the herd during the conversion period, introduce the use of alternative remedies for the treatment of specific ailments and maintain good welfare standards.

All health and reproductive events were recorded daily, with the information from both the herdsman and visiting veterinary surgeon transferred on to a computerised dairy information system (DAISY, 1984). The management aims for the dairy herd were based on achieving good standards of stockmanship, including the early detection of ailments, and the introduction of alternative remedies for the treatment of specific ailments. The use of alternative remedies was introduced in June 1993 and used to partially replace the routine use of conventional medicines (e.g. antibiotics). Prior to the introduction of alternative remedies the herdsmen (full-time and relief) attended training courses held by Elm Farm Research Centre and the Worcestershire College of Agriculture.

Responsibility for identifying mastitis cases, treating them and recording the details was undertaken by the herdsman. Before treatment was given an aseptic sample was taken from the quarter and submitted for bacteriological analysis by ADAS. Samples containing less than 100 colony-forming units/ml were regarded as bacteriologically negative. Milk samples were not examined after treatment and nothing can therefore be reported on bacteriological cure rates. Some samples were also examined from cows which had individual cell counts for National Milk Record samples in excess of 250,000/ml. In these cases separate samples were taken from all functional quarters. Long-acting antibiotics were used during the dry period for all cows in 1992 and half the herd in 1993, with collodion applied to seal both the orifice and skin of the teats of the remaining cows. In 1994 collodion was used to treat all cows.

In addition to the recording of lameness by the herdsman, locomotion scoring (Liverpool University Veterinary School, 1993) was carried out by ADAS staff to determine the incidence of lameness in the herd according to the recording system. The experimental unit was visited thirteen times between March 1993 and July 1994. On each occasion all available cows were locomotion scored to determine the incidence of lameness (number of cases per 100 cows per year) in the herd, to assess the prevalence (proportion of the herd lame at one time) and severity of lameness. These results were not made available to the herdsman who was responsible for treating any cows which he considered to require treatment. A record of these treatments was maintained by him. Scores of 1.0 or 1.5 were regarded as normal. A continuous series of scores of three or more were considered to represent one period of lameness. However, cows with more than one such period often had poor scores (2 or 2.5) between episodes of lameness and, as it is unlikely that these cows had really recovered, the number of episodes of lameness was also calculated, on the assumption that two periods of high scores were the same lameness event unless separated by at least one score of 1.5 or better. Concrete in the buildings was scored for surface finish during the winter of 1993/94 and the cow tracks in use at the time were scored on each occasion during the grazing season. The 1 to 5 scoring system developed by the Liverpool University Veterinary School (1993) was used. As the data was in the form of discontinuous variables, Chi-squared tests were used for statistical analysis.

During the 3-year period all animals under twelve months of age were grazed on clean swards, ungrazed by adult animals for at least six months. On veterinary advice and due to previous problems, these animals were drenched with the anthelmintic Dictol. In 1993 and 1994 the presence of parasites was determined from faecal samples taken from both adult and young stock animals in September and December to determine the presence and levels of lung and intestinal worms, and liver fluke, respectively.

Collaborating farms

Following the identification by UWA staff of ten farms in conversion to organic management, the farms were visited in March/April 1993 to initiate the start of the recording and monitoring of the health status of the individual dairy herds. The main objectives were to record changes in the herd status of the individual farms and to identify any specific problems associated with the change to an organic system. All farmers and herdsmen were requested to record all health and reproductive events in a diary, including events associated with the visiting veterinary surgeon, prior to the transfer of this information on to 3-monthly IGER recording forms. The forms were either filled in by the farmer/herdsman or by an IGER technician during the 3-monthly visit to the farms.

Table 32 Alternative remedies used at Ty Gwyn

Alternative remedy used	Type of ailment treated
Aconite	High temperature, injury, vulval discharge
Arnica	Injury, post-calving bruising
Belladonna	Milk fever
Collodion	Prevention of mastitis
Golden udder/Uddermint	Treatment of clinical mastitis
Hepar sulphuricum	Heated swellings, lameness, clinical mastitis
Herbal pessaries	Retained foetal membranes, vulval discharge
Hypericum-Calendula cream	Cuts and injuries
Iodine solution	Reproductive problems, vulval discharge
Magnesium sulphate	Lameness
Nosode (*Staph. aureus*)	Prevention of mastitis
Phytolacca	Clinical mastitis
Pulsatilla	Reproductive problems, retained foetal membranes
Pyrogen	Retained foetal membranes, vulval discharge

3.6.2 Results

Ty Gwyn

During the 3-year period, priority was given to the health and welfare of the animals in the herd. This involved full consultation with the visiting veterinary surgeons and the treatment of ailments with the most appropriate therapy (i.e. conventional medicines, alternative remedies). The alternative remedies that were used at Ty Gwyn from June 1993 onwards for the treatment of specific ailments are shown in Table 32.

Table 33 Health and reproductive problems recorded in the Ty Gwyn herd (1 April 1992 to 31 March 1995)

Health and reproductive events	1992/93	1993/94	1994/95
Cases/100 cows			
Mastitis	10.3	27.2	27.9
Lameness	1.3	13.6	21.2
Milk fever	6.5	2.7	6.6
Ketosis	0	0	0
Bloat	0	0	1.3
Fertility problems	6.5	13.6	23.8
Vulval discharge	6.5	28.6	14.6
Retained foetal membranes	3.9	2.7	4.0
Abortions	0	1.4	0
Culling rates/annum	16.8	17.7	17.3
Bulk tank			
Somatic cell count levels ('000)	293	215	306
Total bacterial counts (Band)	A	A x 11,B x 1	A

As shown in Table 33 the culling rates for the Ty Gwyn herd were similar throughout the monitoring period. Poor fertility was the prime reason for culling (69.4%), followed by: injury (13.9), bovine spongiform encephalopathy (8.3), milk fever (2.8), age/lameness (2.8) and low yield/mastitis (2.8%).

Between June 1993 and January 1995 a total of 175 milk samples were examined from 47 cows including 88 single quarter samples and 87 multiple quarter samples. Cows were sampled on up to seven separate dates, due to either ineffective treatments or repeated infections. The frequency of sampling is shown in Table 34.

Table 34 Frequency of sampling compared to the number of cows sampled at Ty Gwyn

Frequency of sampling	All samples	Single samples only
1	23	10
2	6	6
3	7	7
4	4	3
5	4	4
6	2	1
7	1	0
Total number of cows	47	31

Table 35 The number of bacteriological findings for samples taken prior to, and as a result of, high somatic cell counts at Ty Gwyn

Organism	Pre-treatment n (% of total)	High cell counts n (% of total)
Staphylococcus aureus	54 (53.4)	21 (23.1)
Other haemolytic Staphylococci	17 (16.7)	16 (17.6)
Streptococcus agalactiae	5 (4.9)	0
Streptococcus dysgalactiae	2 (2.0)	0
Streptococcus uberis	3 (2.9)	0
Corynebacterium	7 (7.0)	0
Pseudomonas	3 (2.9)	0
Bacteriologically negative	11 (11.1)	54 (59.3)
Total infections with one species	60	26
Total of infections with more than one species	17	7

When the distribution of all sampling was considered this gave a high proportion of the samples for cows which were sampled only once. Fifteen cows were sampled only once as a result of high somatic cell counts. Almost half of the total samples taken were from just 8 cows.

The predominant bacteria were the *Staphylococci* with *Staphylococcus aureus* being the most important. However, a high proportion of other haemolytic *Staphylococci* were also present. Most other mastitis-causing organisms were also present but the importance of the environmental organisms was very limited.

The treatment of cows in 1994 with either long-acting antibiotic or collodion at drying-off did not affect the number of cows with clinical mastitis in the subsequent lactation (23.7 and 24.1%, respectively). Following the UKROFS certification a minimum discard time of 14 days was introduced for milk from mastitis cows treated with antibiotics. Concern about the presence of *Staphylococcus aureus* bacterium in the milk samples of a number of cows led to the regular addition of a *Staphylococcus aureus* nosode to the drinking water from October 1993. In the 3- and 12-month periods after the addition of the nosode the mean somatic cell count levels ('000) of the herd was slightly lower (210 and 230) than the mean level of the previous 3- and 12-month periods (252 and 279).

A total of 879 locomotion scores were recorded at Ty Gwyn (Table 36).

Table 36 Incidence of lameness by year of birth at Ty Gwyn

Year of birth	Number of cows	Lameness events	Number of cows lame	Number of scores of 3 or more	Total number of scores
<1987	18	27	13	63	197
1987	10	11	6	19	91
1988	10	11	5	25	90
1989	10	5	4	9	91
1990	26	10	8	11	290
1991/2	21	8	7	9	120
Total	95	72	43	136	879

Of 95 cows, 41 were observed to be lame on at least one occasion. Older cows were more likely to be lame than younger ones but the difference was not significant. The total number of scores of 3 or over was 136, a lameness prevalence of 19% with a preponderance of significantly high scores in older groups ($P<0.01$). Lameness was seldom severe with only four scores of more than 3.5. Consecutive scores of 3 or over were rated as belonging to the same lameness event. On this basis there were 71 lameness events and an annual incidence of about 56%. Significantly more periods of lameness were recorded with older cows ($P<0.05$). Once allowance was made for occasions where periods of lameness were not separated by scores of 1.5 or more, there was a tendency for each age group to have fewer lameness episodes. This was more marked in the older groups and the effect of age group on lameness incidence was significant ($p<0.05$). During the study there were 20 occasions (17 cows) when the herdsman treated cows for conditions likely to influence their ability to walk properly. On 12 of these occasions the cow had been noted as lame when last locomotion-scored, while on a further three occasions the cow was noted as lame at the subsequent scoring. Poor locomotion led to the culling of four cows. Scores for the concrete in the cubicles and collecting yard and for the cow tracks are given in Table 37. These scores indicate that the concrete was generally smooth and the cow tracks generally rough.

Table 37 Summary of locomotion scores for the concrete surfaces and cow tracks at Ty Gwyn

Concrete surfaces (January 1994)	
Cubicle passages	2.7
Feed passages	2.0
Collecting yard	3.0
Exit race	3.0

Cow tracks	Gate	Track	Field entrance
May 1993	3.5	3.4	4.0
June 1993	3.4	3.3	3.3
July 1993	3.3	3.4	3.0
July 1993	3.8	3.2	3.6
August 1993	4.0	3.5	-
October 1993	4.0	3.6	4.0
July 1994	4.3	3.4	3.8

In Table 38 the calculation of the reproductive performance of the cows is based on the number of services, including both artificial inseminations and natural services. The reproductive performance of the herd was monitored using targets defined by MAFF (1984).

Table 38 Reproductive performance of the Ty Gwyn herd (1 April 1992 to 31 March 1995)

	1992/93	1993/94	1994/95
Number of services/pregnancy	1.6	2.0	2.7
Days to conception	116	89	87
Pregnancy rate to first service	52	42	32
% of cows becoming pregnant	90	96	72

Faecal samples taken from twelve adult and twelve young animals in 1993 and 1994 showed, in both years, either the absence or low levels of both lung and intestinal worms and, with the exception of one eighteen month-old heifer in 1994, the absence of liver fluke eggs.

No major ailments were recorded with the young stock animals during the conversion period.

Collaborating farms

The data collected from the individual farms was collated on an annual basis with the individual reports for each farm sent to the farmer at the end of the 1993/94 and 1994/95 periods. As shown below in Table 39, the use of alternative remedies was introduced on all the farms before the start of the period when health data was collected (April 1993 to March 1995). On some farms the use of alternative medicines was introduced prior to conversion, while other farms, including Ty Gwyn, introduced them during the conversion period.

Table 39 Individual farm data for the year when alternative remedies were introduced, compared with the first year of conversion to organic farming

Farm	Start of alternative remedies	Year 1 of conversion
Ty Gwyn	1993	1991
1	1990	1989
2	1985	1990
3	1990	1989
4	1989	1991
5	1992	1991
7	1990	1990
8	1992	1990
9	1990	1991
10	1987	1990
11	1990	1990
12	1991	1991

Mastitis was the main health problem on most farms, with seven farms using a nosode for the prevention of mastitis and nine farms using antibiotics to treat some of the cases of clinical mastitis. Incidence of clinical mastitis, level of somatic cell counts and total bacterial count in the milk (bulk tank) are shown in Table 40.

During the 2-year monitoring period there was a large range between herds in both the number of cases of mastitis and level of somatic cell counts in the milk. However, statistical analyses of the data did not show a correlation between the incidence of mastitis in a herd and the level of somatic cell counts ($r=0.10$, ns). The number of cases of mastitis/100 cows on the four farms where physical treatment, using manual massage of the udder and the application of cold water, was used for treating cases of clinical mastitis were similar at 44.5 to the results from the seven farms not using the method (45.4 cases/100 cows). During the 1993-95 period seven farms used nosodes on a regular basis for the prevention of mastitis; only one farm did not use any antibiotics for the treatment of clinical mastitis. In addition to antibiotics, cases of clinical mastitis were primarily treated with alternative remedies including belladonna, bryonia, conium, phytolacca, pyrogen and scc (sulphur, silicea and carbo vegetabilis) and also udder liniment/gel.

Table 40 Incidence of clinical mastitis, level of somatic cell counts and total bacterial count of the milk on the collaborating farms

	Clinical mastitis (cases/100 cows)		Mean annual somatic cell counts ('000)		Total bacterial count (Band *) of the bulk tank milk	
Year &Farm	93/94	94/95	93/94	94/95	93/94	94/95
Ty Gwyn	27.2	27.9	215	306	A#	A
1	56	69	263	279	A	A
2	40	36	209	173	A	A
3	55	47	337	335	A	A
4	51	103	325	425	A	A
5	29	20	454	490	A#	A
7	54	57	193	210	A	A
8	47	36	132	222	A	A
9	34	42	353	435	A	A
10	19	25	298	240	A	A
11	33	41	199	175	A#	A
Mean	40.5	45.8	270.7	299.1		
Sem	3.70	6.78	26.61	31.61		
12	69		221		A	
Mean	42.9		266.6			
Sem	4.09		24.77			

* Band A= <20,000 Band B= 20,001-100,000; A#= Band A (11 months) + Band B (1 month)

As shown in Table 41, there were large differences between farms in the number of cases of lameness, although the mean number of cases were similar for both years. With the exception of one farm, the incidence of milk fever was not high; the incidence of both ketosis and bloat was generally low.

Table 41 Incidence of lameness, milk fever, ketosis and bloat on the collaborating farms (cases/100 cows)

Farm	Lameness 93/94	Lameness 94/95	Milk fever 93/94	Milk fever 94/95	Ketosis 93/94	Ketosis 94/95	Bloat 93/94	Bloat 94/95
Ty Gwyn	14	21.2	3	6.6	0	0	0	1.3
1	6	3.2	4	6	0	0	0	0
2	102	46	4	0	2	2	2	0
3	44	46	8	0	0	3	2.4	20
4	1.4	8	0	8	0	0	0	0
5	2	1	0	0	0	0	0	0
7	65	64	6	11	0	0	0	0
8	8	16	10	2	0	0	0	2
9	5	3.7	1	0	2	0	9.6	0
10	12	20	4	2	0	0	0	2
11	48	40	14	19	0	0	0	0
Mean	27.9	24.5	4.9	4.9	0.36	0.45	1.3	2.3
Sem	9.42	6.12	1.25	1.73	0.232	0.297	0.83	1.70
12	12		0		4		2	
Mean	26.6		4.5		0.67		1.33	
Sem	8.74		1.21		0.360		0.77	

As shown in Table 42, no major problems were recorded on the farms in terms of reproduction, post-calving problems (vulval discharge, retained foetal membranes) or the number of cases of abortion. Although large differences were recorded between farms in both the number of reproductive problems and cases of vulval discharge, there was no evidence of any major problems.

Table 42 Number of cases of fertility problems, vulval discharge, retained foetal membranes and abortions on the collaborating farms (cases/100 cows)

	Fertility problems		Vulval discharge		Retained foetal membranes		Abortions	
Year:	93/94	94/95	93/94	94/95	93/94	94/95	93/94	94/95
Farm								
Ty Gwyn	13.6	23.8	28.6	14.6	2.7	4	1.4	0
1	14	31	20	14	2.4	3.1	0	1.6
2	4	2.5	0	0	0	0	8.9	0
3	6	10	30	19	3.7	3.4	3.7	5.6
4	0	2.7	1.5	0	5.6	6.7	1.4	6.7
5	10	20	0	0	2.4	0	0	0
7	0	0	2	0	6.3	2.3	4.2	0
8	24	0	0	0	6.5	4	0	8
9	18	13.1	6	4	3.2	8.3	1.3	3.5
10	0	5.9	0	3	3.5	2	0	2
11	0	7	5.4	0	5	2	0.5	1.5
Mean	8.2	10.6	8.5	5.0	3.8	3.3	2.0	2.6
Sem	2.41	2.98	3.39	2.08	0.56	0.72	0.79	0.84
12	0		0		5.9		0	
Mean	7.5		7.8		3.9		1.8	
Sem	2.16		3.19		0.54		0.74	

3.6.3 Discussion

Prior to the current study there has only been limited information from the published literature on the animal health status of organic dairy herds, both from comparisons between individual organic dairy herds and between organic and conventional dairy herds.

Ty Gwyn

As shown in Section 3.6.2 (Table 32) a number of alternative remedies were introduced for the successful treatment of some ailments. However, antibiotics were used for the treatment of many ailments, particularly the more severe cases of clinical mastitis.

The high proportion of single milk samples containing *Staphylococcus aureus* was similar to the pre-treatment findings in the trials conducted to verify the effectiveness of the NIRD five-point mastitis control plan. When the non-specific haemolytic *Staphylococci* were included, the results indicated a considerable problem with *Staphylococcal* mastitis. This organism is difficult to control as it responds only poorly to conventional lactation therapy and the normal control using a combination of culling and dry cow therapy. The use of dry cow therapy on only half of the herd after the first year of the study (and at a time when, prior to the conversion period, cows had been introduced from another herd with a history of *Staphylococcal* mastitis) probably allowed this infection to establish; the change in the incidence of clinical mastitis after the first year would support this conclusion. Other infections were present as only a small proportion of the total but, more importantly, did not appear to be numerically important, suggesting that other mastitis controls were working successfully. In particular, mastitis caused by environmental pathogens did not appear to have been a problem, reflecting the generally satisfactory standard of the management of the cubicles.

The proportion of bacteriologically negative samples was low by the standards of published work. These samples did not necessarily mean that no infection was present, as the cow's immune system might have largely eliminated the infection before the samples were taken. An alternative explanation might be the fact that the infection was due to *Staphylococcus aureus* as this organism does tend to remain present in scar tissue within the udder and then to periodically break out and cause a further case of clinical mastitis. Samples taken as a result of high cell counts showed a very limited range of infections. Again there were a lot of *Staphylococcus aureus* and general haemolytic *Staphylococci*. The recurring nature of many staphylococcal infections makes this organism a potentially important source of high cell count cows. In this case the very high proportion of bacteriologically negative results will mainly have been due to all quarters being sampled when the cow was infected in only some quarters. The proportion of infections due to a mixture of two organisms was higher than expected. One possible explanation would be contamination of the samples. The large number of bacteriologically negative samples from the multiple sampling mitigates against this interpretation, which also appears unlikely as in few of the mixed samples was one organism present at a very low level.

The relative prevalence of cows considered to be lame (between 6 and 22% of the cows seen on any one occasion) is typical of farms previously recorded in mid-Wales and is well within the range of figures found by Liverpool University Veterinary School (1993). The large variation in the proportion of lame cows for the various scoring occasions is due to a combination of factors. The two most important are the age structure of the herd which changes during the course of the year, and the environmental conditions. Feeding is generally accepted as being important but hard evidence of the effects has always been difficult to obtain. Locomotion scores should be at their best when heifers have just joined the herd; thereafter scores should deteriorate during the year. This was true in 1994 but not seen in 1993. In 1993 the best scores were found on the first scoring after turn out. In 1994 poor scores were recorded at turn out.

The incidence of lameness, as determined by locomotion scores, at about 53%, would be regarded as high if compared to many of the published reports. In practice, many of the published reports are based on records of treatments carried out by the farmer, or his vet, and are less than 30%. More recent work by Liverpool University

Veterinary School using the same techniques as this work, gave an overall average of 59%. The large discrepancy between the number of cows observed to be lame and the number treated is probably due to differences between herdsmen in what constitutes lameness and animals with a history of lameness that are classified as not being considered treatable. Based on the farm records of the number of treatments, the incidence would be 16%, which is low in relation to much of the published work. Taken together with the results of the locomotion scoring this suggests that the herdsman was not giving feet the attention they required. A relatively low proportion of animals were culled for reasons relating to lameness. However, as lame cows are less likely to become pregnant than healthy cows, other cows may have been culled for other reasons (e.g. barren) associated with lameness problems.

The concrete surfaces were generally excessively smooth, while the cow tracks and field gateways were rough. Both factors are believed to contribute to increased lameness and are typical of many dairy farms, Liverpool University Veterinary School recorded between 33 and 55% of concrete surfaces as excessively smooth and about 70% of outdoor surfaces as unacceptably rough.

The general health of the herd during the 3-year period was satisfactory, with no major problems recorded. The incidence of clinical mastitis and method of treating individual cases without the routine use of antibiotics provided the main challenge for the herdsman. While the total number of animals monitored was small in terms of meaningful statistical significance, a comparison with conventional herds (Esslemont and Spincer, 1993) showed a lower incidence of disease compared to conventional farms recorded on a similar computer-based system and also a slightly lower culling rate during the 3-year period (17.3 v 20.0%). Esslemont and Spincer (1993) and Klenke (1989) also found slightly lower culling in organic compared with conventional herds (20.8 v 23.3%).

In relation to welfare, the housing facilities at Ty Gwyn were improved following the grooving of concrete surfaces. The length of individual cubicles are currently adequate at 228 cm. However, the length will need to be increased as the size of the animals increases due to the influence of the Holstein breed. Changing from feeding concentrates individually in the parlour to group feeding, where maximum competition between individual animals occurs increased the stress of younger and less dominant animals during the critical early stage of lactation.

Although the animal numbers at Ty Gwyn were relatively small in terms of analysing the reproductive performance of the herd, the following targets, as defined by MAFF (1984), were used to monitor the performance of the herd: days to conception, 90-95; pregnancy rate to first service, 50-60%; number of serves/pregnancy, 1.9 or less; % of cows becoming pregnant, 85-90%. During the 1992-1994 period the performance of the herd was satisfactory, with the increased number of days from calving to conception in 1992/93 attributable to the management decision to delay the service date by 30 days. In the 1994/95 period the poorer pregnancy rate to first service, increased number of serves/pregnancy and lower proportion of cows becoming pregnant, reflects problems associated with changing the type and method of concentrate supplementation.

Collaborating farms

Large differences were recorded between farms in the number of cases of clinical mastitis, with the differences between farms being relatively consistent in both years.

Despite the use of nosodes on most farms for the prevention of mastitis, the mean incidence was higher than the levels reported on other organic farms (Offerhaus *et al.*, 1994) and slightly higher than many conventional farms (Esslemont and Spincer, 1993). The mean number of somatic cell counts in the milk of the individual farms increased during the monitoring period, with consistently high counts on one farm and a continual monthly increase on two other farms, suggesting that the level of sub-clinical mastitis was either high or increasing. Overall the counts were below 400,000, the level at which a reduction in the milk price would occur. However, as somatic cell counts are an important indicator of udder health (Reneau, 1986) and levels above 250,000 will lead to a price reduction from 1996 onwards (Milk Marque, 1995), the problem of high counts on some farms needed to be addressed. The bacterial count of the bulk tank milk was satisfactory on all farms with only three farms (including Ty Gwyn) recording levels above 20,000 for one month only.

Compared to many conventional farms the mean incidence of lameness on the collaborating farms was lower (Esslemont and Spincer, 1993). Offerhaus *et al.* (1994) also reported a lower incidence of lameness on organic farms compared to conventional farms (23.0 v 52.3%). This reduction in lameness might have been due to the benefit of feeding high forage diets that include high dry matter forage (Liverpool University Veterinary School, 1993). The wide variation between farms was attributed to the differences between the farms in both the type and standard of winter housing and the condition of the tracks that are used for moving the cows during the grazing season. Both these factors have been reported to have a major effect on the incidence of lameness in dairy herds (Liverpool University Veterinary School, 1993).

The number of cases of milk fever on the farms supported the findings of Offerhaus *et al.* (1994) that the incidence of milk fever is lower on organic farms. However, these results may be attributed to the lower milk production of the organic dairy herds. Despite the feeding of high forage diets on the collaborating farms, the number of cases of ketosis was lower than the figure generally reported (Reid and Little, 1986), suggesting that the energy composition and forage quality of the individual-farm rations was generally adequate. Offerhaus *et al.* (1994) also reported a low incidence of ketosis in organic dairy herds. Few cases of bloat were reported on the farms, despite the grazing of swards with high white clover, contents with five farms reporting no cases during the 2-year monitoring period.

During the 2-year period the number of recorded fertility problems was relatively low compared with other organic herds (Offerhaus *et al.*, 1994) and conventional herds (Esslemont and Spincer, 1993) . Fertility on a number of the farms was improved by the use of natural service by a beef bull following the initial insemination of most cows with Holstein semen. Mineral deficiencies have been linked to post-calving problems, including both retained foetal membranes and vulval discharge, and fertility problems (Jacklin, 1993). The relatively low incidence on the farms of post-calving problems suggested that the mineral status of the fed diets was adequate.

Farmers experience

The practice of maintaining animal health by using preventative management, rather than treatments as required by the organic standards, is potentially one of the great obstacles for dairy farmers in conversion to organic farming. However, for some farmers, health problems of the cows under conventional management, or the dislike of using conventional medication for their animals, and/or for the family, was a reason to consider converting to organic farming as an alternative option. On two farms changing the treatment of the cows to homeopathy or alternative remedies was the first change in the process of conversion. One other farmer also stated that his greatest worry in the whole process of conversion on the farm was how the cows would cope with a move away from antibiotics.

Asked about problems with animal health, two farmers stated that they had no problems apart from the health problems normally recorded in a dairy herd. Specifically mentioned were the following animal health problems during conversion, even though alternative treatment or management changes had been identified as solutions:

- Clinical mastitis and summer mastitis
- Internal parasites
- Trace elements (copper and iodine)
- Bovine spongiform encephalopathy
- Feet problems.

In looking for alternative treatments, most farmers came into contact with homeopathy and one farmer had, in his own words ‘a steep learning curve about homeopathy. Mentioned also were other more old fashioned treatments, especially for mastitis, massage, cold water therapy and some herbal cures and remedies.

In some cases the vet was very supportive and helped to find alternative solutions, whereas in other cases the vets were described as sympathetic but not knowledgeable. In the latter cases the farmers reported that they made less use of the vet than before conversion, but used alternative remedies and consulted other vets outside their normal area for advice.

When the farm was not certified for organic milk production, compliance with the health regulations of the organic farming standards was less strict, even though in all cases some effort was made to follow similar principles.

3.6.4 Conclusions

The monitoring of the health and fertility of the dairy herds showed mastitis to be the main health problem for the organic dairy farmer. Many cases of clinical mastitis were successfully treated with alternative remedies, with many farms only using antibiotics to treat the more severe clinical cases. The level of somatic cell counts was higher than normally expected on three of the farms. No other health problems were identified as being increased due to the change from conventional to organic farming.

In the first year of the study the incidence of mastitis at Ty Gwyn was low but then increased to a figure higher than expected in the remaining two years of the study. The most likely explanation for this increase was the withdrawal of the use of dry cow therapy. A large proportion of the cases of clinical mastitis were recorded with a small number of cows. The most important group of pathogens were the *Staphylococci* which respond poorly to conventional treatment and it is important to ensure that staphylococcal mastitis is well controlled before phasing out dry cow therapy. The spread of Staphylococcal mastitis within the herd could be continuing and should preferably be monitored on a regular basis. An alternative approach to the problems of *Staphylococci* infections was the addition of a *Staphylococcus aureus* nosode to the drinking water of the dairy herd, as a preventative remedy, slightly reduced the somatic cell count level of the bulk tank and may have the potential to increase the immunity of the herd to outbreaks of clinical mastitis. Other options for controlling the number of cases of clinical mastitis and variations in the somatic cell count of the bulk tank milk would be the culling of cows with persistent clinical mastitis and/or high cell counts and a change to the calving pattern from a set period to all the year round calving.

Both the incidence and prevalence of lameness in the herd can be regarded as normal but the proportion of lame cows identified and then generally treated by the herdsman was lower than normally expected. The surfaces of the cubicle and feed passages were undesirably smooth while the cow tracks had a tendency to be rough.

The experience from Ty Gwyn has shown that in terms of the health of the dairy herd the introduction and successful use of alternative remedies to replace conventional medicines (e.g. antibiotics) for the treatment of specific ailments is dependent on both the herdsman and the visiting veterinary surgeon. The ability of the herdsman to detect signs of ill health in the early stages, particularly clinical mastitis, is essential as is their willingness to use suitable alternative remedies in place of the routine use of antibiotics and other conventional medicines. The expertise of the visiting veterinary surgeons in the homeopathic approach to animal health and use of alternative remedies also has a major influence on the therapies used to treat specific ailments.

SECTION 4: ANALYSIS OF THE FINANCIAL PERFORMANCE DURING THE CONVERSION PROCESS

By S. Padel, B. Kenworthy, P. Midmore, N.H. Lampkin and L. Langstaff

4.1 Introduction

The main purpose of this section is to present data on the impact of the conversion on the financial performance of the farms. The section includes descriptions of the methods of data collection and the conventional comparisons, and the results and discussion of the financial performance of the dairy cow and the whole farm enterprise for all eleven (twelve for the dairy results) farms in the study.

4.2 Methodology

4.2.1 Data collection

As noted in section 2, the financial monitoring of farms in the sample was carried out by ADAS, although the design and supervision of the process were the responsibility of UWA. In setting up the data collection procedure, two main research questions needed to be addressed, namely the process and costs of conversion to organic production, and the elements of change necessary to achieve the premium prices available for organic produce. The procedure required all changes occurring on farms as a result of the conversion to be tracked; for example: changes in the structure of enterprises due to conversion, including the introduction of new enterprises; changes in physical output, milk yield, forage yield, crop yield and stocking rates; and changes in labour requirement. It also needed to determine indirect changes associated with these, particularly new information needs that may be supplied through training and advisory services. Finally, in order to obtain premium prices, changes such as developing processing or retailing activities and associated capital investment, increased labour inputs, variable costs (e.g. transport, packaging, advertising) and the costs of certification, needed to be identified.

As the basis for collection of financial information, the Farm Accountancy Data Network standard (FADN, 1988) was adopted particularly as this project is linked with similar studies in other European Union countries. The FADN standard has however, needed some modification to cope with a number of issues specific to this study. The most important extension was to attempt a division, during the conversion period, between the organic, in-conversion and remaining conventional activities of the farm, the variable costs which may be allocated directly to them, together with a similar division of labour and capital costs. Following the process of conversion through required a cropping history and conversion plan. Modelling aspects of the changes in physical output of the farm required some physical information on forage yields. Moreover, quantifying the importance of special marketing and processing activities required to achieve premium prices, meant that these needed to be taken into account separately .

These extensions were incorporated into a set of spreadsheets that facilitated the process of data collection and verification, and allowed key efficiency indicators to be calculated for the farm as a whole. Each farm also provided a full set of accounts on these for the last pre-conversion year, to determine the system starting point and to provide a benchmark to compare subsequent performance against that of similar farms. A summary of the initial design of the data set is provided in Box 1.

Box 1 Summary of farm information collected

- Standard set of FADN accounts (land use, labour, cropping, livestock, costs, assets and investments) for each year of the conversion period and the year before the conversion started
- Field cropping history with field sizes, cropping history and state of conversion
- Allocation of farm labour to specific enterprises
- Allocation of specific livestock costs to major enterprises such as the dairy herd, suckler herd, and replacement stock
- Allocation of specific crop costs to major enterprises such as arable and forage crops, grassland
- Calculation of gross margins for the main enterprises of the farm, total gross margin, farm profit, net farm income, management and investment income and other performance indicators

For the collection of the data directly on the farm, an Excel spreadsheet based computer package, called OFA (Organic Farm Analysis) was developed and has been used both by ADAS to collect the data on the farms in this study, and by UWA to facilitate the further analysis of the data. OFA is a tool for the analysis of farm performance that uses the farm accounts and additional information from other sources (enterprise costings, field records, invoices) to provide a more detailed picture of the individual enterprises for the analysis. It is specifically suitable for analysis of organic farms, where a diverse structure including processing and marketing enterprises on the farm is frequently found. In many cases this makes it necessary for internal transfers of products or livestock between different enterprises be identified, to allow a fair comparison between enterprises on the farm and between farms. The package assists with the reconciliation of the whole farm performance calculated on the basis of those transfers but using the figures as recorded in the farm accounts. OFA also offers the possibility to adjust opening and closing valuations for farm management purposes and yet still be able to compare the final profit and loss figures with those in the audited accounts. In farm accounts, stocks of cereals are, for example, frequently valued at conventional market prices. Adjustment of valuation can also be used to include seed costs of a crop that was harvested in a different financial year. As changes in the area of certain crops are common during conversion, the effect on the variable costs for individual enterprises can be significant if no adjustments are made.

In addition to the considerable volumes of numerical data this provided for analysis, the interpretation of the conversion process on each farm has needed additional, qualitative study (for a review of the methodology, see Patton (1990). This has been undertaken through in-depth interviews with the collaborating farmers on the consultative panel. The subjects explored included motivation for conversion, the planning and implementation of the conversion plan, the difficulties that were encountered during the conversion, plus the tactics adopted to overcome them, and the adequacy of training and extension services specific to organic systems. Subsequent parts of this section make use of the information and insights from this part of the data collection to explain individual variations in the response to conversion, in conjunction with the quantitative information summarised in Box 1.

4.2.2 Conventional comparison using cluster analysis

Farm revenues and costs are substantially affected by a range of factors and, as a result, some means needs to be found to compare the economic performance of each farm in the consultative panel with that which might have occurred, had they remained in conventional production. (For a review of methods of farm comparison see Lampkin, (1994b)). There are effectively three options which may be used to deal with this issue. Each farm might be paired and compared with an equal-sized, similarly managed conventional farm. However, the difficulties in selecting and monitoring farms which had a satisfactory degree of likeness for each of the eleven farms were felt to be too great and would over-emphasise contextual factors. Equally, although the farm business survey publishes average accounts for farms of similar type and business size (the relevant provinces being Wales, Exeter and Reading), several members of the consultative panel were on the boundaries of business size classes, and factors other than exclusively business size (based on a now considerably dated set of "standard" gross margins) were felt to be more important, particularly land area, grassland management system, and what proportion of the farm area was owned by the farmer. These factors were incorporated into the selection of a small group of similar farms, using cluster analysis, that were adopted to provide comparative economic data.

Cluster analysis has been used extensively in social sciences as a method of deriving groups of similar phenomena having a number of different characteristics. Examples from related fields of study include classification of farming systems as an alternative to the FADN standard (Jenkins, 1988), or contribution to the classification of rural areas (Hodge and Monk, 1991). A concurrent study of organic farms in Germany also uses this method to select comparison groups (Schulze Pals, 1994).

The mechanics of cluster analysis are described in the Statistical Package for the Social Sciences manual (SPSS, 1990). Hierarchical cluster analysis consecutively clusters individuals and groups together, on the basis of the minimum Euclidean difference between multiple indicators which distinguish each case or group of previously clustered cases. Our aim has been to generate a cluster of 8 or more similar farms, including each of our converting farms and others from the FBS sample: the data have been drawn from the Economic and Social Research Council's Data Archive at the University of Essex. The criteria used for clustering relate to the last pre-conversion year of each member of the panel, and are described in Box 2. Table 43 provides details of the clustering procedure and Table 44 provides key indicators for the clusters which were derived. A different coding has been used for these tables to protect the confidentiality of the farmers concerned.

Box 2 Variables used in the cluster analysis

- Farm area
- Proportion of land which is owner occupied
- Proportion of land under temporary leys and permanent grass
- Grazing livestock carried in livestock units
- Dairy cows as a proportion of total livestock units
- Milk quota
- Total farm output
- Dairy output as a proportion of total output

Table 43 Clustering procedure

Farm	Year	Base	FBS Region	Cluster
T G	1991	203	Wales	10
1	1988	113	Reading	7
2	1989	140	Wales	11
3	1988	113	Exeter	14
4	1990	200	Exeter	15
5	1990	200	Reading	11
7	1989	140	Wales	11
9	1990	200	Exeter	11
10	1989	139	Exeter	16
11	1989	139	Exeter	11
12	1990	177	Wales	11

To test the reliability of the clusters for our purpose, the data for the FBS groups, in which each farm would have fallen had it been an FBS farm, were collected. The average for some key parameters from the study farms, the FBS groups and the groups derived by cluster, shown in Table 45 indicate clearly the close match between the study farms and the cluster, even though the correspondence is not equally good for all variables.

Table 44 Summary results of the clustering procedure

Farm	Area (UAA)	Land owned	Grass land	L.stock	Dairy cows	Total output	Dairy output	Milk quota
Unit	ha	% UAA	% UAA	GLU	%GLU	£	% £	‘1000 l
T G	67.4	0	100	138.8	95	124112	98	525
Cluster	*50.0*	*79*	*93*	*90.9*	*49*	*60318*	*70*	*187*
A	217.7	100	44	224.9	47	269151	38	530
Cluster	*184.3*	*52*	*60*	*244.6*	*69*	*267436*	*69*	*926*
B	86.6	0	76	135.6	66	114048	95	550
Cluster	*75.7*	*53*	*87*	*141.2*	*58*	*120554*	*70*	*418*
C	75.7	0	93	97.8	72	85692	82	323
Cluster	*66.1*	*62*	*81*	*105.0*	*59*	*88935*	*72*	*323*
D	66.3	100	62	77.0	61	78013	62	219
Cluster	*65.0*	*72*	*93*	*108.0*	*51*	*79484*	*69*	*234*
E	45.5	100	96	71.8	52	60504	79	89
Cluster	50.0	79	93	90.3	49	60318	70	187
F	71.6	13	77	135.9	52	105978	76	325
Cluster	*72.7*	*77*	*79*	*111.8*	*62*	*98571*	*75*	*337*
G	50.1	100	93	91.8	73	78013	62	219
Cluster	*57.4*	*75*	*91*	*100.8*	*57*	*72753*	*75*	*253*
H	343.6	100	64	364.1	86	500427	68	1591
Cluster	*333.2*	*42*	*53*	*385.85*	*66*	*479890*	*59*	*1460*
I	217.7	100	44	224.9	47	269151	38	530
Cluster	*184.3*	*52*	*60*	*244.6*	*69*	*267436*	*69*	*926*
J	458.5	0	35	263.8	40	446014	34	562
Cluster	*333.2*	*42*	*53*	*385.9*	*66*	*479890*	*59*	*1460*

Table 45 Performance indicators of study farms, clusters and FBS groups in the last year of conventional management

	Unit	Average study farms	Average for clusters	Average for FBS groups
Farm size (effective UAA)	ha	162	157	121
Tillage area (area in rotation)	ha	146	89	n.a.
Total livestock (LU)	LU	201	163	163
Stocking rate	GLU/ha	1.81	1.57	1.82
Milk quota per hectare UAA	litres/ha	4,238	5,901	n.a.
Cow numbers	No	117	110	90
Milk yield	l/cow	5165	n.a.	5111
Milk sales	£/cow	992	n.a.	937
Dairy output as percent of total	%	68%	65%	n.a.
Output	£/ha	1,403	1,369	1356
Variable costs	£/ha	486	499	535
Gross margin	£/ha	917	869	787
Fixed costs	£/ha	814	682	671
NFI (Net farm Income incl. BLSA)	£/ha	201	260	280
MII (Mang. & Invest.Income)	£/ha	103	187	153

4.3 Results of the farms in the study

4.3.1 Presentation of the results

The main subject of this study is the effects of the conversion process on the ten commercial farms, despite the fact that conversion started in different years on the farms (see Section 2.3 and 2.4). We have therefore chosen to identify the different years of the conversion process by Year 0 to Year 5, instead of using the calendar years, wherever results from different farms are compared with each other. Year 0 refers to the last year under conventional management, Year 1 is the first year of conversion and so on. Table 46 shows the number of years studied and the calendar year that corresponds with Years 0 to 5 on each of the farms.

Table 46 Years of conversion and calendar years for each farm

	No of years studied	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Accounts ending
TG	4	1991/92	1992/93	1993/94	***1994/95***	n.a.		31-Mar-95
1	6	1988	1989	1990	1991	1992	***1993***	31-Dec-93
2	5	1989/90	1990/91	1991/92	1992/93	***1993/94***	n.a.	31-Jul-94
3	6	1987/88	1988/89	1989/90	1990/91	***1991/92***	***1992/93***	30-Sep-93
4	5	1990/90	1990/91	***1991/92***	***1992/93***	***1993/94***	n.a.	30-Sep-94
5	4	1990/91	1991/92	1992/93	1993/94	n.a.	n.a.	31-Mar-94
7	6	1989	1990	1991	1992	***1993***	***1994***	31-Dec-94
8#	5	1989/90	1990/91	1991/91	1992/93	1993/94	***1994/95***	31-Mar-95
9	6	1990/91	1991/92	1992/93	***1993/94***	***1994/95***	n.a.	30-Jun-95
10	5	1989/90	1990/91	1991/92	1992/93	1993/94	n.a.	31-Mar-94
11	5	1988/89	1989/90	1990/91	1991/92	1992/93	n.a.	30-Sep-93
12	5	1990/91	1991/92	***1992/93***	***1993/94***	***1994/95***	n.a.	30-Apr-95

Italics indicate organic certification for the herd. #dairy costings only

Farm 1 had already started in 1985 with a small area of crops, but the conversion of grassland and livestock did not start before 1989. It was decided to set the base year on the farm to 1988, before any conversion of forage area or livestock enterprises had started. The number of years in the study period could therefore be limited without any disturbance to the subject of the study, the dairy enterprise.

The figures in Section 4.3 show the trend for the eleven farms, as well as the average of the 10 commercial farms and the results for Ty Gwyn (unless indicated otherwise). Because the averages are calculated over different years on the farms, they should only be taken as indicators of a tendency; more important are the changes in parameters for the individual farms.

When results are compared with Year 0, the last conventional year, Year 4 of the conversion is usually used, as the data for this year is the latest available for most farms. For Farm 5 and for Ty Gwyn, data was only available until the third year of conversion, so Year 3 had to be used. Therefore, the averages for Year 4 contain 9 instead of 10 farms. It was felt that the benefit of including a later year in those comparisons would outweigh the disadvantage of a reduced number of farms in the average. Where appropriate information from the analysis of the interviews carried out with the ten commercial farmers have been included in this section.

4.3.2 Dairy cow, financial performance

The impact of conversion on animal production is discussed in detail in Section 3.5. There it was concluded that reductions in stocking rate and milk yield of up to 10% can occur, with those farms with comparably higher performance before conversion being more likely to be affected. Frequently, output reductions are seen to be compensated by premium price marketing for organic products. The certification of the herd and access to premium price are therefore important events in the conversion of a dairy farm.

The farms in the study qualified for full certification of the herd in different years. Three farms had already achieved full organic status for their cows by the end of 1992: four further farms acquired the status in 1993; three farms qualified in 1994. The remaining two farms were aiming for certification in 1996 or 1997 (see Table 47). However, full certification for the herd did not in all cases mean that premiums for all or part of the milk sales could be realised. The farms in Wales were able to sell at least some of their milk to two regional milk processors. The farms in Gloucestershire and Somerset are now also able to sell their milk with a premium, even though that was not the case during the study period. It is only in Devon that no market outlet exists, so that those farmers were selling their milk at conventional prices, and did not apply for full certification of the herd.

The development of the *milk price* for all farms is shown in Table 47. Like Ty Gwyn, farms 2, 3, 7, 9 and 12 were able to sell at least part of their milk with a premium in the years of the study period, which explains a considerable amount of variation in the milk prices. Unfortunately, historic records from the dairy costings are not sufficiently detailed to explain any other variation in milk price on the basis of milk quality. On Farm 1 slightly better prices in 1992 and 1993 might be explained by the use of an Ayrshire herd.

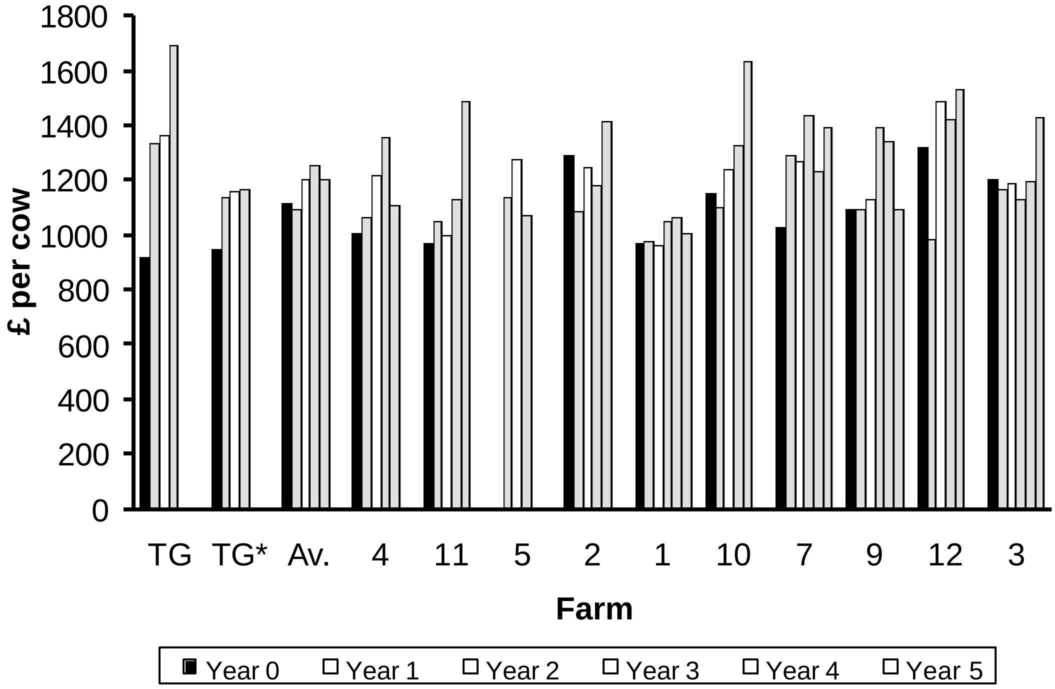
Table 47 Changes in milk price (p/l) on all farms during the period of study

Farm No	1988	1989	1990	1991	1992	1993	1994
TG				18.89	19.46	21.13	22.27*
Av.	18.07	18.63	19.59	19.40	20.23	22.15	24.21
1	18.23	18.25	20.84	19.78	19.88	19.89*	
2		19.29	19.78	19.96	21.13	22.99*	
3	17.91	17.71	19.00	18.33	18.60*	23.87*	
4			20.25	19.60	19.87*	20.78*	21.25*
5			19.51	21.75	20.52	20.13	*
7		18.97	18.11	17.71	17.01	22.61*	
8			18.96	18.57	19.27	20.18	21.97*
9			18.48	17.30	18.91	21.57*	24.63*
10		19.24	19.82	20.10	21.04	22.20	
11		18.34	18.85	18.20	19.13		
12			21.94	22.10	27.14*	27.30*	28.98*

* organic certification for the herd.

The total *dairy output* includes the milk output, cull cows and calf sales, quota income, valuation changes and costs for dairy cow replacement, and quota leasing or other quota related charges. In all figures relating to the dairy cows performance farms have been sorted according to milk yield in year 0, with the lowest yielding farms to the left of the figure. Dairy output increased on the majority of the commercial farms by an average of 8 % by Year 4 compared to Year 0. This is much smaller than the increase at Ty Gwyn of 85% (see Fig. 29) which is largely attributed to quota leasing which accounted for £200 per cow in Years 1 and 2, and £500 in Year 3. They were aided by quite high leasing prices over this period of the conversion process. Hence, the result for Ty Gwyn without the quota income has been included in Fig. 29. A substantial increase in output may be observed on most farms where premium prices were available in the later years of the study.

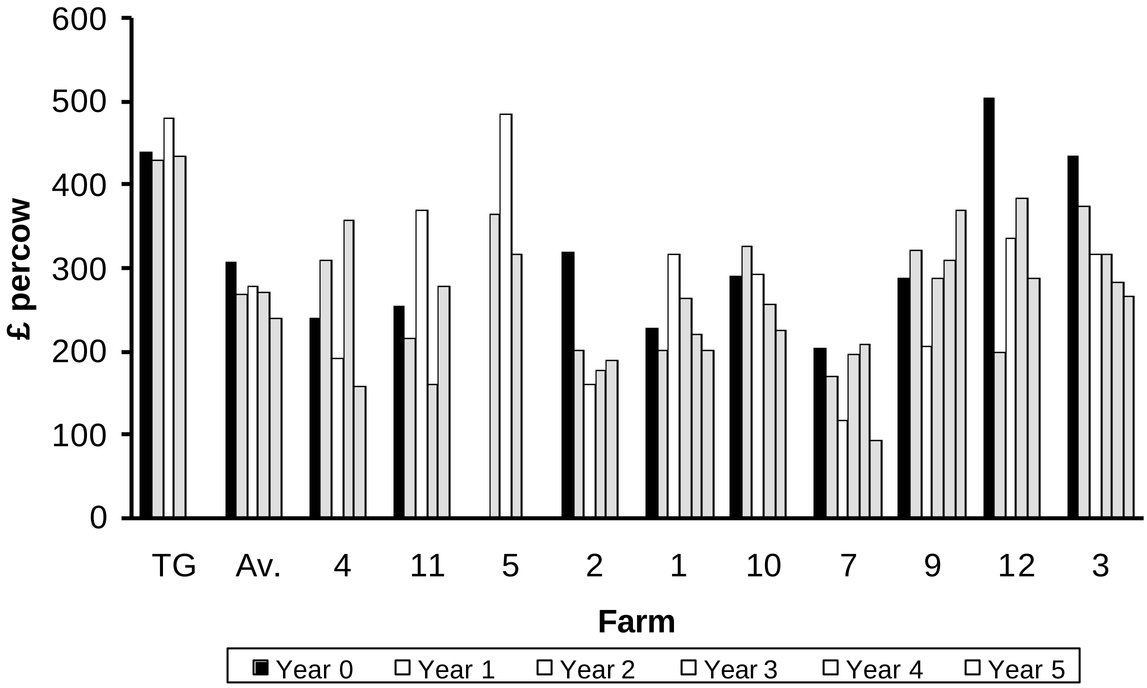
Fig. 29 Dairy cow output (£ per cow)



* Ty Gwyn without income from quota

A comparison of the *variable costs* for Ty Gwyn with figures for other specialist dairy farms with over 80 cows in Wales shows that Ty Gwyn had higher costs for both veterinary and dairy sundries in Year 0 and 1. Also the costs for forage production on the farm were higher than for the conventional comparison in Year 0. This can be partly attributed to the fact that charges for contract work were higher for Ty Gwyn, because almost all work carried out has been accounted for as done in this way. The variable costs for Ty Gwyn were also substantially higher than for the average of the commercial farms (see Fig. 30). These costs were reduced by about 20% during conversion, whereas at Ty Gwyn the variable costs remained unchanged. The reductions in variable costs can be mainly attributed to savings in fertilisers, purchased concentrates and veterinary and medical bills. Changes in variable costs on farms might partly be explained by forage quantity and quality and compensatory spending on concentrates. As the data was collected historically it was not always possible to identify or rectify errors in the physical value for the opening and closing valuation of the farm accounts. The data used in calculating these values was not necessarily kept on the farm, for example, the breakdown of dead stock valuation. Some large variations which occurred might partly be explained by valuation inaccuracies.

Fig. 30 Variable costs (£ per cow)

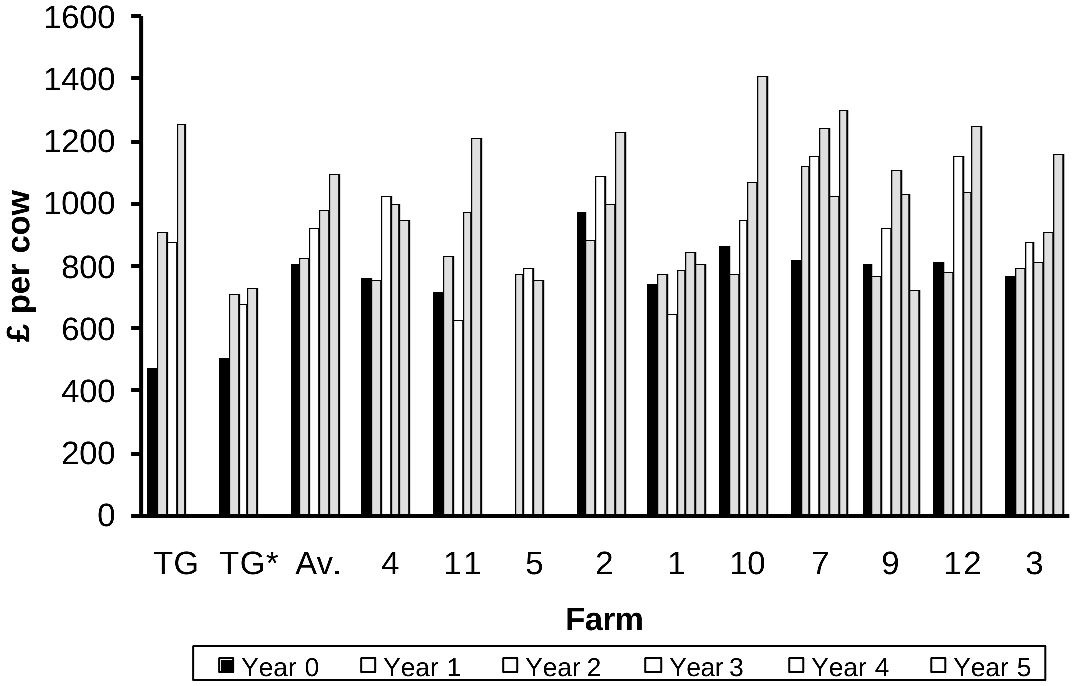


The *dairy cow gross margin* for all farms has been chosen as a parameter for comparison (rather than other margins) because all output and variable costs are included and it gives an overall impression of the performance of the dairy herd. The gross margin per cow increased substantially for Ty Gwyn, as a result of increasing output, especially from leased quota, and only small changes in the variable costs (see Figs 30 and 31). Compared to the conventional farms, the gross margin for Ty Gwyn is lower in Year 0 and Year 2 and slightly above the conventional value in Year 3.

Without the income from quota leasing, the gross margin per dairy cow for Ty Gwyn would have been £504 in Year 0 and £729 in Year 3. This represents an increase of 45% between Year 0 and Year 3, and was more in line with the increases on the other farms (see Fig. 31). In monetary terms, the gross margin per cow (without quota income) for Ty Gwyn was lower than the average for the commercial farms. The average gross margin per cow also increased on the commercial farms but, as with the output, the increases were smaller (35% compared to 165% increase at Ty Gwyn).

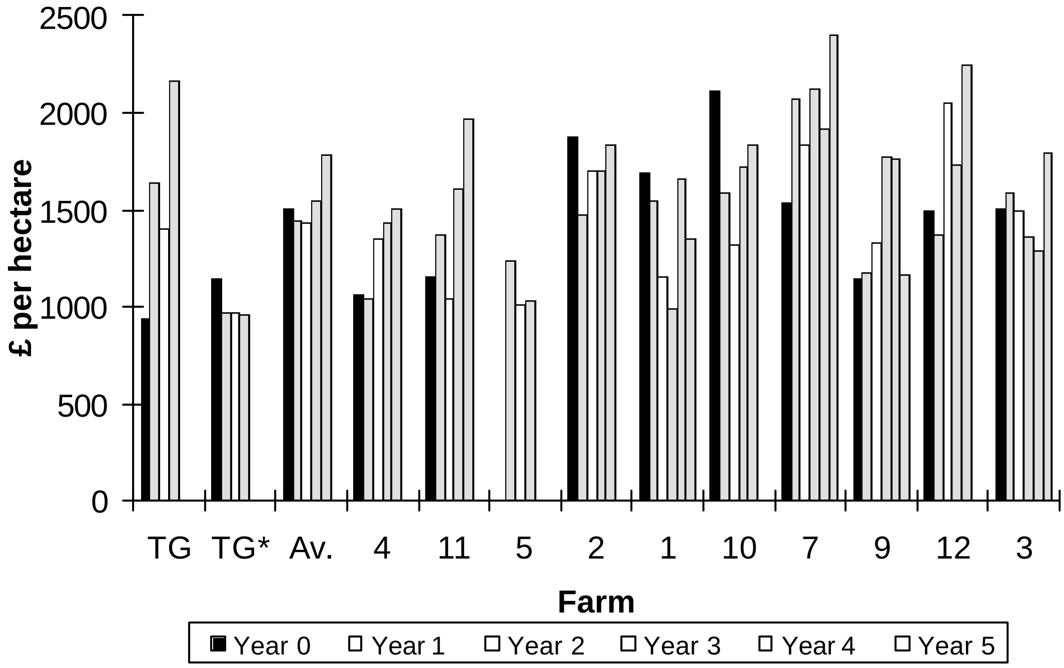
Over the conversion period, gross margins per hectare showed trends similar to the changes in gross margin per cow (see Fig. 32). Since forage area expanded on many farms as a result of the conversion, the average increase was less, at 13%. Only on Farm 2 was the trend different; as a result of a substantial increase in forage area per cow, the gross margin per hectare was slightly reduced, whereas the value per cow had increased. The large variation in the gross margin per forage hectare on Farm 1 is likely to be influenced by crop rotational circumstances; forage legumes in excess of feed requirements were produced to improve soil fertility.

Fig. 31 Gross margin (£ per cow)



* Ty Gwyn without income from quota

Fig. 32 Dairy cow gross margin (£ per hectare)



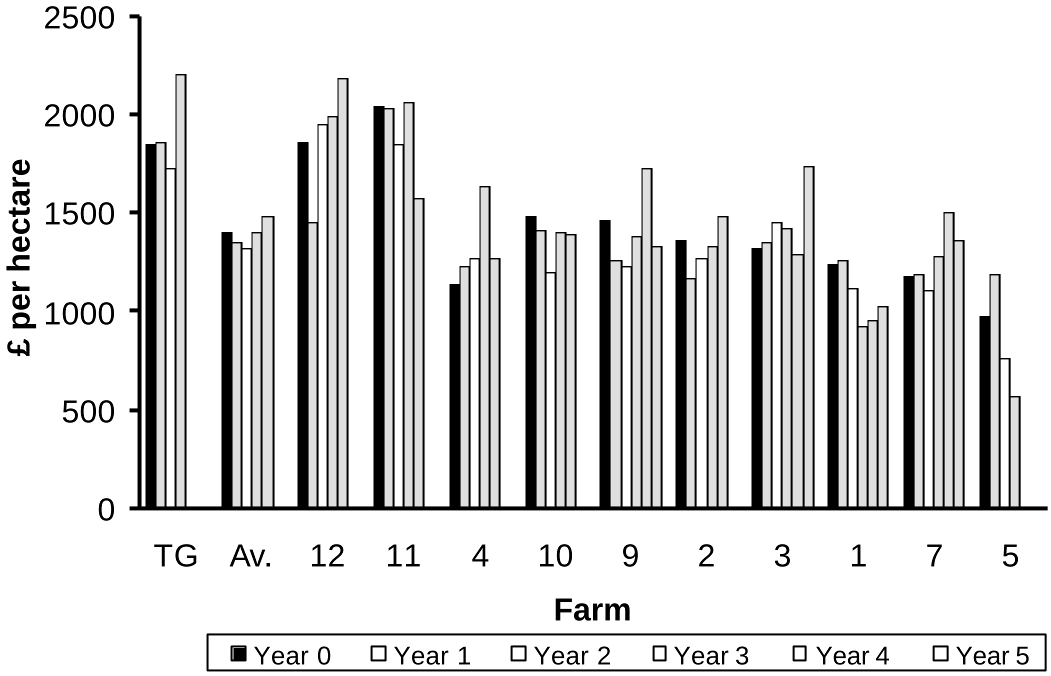
* Ty Gwyn without income from quota

4.3.3 Whole farm results

Output

The overall output of Ty Gwyn reduced somewhat in the first two years, but by Year 3 was higher than Year 0 of the conversion. Compared with the FBS Specialist Dairy Farms in Wales, the output for Ty Gwyn was slightly higher in Year 0 and slightly lower in Year 1. As outlined above, a substantial part of the output on a per cow basis is as a result of income from quota leasing (about 7% in Years 1 and 2, 30% in Year 3). The total output per hectare of the commercial farms was reduced in the first two years and returned to pre conversion level in Year 3. By Year 4 it was 6% higher than in Year 0. In Year 4 four farms reduced, one farm maintained and six farms increased their output (between 12 and 27%) compared with Year 0 (see Fig. 33).

Fig. 33 Whole farm output (£ per hectare)



Total variable costs

Variable costs on Ty Gwyn were considerably higher than the FBS specialist dairy farms in Wales at the beginning of conversion and were reduced to a level a little over average in Year 1. A further reduction of variable costs occurred in Year 2 of the conversion, followed by an increase in Year 3.

The total variable costs per hectare UAA of the ten commercial farms were reduced on average by 10% in Year 1 and by approximately 20% in Year 4 of the conversion, in comparison with the last conventional year. Of the eleven farms (including Ty Gwyn) eight reduced their variable costs, two farms (No. 4 and 11) maintained the same level and only Farm 7 had increased variable costs per hectare (see Fig. 34).

Fig. 34 Total variable costs (£ per hectare)

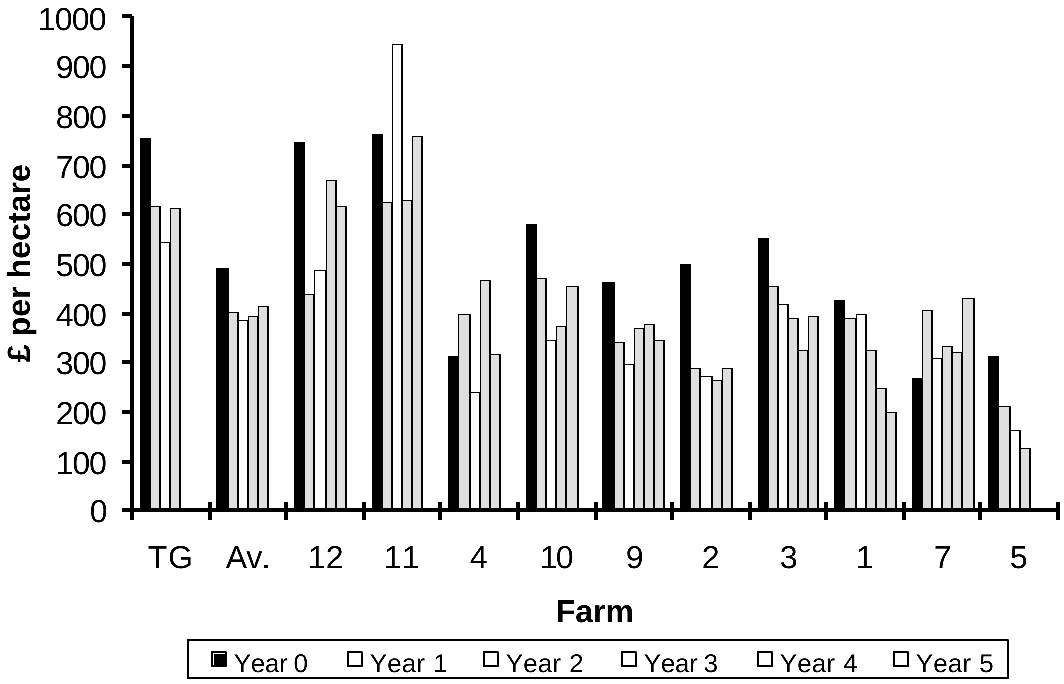


Table 48 Changes in variable costs during conversion

	Number of farms			
	Increasing costs	Decreasing costs	No change	Not available
Seed	6	3		1
Fertiliser	3	6	1	
Other crop costs	0	5		5
Purchased concentrate	5	5	1	
Home grown concentrate	2	1		7
Other feed	8	1		1
Vet. and med.	3	6		1
Other livestock costs	4	4	1	1

Fig. 34 also shows large variation between the variable costs of some farms in different years. Farm 11 reduced spending on fertiliser considerably in Year 1, without any investment in sward improvement, and was consequently faced with higher spending on concentrate and fertiliser in Year 2 as a result of feed shortages. Similarly, Farm 4 reduced spending on fertiliser to nil in Year 2, but had increased spending in the following year.

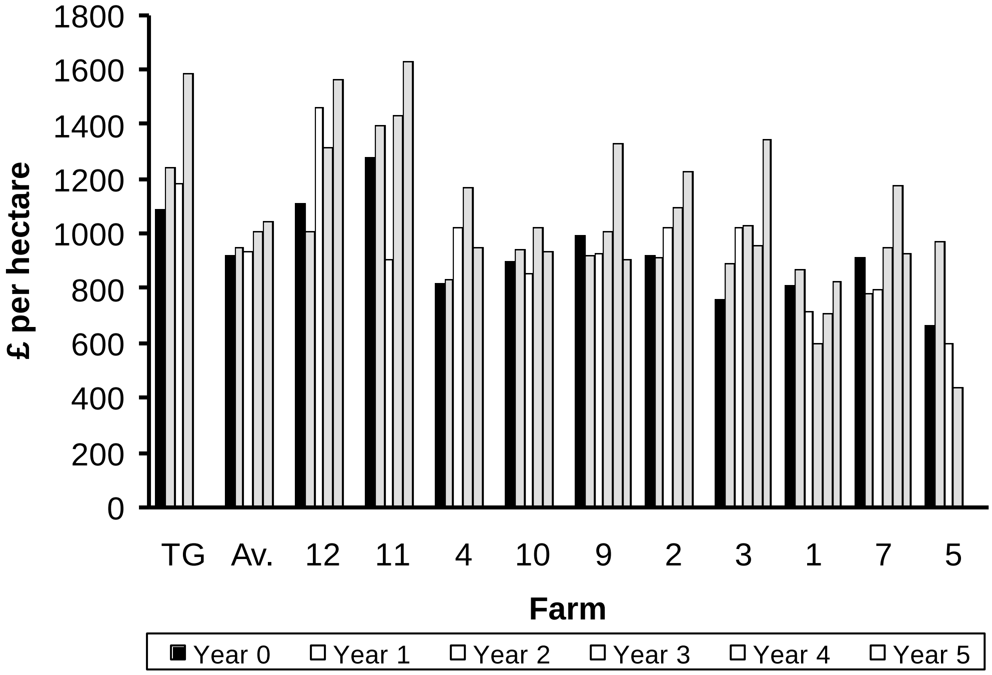
As the farms vary in size and cow numbers, a direct comparison of the total variable costs as presented in the FBS summary is not very useful. The relative spending in Year 4 of conversion compared to Year 0 gives some indication of the reasons for the overall reduction in variable costs (see Table 48). In the majority of cases, overall reductions in variable costs can be attributed to decreasing costs for fertiliser, other crop costs and veterinary and medical expenses. Eight farms did not use any home-grown cereal for feeding. The total veterinary and medical costs were reduced on seven and increased on three of the farms studied.

Whole farm gross margin

Ty Gwyn's whole farm gross margin increased by 18 % in Year 1, was slightly reduced in Year 2 and increased again in Year 3. The average whole farm gross margin of all commercial farms increased by approximately 15% in Year 4, compared to Year 0. As for output and variable costs, the farms vary in their results, with two farms decreasing and the remainder increasing their total gross margin per hectare (see Fig. 35).

Most farms showed some initial reduction in the first or second year of the conversion of up to 44% in the gross margin per hectare but it, in most cases, then improved to above that of the last conventional year. The results of the individual farms compared to conventional comparisons are discussed in more detail below.

Fig. 35 Whole farm gross margin (£ per hectare)



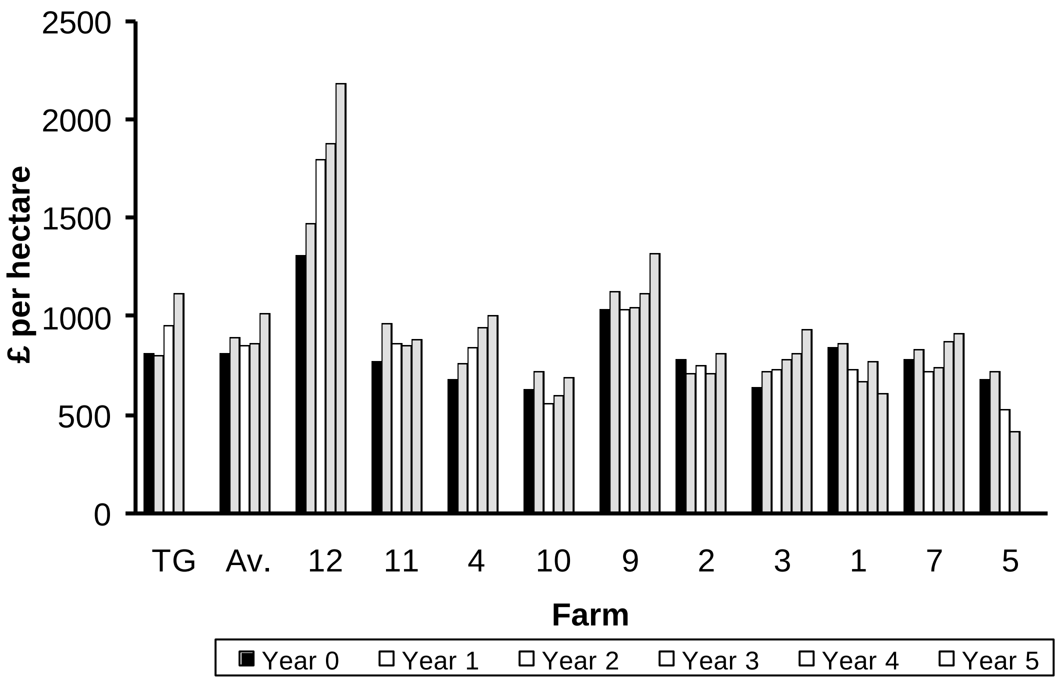
Fixed costs and labour

Fixed costs of Ty Gwyn were constant in the first two years of the study and increased in the last two years (Year 2 and 3), due to increasing costs in general farming expenses. As Ty Gwyn was managed together with Lodge farm, and both farms used the same machinery, the work carried out at Ty Gwyn was charged at current contract rates. All labour was fully costed and 1.5 workers and 0.2 Annual Labour Units (ALU) of the farm managers time were allocated to Ty Gwyn. That allocation remained the same over the whole study period. However, because Ty Gwyn was part of a larger experimental farming enterprise, the allocation of labour and fixed costs to the specific unit needed in many cases to be estimated and might not reflect accurate changes in expenditure.

The commercial farms, on average, increased their fixed costs in the period between the last conventional year and the fourth year of conversion by about 25%, varying from increases of up to 45% per hectare on five farms to reductions on the other five farms, partly as a result of increases in size and, in one case, reduced expenses resulting from the arable area going into set aside (see Fig. 36). The average change includes increases for paid regular labour of about 30% and a reduction in all machinery related costs of about 10%.

Whether or not the changes in fixed costs on the individual farms were related to the conversion can not be answered clearly from the data available. Specific conversion-related investment was not identified in the farm accounts, and the interviews indicated only very few cases where investment was required as part of the conversion. Farm 1 needed to invest in housing and fencing as a result of increasing stock numbers during conversion. Farm 5 had to enlarge the size of the bulk tanks to cope with less frequent collection of the organic milk and on Farm 7 a new muck spreader, specifically designed for fine and wide dispersal, was purchased. Several farmers mentioned upgrading of parlour and milking equipment and two farms changed from cubicles to loose housing. Some of these investments were undertaken when replacement would have been necessary, so they can not strictly be identified as new investment specifically related to the conversion.

Fig. 36 Fixed costs (£ per hectare)



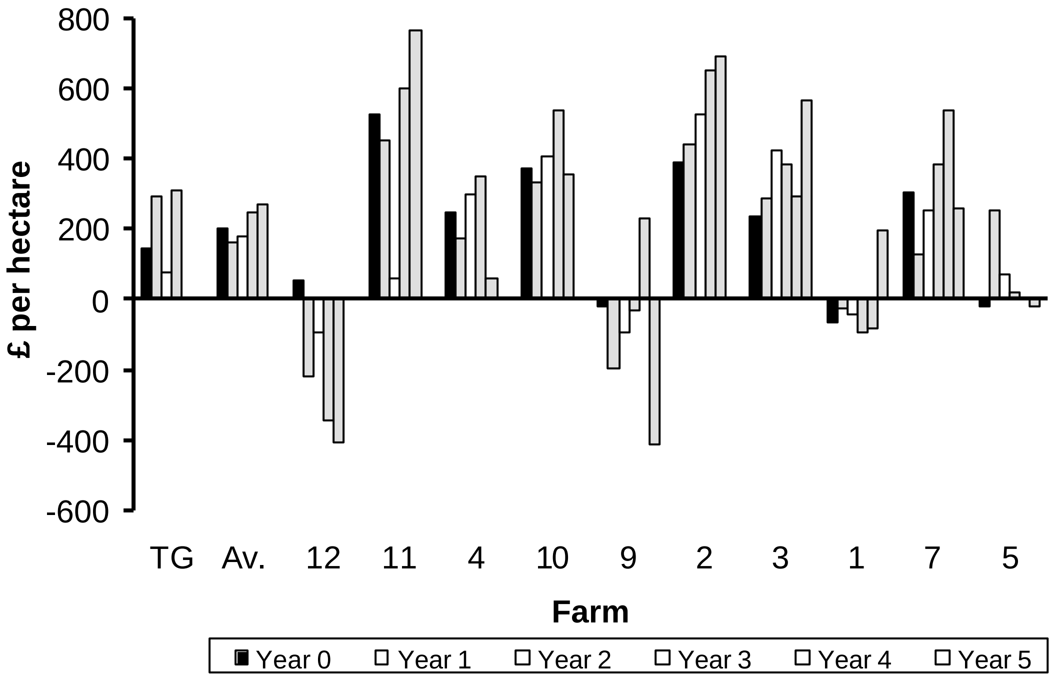
The commercial farms experienced on average an increase of 17% in ALU. This was a result of two farms employing a new person , whereas only small changes took place on the other farms. The data on *farm labour* was collected historically, in the last year of the study, and is therefore based on the farmers' recollection of the period. The increase in wage costs for paid regular labour which includes wage rate increases is 27%. On the basis of this data it can be concluded that on some farms, but not all, more labour was needed as a result of the conversion.

Net farm income

The Net Farm Income (NFI) for Ty Gwyn increased in the first year, fell again in the second year and then increased further in the third year of the conversion process. Interpreting the NFI figures for Ty Gwyn, it has to be kept in mind that all labour was fully costed as there was no family labour on the farm and comparisons on the level of NFI income with other farms were affected by that.

The NFI per hectare of the commercial farms also increased on average by 20% in the third year of the conversion, compared to the last conventional year. As Fig. 37 shows, the variation between the farms is considerable. Farms 1, 5, 9 and 12 had negative NFI figures for parts, or all, of the conversion period and showed substantial reduction in NFI during the conversion period, which can partly be explained from the specific on-farm situations discussed below.

Fig. 37 Net farm income (£ per hectare)



4.4 Comparison with conventional results and discussion

Performance of organic farms is not only influenced by the organic management but also by external factors that affect conventional farming in general, as outlined in Section 2.1. Changes in the performance of farms in conversion to organic management are, therefore, only likely to represent a true effect of the conversion if that development differs significantly from the development of similar conventional farms.

4.4.1 Dairy cow gross margins

As shown above the average dairy cow gross margin of Ty Gwyn and the commercial farms rose during the period of the study. Because such data was not available from the FBS data used for the cluster comparisons, the results for the average of the ten commercial farms in the first three years of conversion were compared with the development on the national level as published by MAFF(1994)(see Table 49).

Table 49 Dairy cow gross margin of the study farms compared to national trend

	10 study farms			UK average			
	Year 0 1988-90	Year 3 1991-93	Relative %	1989/90	1992/93	Relative %	Difference in relative value
Milk yield (litres)	5165	5240	101	5317	5649	106	-5%
Milk price (ppl)	19.2	20.6	107	19.2	20.8	108	-1%
Net milk quota	21	22	107	14	7	50	57%
Output (£/cow)	1114	1249	112	1097	1231	112	0 %
Variable costs (£/cow)	307	272	88	395	436	110	-22%
Gross margin (£/cow)	807	977	121	716	813	113	8%
Gross margin (£/ha)	1482	1527	103	n.a.	n.a.	n.a.	n.a
Gross margin (£/litre)	0.16	0.19	119	0.13	0.14	107	12%

Table 49 shows that the milk yield in Year 0 was lower than the national average and the increase in milk yield was lower on the study farms. The milk price and the output per cow followed similar trends in both groups. Other sales, such as quota income, as indicated by the high difference in relative value for the study farms and the national average and the average reduction of variable costs per cow on the study farms, compared to increasing costs on national level, were helping to more than compensate for losses in production and milk output.

On the basis of the data available it can be concluded that the increase in *gross margin per cow* was slightly larger for the study farms than for the national average. Similar results were obtained for the earlier case studies (Lampkin, 1993). In several studies of organic dairy production, *dairy gross margins per hectare* were found to be lower as a result of lower stocking rates (see Section 2.1). In contrast, in this study the average dairy cow gross margins per hectare increased by 3% by Year 3 and by a further 15% in Year 4, when some of the farms sold at least part of their milk with an organic premium. An increase in gross margin per hectare was observed on half of the farms whilst the remainder experienced a decrease. The increasing average gross margin per hectare, compared to falling values in other studies, is likely be related to the lower reduction in stocking rate in this study compared to others.

4.4.2 Whole farm results

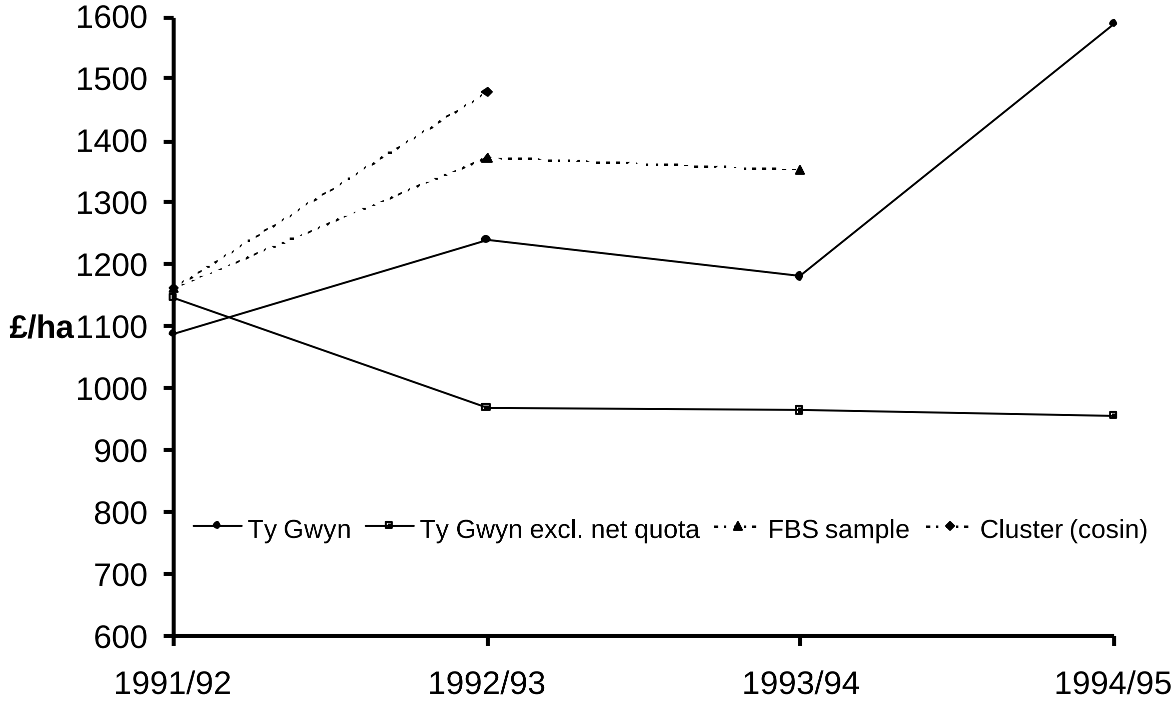
Comparisons with the clusters

The preceding analysis has demonstrated that Ty Gwyn and the average of the commercial farms experienced increased income figures per hectare over the 4 year conversion period. To isolate the true effects of the conversion, each farm has been compared individually with a cluster of conventional farms (see Section 4.2). The results for total farm gross margin and NFI per hectare are discussed in the following section for each farm and in turn compared to other study farms of similar type and conversion strategy.

Specialist dairy farms with rapid conversion

Because of the status of *Ty Gwyn* as a research farm, and the potential impact on the fixed costs, it was decided to make comparisons in terms of gross margin per hectare, rather than NFI. Despite larger size, higher output and variable costs than the conventional cluster in the last year of conventional management, the gross margin per hectare is similar. In the first year of conversion the conventional cluster (and the published FBS accounts) experienced an increase in total farm gross margin, which Ty Gwyn also showed when income from quota leasing is included. If quota income is excluded, a substantial reduction in gross margin compared to the conventional cluster would have occurred (Fig. 38).

Fig. 38 Gross margin (£/ha) of Ty Gwyn (with and without income from quota leasing) compared to FBS and cluster data



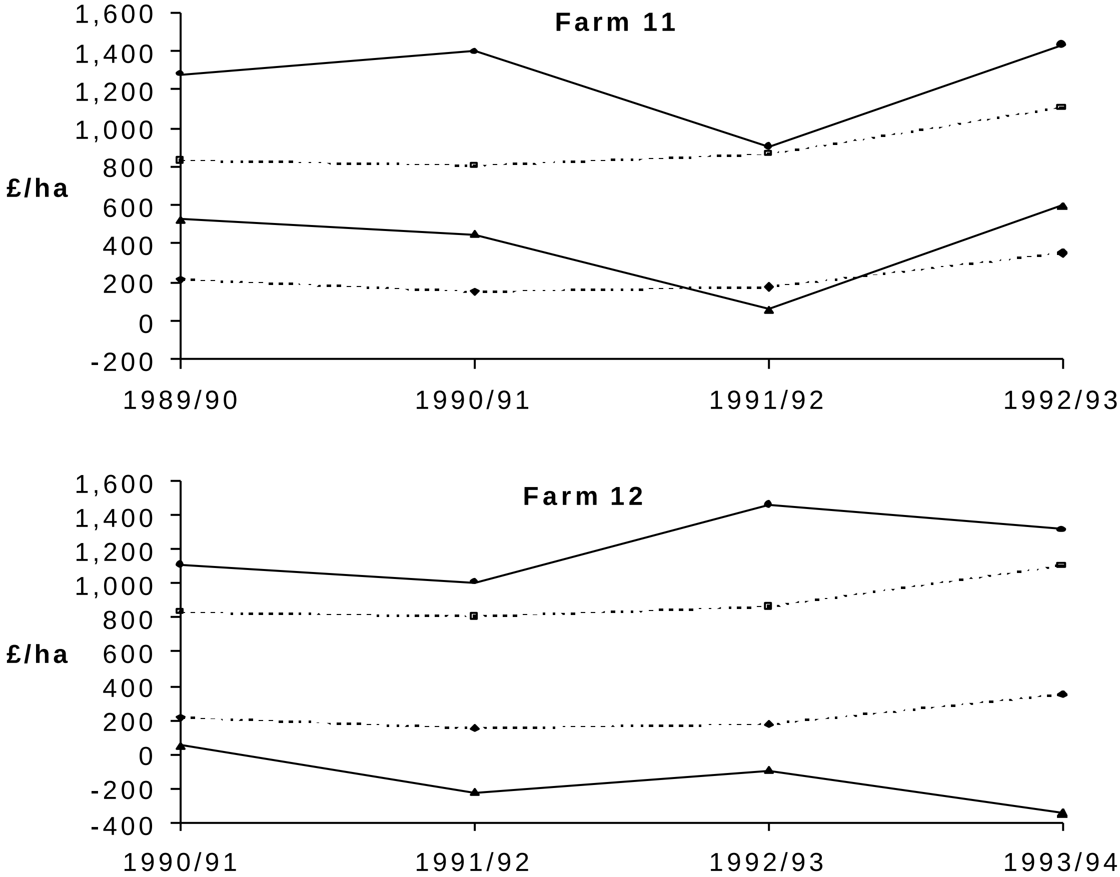
Like Ty Gwyn, two other commercial farmers opted for a rapid conversion strategy. In one case this was chosen because a premium price for the milk appeared likely in the future (this did not occur) and, in the other case, the farmer felt that the change from the already low fertiliser input to organic management on the land would not be too dramatic.

Farm 11 had similar total farm output but was substantially smaller than the conventional comparison. The values for gross margin and NFI per hectare in the last year of conventional management were therefore higher. The effect of the rapid conversion can clearly be seen in the second year of conversion, where a shortage of forage, and the need to purchase feed, coincided with major expenses for reseeding and liming to improve the sward productivity. In the following year, both NFI and gross margin recovered to levels similar to those before conversion (Fig. 39).

Farm 12 was also smaller in size and achieved higher output and gross margin than the conventional group in the last conventional year. As a result of higher fixed costs, which were partly due to a major non-farming enterprise, the NFI was much lower. Despite rapid conversion, the total gross margin per hectare increased, even though further increases in fixed costs, caused by expansion of the other enterprise, led to dramatic reduction in NFI (Fig. 39).

Conclusions: rapid conversion of specialist dairy farms. If the leasing income is excluded for Ty Gwyn (and this is justified because of the high leasing prices in the years of conversion of Ty Gwyn), two of the three dairy farms that converted all land in the same year showed reductions in gross margin of up to 44% in the first or second year of conversion (see Fig. 39). However, if the strategy is chosen to get access to a premium market as quickly as possible, or if the loss of income from milk production can be offset by other income, it is possible that conversion of a specialist dairy farm in the shortest possible period is the most profitable option.

Fig. 39 Gross margin and NFI (£/ha) of specialist farms converting "all at once" compared to conventional clusters



Specialist dairy farms with staged conversion

The other five specialist dairy farms in the study converted land in two (Farms 4,9,10) or three stages (Farms 2,3) (Figs. 40a and b)

Despite larger size and lower total farm output, the gross margin and NFI per hectare on *Farm 4* were almost identical to the conventional comparison group in its last year of conventional management. The farm showed a fairly similar trend in gross margin but, as a result of increases in paid labour and machinery costs, a lower increase in NFI compared to the conventional cluster.

Farm 9 was similar in size and output, but lower in variable costs and had therefore a higher gross margin per hectare than the conventional cluster. Substantially higher fixed costs before conversion started led to lower NFI income per hectare. During the period of conversion the farm suffered reduction in gross margin per hectare and further increases in fixed costs for several years lead to further reductions in NFI income per hectare. The conversion period coincided on this farm with substantial improvements by the current owner who had taken over the farm in the recent past.

Even though *Farm 10* was larger than the conventional comparison group in NFI per hectare the farm compared very well before the conversion started. During the period of conversion the total gross margin per hectare was reduced, mainly since arable cropping ceased, whereas the conventional cluster increased in gross margin, after a reduction in the first year. The conventional farms suffered a greater reduction in NFI in the first year, but the increases were greater in the following two years.

With a slightly smaller but similar output and lower variable costs, *Farm 2* achieved a higher gross margin per hectare than the conventional cluster in the last conventional year; because of higher fixed costs on Farm 2 the NFI per hectare was almost identical. During the conversion the farms followed very closely the trend of the conventional cluster, with steady increases in both gross margin and NFI per hectare.

Farm 3 was larger, but with lower output in cropping, than the conventional cluster in the last year under conventional management. Resulting from higher variable costs, the total NFI income, and the NFI per hectare, were substantially lower than for the conventional cluster. During the period of conversion the farm increased both gross margin and NFI in the first year, whereas the conventional cluster experienced a reduction in both measures. In this year only a small proportion of the land was included into the conversion. In the next year cropping ceased, which led to a reduction in output. This was reflected in a reduction in gross margin, compared to the conventional group, in the final year of analysis.

Fig. 40a Gross margin and NFI (£/ha) of specialist dairy farms converting in stages compare d to conventional clusters

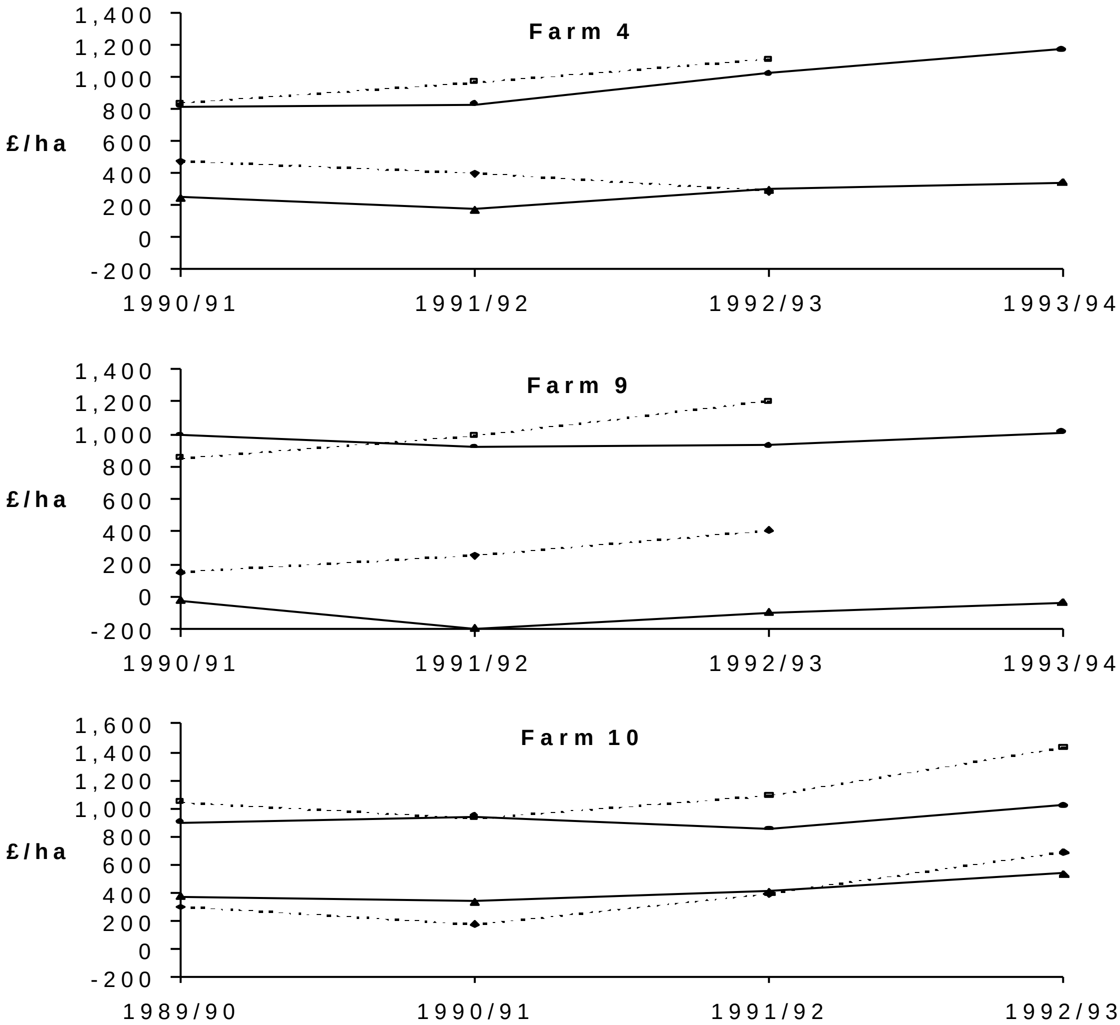
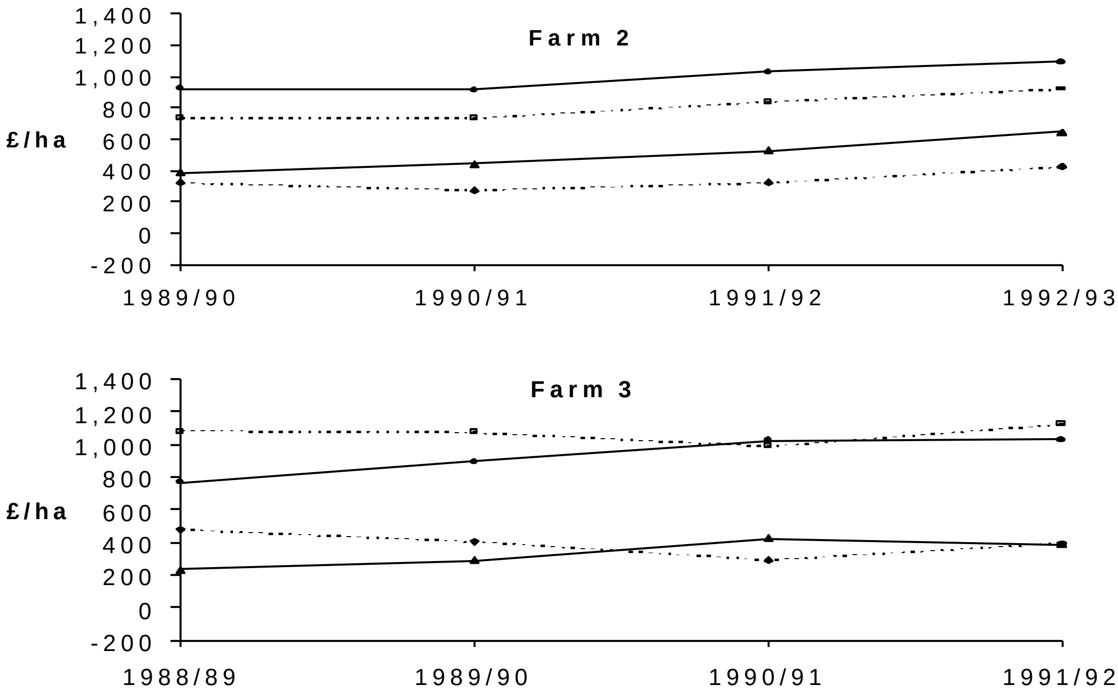


Fig. 40b Gross margin and NFI (£/ha) of specialist dairy farms converting in stages compared to conventional clusters



Conclusions: specialist dairy farms with staged conversion. Farms 4, 9 and 10 converted the land to organic management in two large blocks. Farm 4, which was farmed extensively before the conversion started, increased both gross margin and NFI over the whole period, whereas the other two farms showed initial reductions in gross margin or NFI. In one case this reduction was also experienced by the conventional comparison group and both the farm, and its conventional comparison group, increased afterwards.

Farms 2 and 3, which followed a longer staged conversion (with 3 steps, until all land was brought into the conversion) showed minimal disruption of the income development, compared to the conventional cluster. The study period for which conventional comparisons are available is not long enough to fully assess the impact of the established organic system on these farms.

Mixed dairy and arable farms

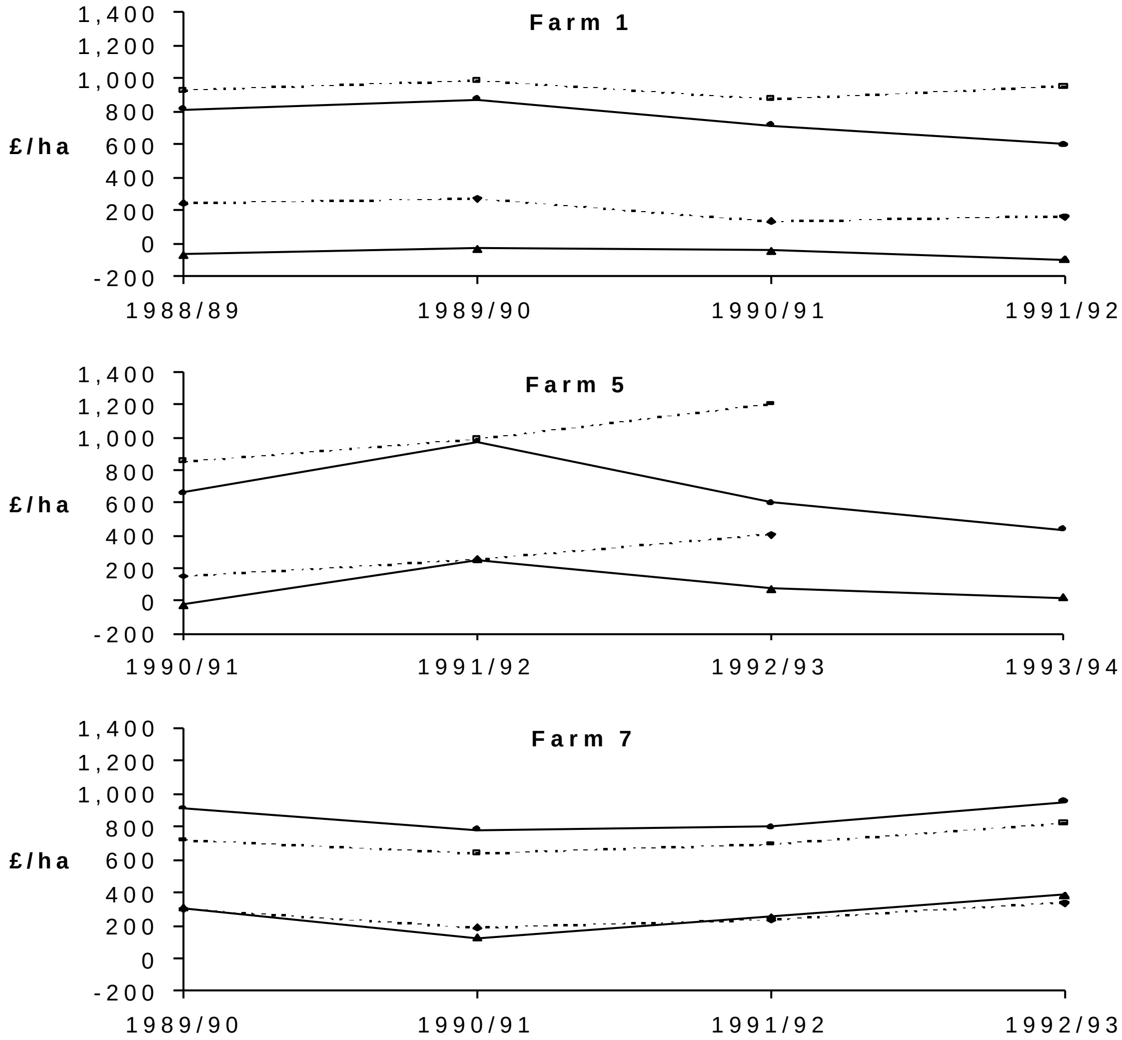
Farm 1 was larger than the cluster, even though total output and variable costs matched well. The total fixed costs were about 15% higher on Farm 1, mainly as a result of 50% higher charges for paid labour. All labour was employed and was also involved in the running of conventional share farming land, not included in the study. As a result the NFI figures did not represent the true situation of the farm. The farm had already started the conversion on some cropping land before the first year of study and had not completed the protracted conversion process. The impact of the conversion of the dairy herd on the overall performance of the farm was lower on this farm than on most other farms in the study. In the first two years of conversion the gross margin and NFI per hectare followed similar trends, even though the NFI was at a substantially lower level. A reduction in both NFI and gross margin in Year 3 was related to a substantial increase in farm size in that year. As a result, the cluster did not match the farm in its new structure and size. The total gross margin per hectare was only marginally reduced (Fig. 41).

Similarly *Farm 5* was larger than the cluster, but with lower total output and variable costs. Again, the fixed costs were higher and the income lower than for the cluster (5%) caused by 35% higher charges for employed labour. Income increased initially, followed by a substantial reduction in both NFI and gross margin in Year 2, whereas the conventional cluster experienced a corresponding increase. The increase in the first year was related to income remaining from the arable enterprise, a farm sale for unwanted arable equipment and income from set-aside. The following reduction was caused by a decrease in arable output, to 40% of that achieved by the cluster farms. As in the case of Farm 1, the change in structure of this farm led to a loss of match of the farm with the cluster.

Farm 7 was matched very well with the cluster, even though the proportion of cropping was higher. The farm followed closely in gross margin and NFI per hectare with the conventional cluster in the first 3 years. The income reduction in the first year, of about 15%, was also experienced by the cluster and was likely to be related to a drought, reported by the farmer in the first year of conversion.

Conclusion: for mixed and arable farms. Two of three farms in the study experienced some reduction in income, but in both cases the conversion coincided with, or led to, major restructuring of the farm. The third farm did not experience any substantial loss of income compared to the conventional comparison group. From that it can be concluded that, depending on the conditions of the farm before conversion started, a loss of income as a result of the conversion can (but need not necessarily) occur.

Fig. 41 Gross margin and NFI (£/ha) of mixed dairy and arable farms converting in stages compared to conventional clusters



Because of the slower conversion of these farms, the study period was not long enough to monitor whether a new level of stability could potentially be achieved with those farms that were restructured, once full certification of the farm had been attained (see Fig. 41).

Average development

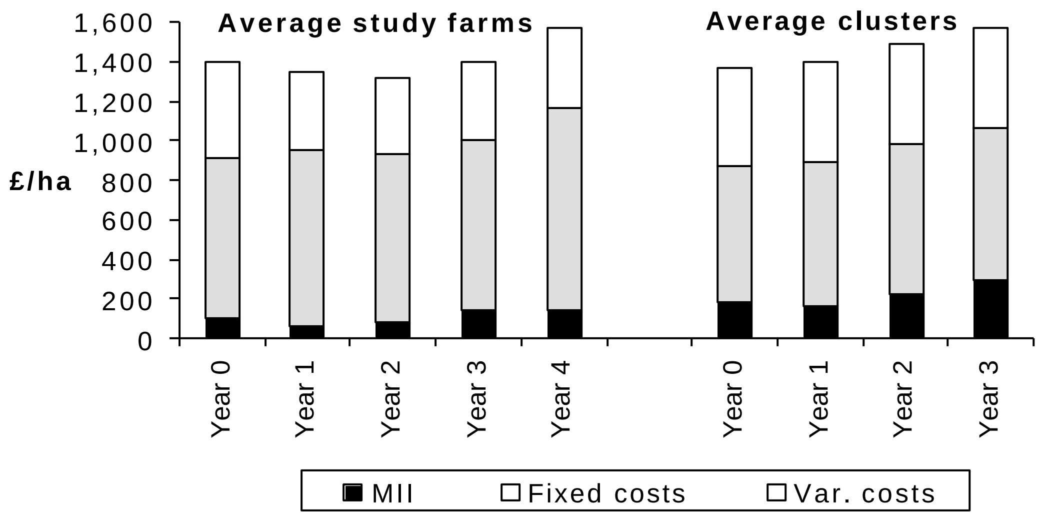
Based on the values for each farm, averages for the whole group have been calculated and are shown in Fig. 42 and Table 50. After initial reductions, the overall output returned to pre-conversion levels in the third year of conversion, whereas similar conventional farms increased output. This was mainly caused by reductions in arable output. Reductions in variable costs led to steady increases in the average whole farm gross margin during the study period, but the increase was smaller than for similar conventional farms.

Fixed costs returned, after an initial increase, to pre-conversion levels, even though the average values were higher than for the conventional cluster before conversion started. The conventional group increased fixed costs in the same period at a higher rate.

The average Net Farm Income (NFI) per hectare increased to levels above the last conventional year in the third year of conversion, after reductions in the first two years. Comparable conventional farms only showed a reduction in what would have been the first year of conversion of the sample farms. The farms achieved a better result in the fourth year, once premium prices were available for more than half of the farms, but no data for conventional comparison is available for that year.

The average NFI per hectare was reduced but, as shown above, the development of the farms varied widely and special circumstances coincided with the period of conversion. The Management and Investment income increased at a higher rate than the NFI, but the development was still not equal to the conventional comparisons.

Fig. 42 Total output*, variable and fixed costs and MII (£/ ha) of the ten commercial farms.



* Total output is represented by the whole column.

Table 50 Average farm performance compared to clusters (£/ha)

		Year 0	Year 1	Year 2	Year 3	Year 4	% Change (Y3/Y0)
Output	Farms	1,403	1,352	1,319	1,398	1,573	100
	Clusters	1,369	1,398	1,479	1,571		115
	Clusters=100%	102	97	89	89		
Variable costs	Farms	486	400	385	392	409	81
	Cluster	499	507	507	507		101
	Clusters=100%	97	79	76	77		
Gross margin	Farms	917	952	934	1,006	1164	110
	Clusters	869	890	972	1,065		122
	Clusters=100%	105	107	96	94		
Fixed costs	Farms	814	888	854	863	1015	106
	Clusters	682	720	752	770		113

	Clusters=100%	119	123	114	112		
MII	Farms	103	64	79	143	148	139
	Clusters	187	169	227	294		157
	Clusters=100%	55	38	35	49		
NFI (incl. BLSA)	Farms	201	162	181	244	271	121
	Clusters	260	244	308	388		149
	Clusters=100%	78	66	59	63		

Financial impact of the conversion

Based on the income development for the clusters, a projection was calculated for Ty Gwyn and the average of all commercial farms. The difference between the real income development of the farms and the projection represents the costs of the conversion. According to this, Ty Gwyn experienced conversion costs in the range of £14 per hectare per annum, whereas the value for the commercial farms was £50 per hectare per year in the first two or three years of conversion. Because the conventional data was not available for year 4 the effect of the premium on the milk could not be compared.

Because of the techniques used, calculations were only possible for those farms that had a positive NFI during the study period. To get a true picture for all farms a similar calculation was carried out on the level of gross margin and is shown in Table 51.

Table 51 Costs of conversion (£ per ha per year) based on NFI and gross margin projections

Farm Type and conversion		Size (ha)	Conversion costs based on: NFI projection	GM projection
Spec.dairy, "all at once"	TG	65	14	69
	Farm 11	>200	187	181
	Farm 12	<100	n.a.	- 28
Specialist dairy, 2 steps	Farm 4	<100	-55	86
	Farm 9	>200	n.a.	357
	Farm 10	<100	93	57
Specialist dairy, 3 steps	Farm 2	<100	- 127	34
	Farm 3	<100	- 187	- 236
Mixed dairy, staged	Farm 1	>200	n.a.	90
	Farm 7	<100	4	67
Arable, staged	Farm 5	>200	n.a.	67

4.4.3 Discussion

The farms in the study, which probably represent the dairy farms converting at that time reasonably well, were not amongst the more intensive dairy farms in the UK. However, the variation between the farms before conversion was considerable and some farms showed higher intensity than similar conventional farms (see Table 5). Conclusions based on the findings of this study are therefore not likely to be true for dairy farms of a very high intensity.

The milk yield of about 5100 litres was, on average, maintained throughout the conversion period, so that the farms achieved a higher milk yield than reported by Houghton, (1990), but lower than reported by Redman, (1991) and lower than the conventional national average. Milk yield on the farms reacted differently during the process of conversion; farms with milk yields lower than the sample average before conversion showed increases, whereas farms with higher yield levels showed reductions in milk yield.

Those changes in milk production were not reflected in dairy cow gross margin and in whole farm results, because of changes in other output and variable costs. In Year 3 of the conversion, the sample farms showed higher gross margins per cow and per litre than the national average for the UK, which is similar to findings in other studies (see Section 2.18).

The stocking rates were higher on the study farms (2 LU/ha on average) than for the cluster groups, but lower than for the Genus Milkminder sample (see Table 5). Again, the farms reacted differently during the process of conversion, and there was a tendency for greater reductions on those farms with higher stocking rates before the conversion to organic management started. Initial reductions in stocking rate during the first two or three years of conversion arose because of the time needed to establish clover in the swards, either by reseeding or other means of renewing the grassland.

The permanent reductions, of around 10%, in stocking rate observed, contrast with the results of the physical monitoring of the forage productivity, where performance more comparable with conventional management was found. It is, therefore, likely that forage demand increased as a result of reduced concentrate feeding on the farms. The average reductions in stocking rate are lower than those reported in other studies, where differences of about 20% between organic and conventional were reported (see Section 2.1.8). Because of the smaller reductions in stocking rate the dairy cow margin per hectare increased on average during the conversion period. This stands in contrast to the findings of most other studies where the margins per hectare were found to be lower under organic than under conventional management (see 2.1.8). Similar results were found by Lampkin (1993) for one specialist dairy farm.

Although average output fell during the first two years of conversion, dairy enterprise and total farm gross margin increased steadily over the whole study period, as indicated by reduced variable costs of about 20% in the first three years of the study. This clearly demonstrates a potential of the organic management to compensate for reduced output, by saving costs. These reductions were mainly caused by savings on fertiliser and other crop costs and, to a lesser extent, in savings on veterinary and medicine costs and purchased concentrate. Similar reductions have also been found in other studies of organic dairy farms Padel and Lampkin (1994).

Whole farm gross margin per hectare did not increase on all farms over the study period. The biggest reductions (of up to 44%) occurred on two arable/mixed farms and on one specialist dairy farm that opted for an all-at-once conversion in the first two years. In Year 3 the farms had, on average, returned to the pre-conversion level of gross margin, or above, and reached an average value similar to the average for conventional comparison groups, even though the conventional clusters had shown a higher increase. All specialist dairy farms and one mixed dairy farm achieved whole farm gross margins similar to, or above, pre-conversion levels. The findings indicate the potential that, after a conversion period, performances levels similar to conventional can be achieved without premium prices, depending on the circumstances on the farm. This stands in contradiction to some other studies of the performance of organic dairy farms, where a premium was found generally to be necessary to compensate for yield reductions for fully certified holdings (see Section 2.1.8).

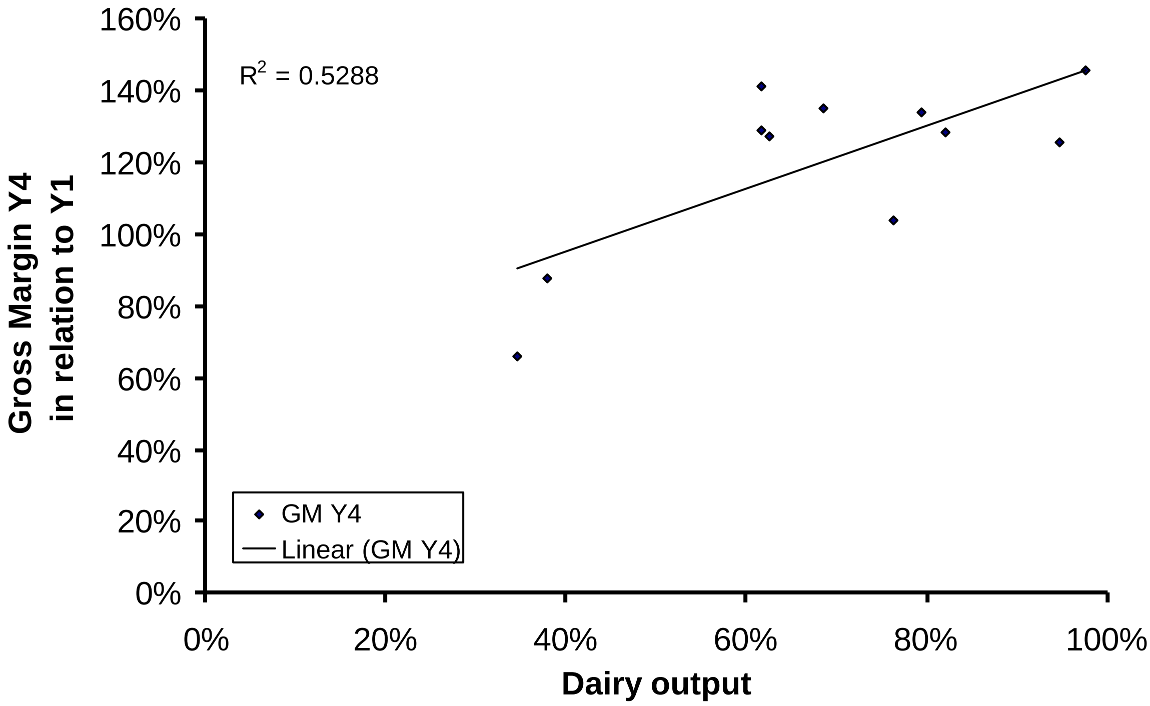
One reason for these differences might be the specialised nature of the farms in this study. Larger reductions in gross margin may be associated with farms with a smaller proportion of dairy in the output prior to conversion. Fig. 43 shows the proportion of gross margins in Year 4 relative to Year 0 in comparison to the proportion of dairy in the output in Year 0.

This corresponds well with the earlier case studies Lampkin (1993), where the specialised farm maintained income without premium prices in later stages of conversion and out-performed the conventional comparison, whereas the more mixed farm achieved lower results than the conventional farm. The result could also reflect that, before CAP reform, the gross margins for dairy farms in general (organic and conventional) improved more rapidly than for arable farms. The better performance of specialised dairy farms can partly be explained by the nature of the dairy cow as a ruminant, where fertility-building forage legumes can be fully utilised, whereas in a mixed farming or arable situation, fertility has to be built up to support the cash crops in the rotation.

Increases in fixed costs on some farms can partly be attributed to increases in wage costs, which were also identified in previous studies (see 2.1.7). The data on Labour

Units were regarded as less reliable, because they were based on the farmers' recollection, rather than records of the farm labour. Some farmers expressed the view that labour had increased but others reported to have less work since the farm was converted.

Fig. 43 Relative gross margin in comparison to proportion of dairy in the output



For the majority of farms, the NFI figures per hectare also returned to pre-conversion levels in Year 3 but, in some cases, increases in fixed costs were greater than increases in gross margin; falling NFI figures were the result. As argued above, not all changes in fixed costs can be attributed to the conversion and caution is therefore advisable when interpreting the average results of the income development.

The calculated costs of conversion, of approximately £ 50 per ha, for the first two or three years of conversion (in terms of lost NFI compared to conventional development), are lower than those previously calculated (Lampkin, 1994), where costs of conversion of specialist dairy farms were estimated to be in the range of about £100 per ha per year for a five-year period. Whether or not with access to premium prices, the increased performance of the farms in Year 4 would have led to levels similar to conventional farms (and therefore no further costs of conversion) can not be determined, as the conventional data for those years are not yet available.

4.5 Conclusions

- Reductions in stocking rate can mainly be attributed to reduced concentrate feeding and subsequently higher forage demand.
- Rapid conversion led to feed shortages and associated problems.
- Gross margin per dairy cow and litre in the third year of the study were higher than the national average for the UK.
- The whole farm gross margin increased steadily over the study period and demonstrated the cost saving potential of organic management, by reducing inputs such as fertiliser.
- After an initial conversion period some farms showed income levels similar to conventional farms in the third year of conversion, without access to premium prices.
- Premium prices in Year 4 helped to improve performance.
- Contrary to widespread opinion that organic farming is only suitable for mixed farms, the specialist dairy farms appeared to adjust better to the organic management, especially where a staged conversion was chosen.
- Mixed and arable farms, depending on the condition of the farm, were more likely to have income losses than specialist dairy farms, although the income situation for those farms might have been more affected by the CAP Reforms than the dairy farms.
- Management intensity before conversion is likely to influence performance during the conversion period, but these effects could not be clearly isolated in the small sample of farms.
- The conversion period led to conversion costs of about £50 per hectare per year in the three years of conversion, but the variation between the farms was significant.
- Access to a premium for the milk was, by and large, not available in the first three years of the conversion, and was therefore not a means by which to finance the conversion process; however, quota leasing and the sale of breeding livestock had a role to play.
- Farms that followed single step conversion appear to have suffered more losses in income but the conversion strategy did not have any financial implications for the whole study period.

SECTION 5: REFERENCES

Adams, W.A. and Evans, G.M. (1990). Input/export relationships of major ions in west Wales catchments. *Agricultural Ecosystems and Environment*, **32:** 13-24.

ADAS (1995).The effect of organic farming systems on aspects of the environment. A review prepared for Agricultural Resources Policy Division of the Ministry of Agriculture, Fisheries and Food, London.

Agricultural Research Council (1980). The Nutrient Requirements of Ruminant Livestock. *Technical Review*. Farnham Royal, CAB.

Allen, S.E. (1989). Chemical Analysis of Ecological Materials. Second edition. Oxford, Blackwell Scientific Publications.

Arden-Clarke, C. (1988a).The environmental effects of conventional and organic/biological farming systems. 1. Impacts on the soil. *Research report RR-16*. Political Ecology Research Group, Oxford.

Arden-Clarke, C. (1988b).The environmental effects of conventional and organic/biological farming systems. II. Impacts on the crop eco-system, wildlife and its habitats. *Research report RR-17*. Political Ecology Research Group, Oxford

Baars, T. and Buitink, I. (1995). Enkele aspecten van ziektepreventie in de biologische veehouderij:gezondheid bevorderen, natuurlijk gedrag ondersteunen. Report by the Louis Bolk Institute, Driebergen.

Becana, M. and Sprent, J.I. (1987). Nitrogen fixation and nitrate reduction in root nodules of legumes. *Physiologia Plantarum*, **70:** 757-765.

Campbell, D. (1995) Dairy sectors looks likely to mature. *New Farmer and Grower* **46:** 20-21.

Chamberlain, A.T.(1994). RUMNUT. Ruminant nutrition program published by A.T.Chamberlain, Reading.

Clement, C.R. and Hopper, M.J. (1968). The supply of potassium to high yielding cut grass. *NAAS Quarterly Review,* **79:** 101-109.

Cuttle, S.P. and James, A.R. (1995). Leaching of lime and fertilisers from a reseeded upland pasture on a stagnogley soil in mid-Wales. *Agricultural Water Management* (in press).

Cuttle, S.P., Hallard, M., Daniel, G. and Scurlock, R.V. (1992). Nitrate leaching from sheep-grazed grass/clover and fertilized grass pastures. *Journal of Agricultural Science*, **119:** 335-343.

DAISY (1984). Dairy Information System. Published by University of Reading, Reading, UK.

Dampney, P.M.R. and Unwin, R.J. (1992). More efficient and effective use of NPK in today's conditions. In: *Forward with Grass into Europe. (eds. Hopkins, A. and Younie, D.).* Occasional Symposium No.**27**. British Grassland Society, pp. 62-72.

Down, K.M., Jollans, J.L., Lazenby, A. and Wilkins, R.J. (1981). The distribution of grassland and grassland usage in the UK. In: *Grassland in the British Economy (ed. Jollans, J.L.).* CAS paper **10**. Reading pp. 580-3).

EC (1992). *Council Regulation (EEC) No 1765/92. OJ.*

Esslemont, R.J. and Spincer, I. (1993). The incidence and costs of diseases in dairy herds. *Dairy Information System Report* No.**2**. University of Reading, Reading.

FADN (1988). Handbook of legislation, instructions, notices for guidance, Section III: the farm return. Office for Publicationms of the European Communities.; Luxembourg.

FBS (1992). Farm Business Survey in Wales, Statistical Results for 1991/92. University of Wales; Aberystwyth.

FBS (1993). Farm Business Survey in Wales, Statistical results for 1992/93. University of Wales; Aberystwyth.

FBS (1995). Farm Business Survey in Wales, Statistical results for 1993/94. University of Wales; Aberystwyth.

Fowler, S.M., Watson, C.A. and Wilman, D. (1993). N, P and K on organic farms: herbage and cereal production, purchases and sales. *Journal of Agricultural Science*, 120: 353-360.

Genus (1994). Genus Milkminder Annual Report 1993/94. Published by Genus.

Greenpeace (1992). Green fields- grey future. EC agricultural policy at the crossroads. Greenpeace, Amsterdam

Hodge, I. and Monk, S. (1991). In search of a rural economy - Patterns and differentiation in non-metropolitan England. *Land economy monograph* **20**, Granta; Cambridge.

Holliday, R. J. (1989). White clover use on the dairy farm. *FMS Information Unit Report*, **65**. Milk Marketing Board; Thames Ditton.

Holmes, W. (1989). Grass: its production and utilisation. 2nd edition, British Grassland Society, Blackwell Scientific, Oxford.

Houghton, M. and Poole, A. H. (1990). Organic milk production. *Genus Information Unit Report*, **70**. Genus Management; Wrexham.

Jacklin, D. (1993). Minerals and fertility: myth, mystery or mathematics ?. *Dairy Farmer* August 1993.

Jarvis, S.C. (1993). Nitrogen cycling and losses from dairy farms. *Soil Use and Management*, **9:** 99-105.

Jenkins, T. N. (1988). Farm classification: a study with particular reference to Welsh agriculture. Aberystwyth, University of Wales.

Klenke, B. (1989). Investigations on cattle herds under different types of management with special reference to milk yie ld, health and fertility. PhD Thesis, Tierarztliche Hochschule Hanover, Germany.

Krutzinna, C., Hermann, H. J., Woelfert, J. and Boehncke, E. (1995). Kennzahlen der ökologischen Milchviehhaltung. *Lebendige Erde* **1995:** 281-286.

Lack, P. (1992). Birds on lowland farms. London: HMSO

Lampkin, N. H. (1990). Organic Farming. Farming Press, Ipswich.

Lampkin, N. H. (1993). The Economic Implications of Conversion from Conventional to Organic Farming Systems. Ph.D. Thesis, Department of Economics and Agricultural Economics, University of Wales; Aberystwyth.

Lampkin, N. H. (1994a) Changes in physical and financial performance during conversion to organic farming: Case Studies of two English dairy farms. In: *The economics of organic farming: An international perspective. (eds. N. Lampkin and S. Padel*). CAB International; Wallingford, pp 223-242.

Lampkin, N. H. (1994b) Researching Organic Farming Systems. In: *The Economics of Organic Farming. (eds. N. H. Lampkin and S. Padel)*. CAB International; Wallingford, pp 27-39.

Lampkin, N. H. and Measures, M. (1995). 1995/6 Organic farm management handbook. University of Wales Aberystwyth and Elm Farm Research Centre; Aberystwyth, Newbury.

Liverpool University Veterinary School (1993). An epidemiological study to determine the risk factors of lameness in dairy cows. University of Liverpool Final Report June 1993.

MacRae, R.J, Hill, S.B, Mehuys, G. R. and Henning, J. (1990).Farm-scale agronomic and economic conversion from conventional to sustainable agriculture. *Advances in Agronomy,* Vol. **43:** 155-198.

MAFF (1984). Dairy herd fertility. HMSO, London.

MAFF (1985). The Analysis of Agricultural Materials. London, HMSO.

MAFF (1994). *Farm income in the United Kingdom: 1992/93.* Ministry of Agriculture, Fisheries and Food; London.

Milk Marque (1995). A guide to milk quality, cooling and every other day collection. *Milk Marque Report 1995* Milk Marque, Worcester.

Mulvany, P. (1977). A body condition scoring technique for use with British Friesian cows. *Animal Production* **24**: 157-158.

Murphy, M.C. (1992). Organic farming as a business in Great Britain. Agricultural Economics Unit, University of Cambridge, Cambridge.

Newton, J. (1992). Herbage production from organic farms. *Research Notes*, No **8**, Elm Farm Research Centre. Newbury.

Newton, J. (1994). Herbage production on organic farms. *Elm Farm Bulletin* **11:**3-4. Newbury.

Newton, J. and Stopes, C. (1995). Grassland productivity or organic farms, 1992-94. *Elm Farm Bulletin* **18:** 2-6.

Newton, J., Philips, L., Woodward, L. and Stopes, C. (1995). Grassland productivity from organic farms in the UK. *New Farmer and Grower*, **45:** 16-17.

Offerhaus, E.J., Baars, T. and Grommers, F.J. (1994). Gezondheid en vruchtbaarheid van melkvee op biologische bedrijven. Report for 1994 of the Louis Bolk Institute. Louis Bolk Institute, Driebergen.

Padel, S. and Lampkin, N. H. (1994a). Conversion to organic farming: An overview (Chapter 17). In: *The economics of organic farming: An international perspective. (eds. N. Lampkin and S. Padel).* CAB-International; Wallingford, pp 295-313.

Padel, S. and Lampkin, N. H. (1994b). Farm-level performance of organic farming systems: An overview. In: *The economics of organic farming. (eds. N. H. Lampkin and S. Padel).* CAB International; Wallingford, pp 210-219.

Patton, M. Q. (1990). Qualitive Evaluation and Research Methods. Sage publications; London.

Paul, A.A. and Southgate, D.A.T. (1978). The Composition of Foods. *MRC Special Report* No. **297**. Ministry of Agriculture, Fisheries and Food/Medical Research Council. London, HMSO.

Poulton, S. and Langton, S. (1993). The ADAS National Survey of Small Mammals in Hedgerows; The relationship between small mammal numbers and hedgerow characteristics. ADAS Unpublished Report.

Poulton, S. and Langton, S. (1994). The ADAS National Survey of Small Mammals in Hedgerows; The relationship between small mammal numbers in hedges and the adjacent crop. ADAS Unpublished Report.

Preston, R.L. and Linsner, J.R. (1985). Potassium in animal nutrition. In: *Potassium in Agriculture. (ed. Munson, R.D.)* pp.595-617. Wisconsin, American Society of Agronomy.

Prins, W.H., DenBoer, D.J. and van Burg, P.F.J. (1985). Requirements for phosphorus, potassium and other nutrients for grassland in relation to nitrogen usage. In:. *Grassland Manuring. (eds. Cooper, J.P. and Raymond, W.F.)* Occasional Symposium No.**20**. *British Grassland Society*, pp. 28-45.

Rantzau, R., B. Freyer and Vogtmann, H. (1990). Umstellung auf ökologischen Landbau. *Angewandte Wissenschaft*, **389**. Landwirtschaftsverlag; Münster-Hiltrup, .

Redman, M. (1991). Organic dairy costings: update. *New Farmer and Grower*. **33**(Winter):20-21.

Redman, M. (1992). Organic farming and the countryside. Report for the Countryside Commission. British Organic Farmers, Bristol.

Reid, I.M. and Little, W. (1986). Health. In: Principles and practice of feeding dairy cows. Technical Bulletin No.**8**, National Institute for Research in Dairying. NIRD, Reading.

Reneau, J.K. (1986). Effective use of dairy herd improvement of somatic cell counts in mastitis control. *Journal of Dairy Science* **69:** 1708-1720.

SA (1995). Standards for organic food and farming. Soil Association organic marketing company Ltd; Bristol.

Schulze Pals, L. (1994). Ökonomische Analyse der Umstellung auf ökologischen Landbau. Schriftenreihe des BEMLF, Landwirtschaftsverlag; Münster Hiltrup.

Skinner, R.J., Church, B.M. and Kershaw, C.D. (1992). Recent trends in soil pH and nutrient status in England and Wales. *Soil Use and Management*, **8:** 16-20.

SPSS (1990). SPSS reference guide. SPSS Inc.; Chicago.

Thomas, C. and Young, J.W. (1991). Milk from grass. ICI Agricultural Division with GRI Hurley and SAC.

Thomas, D. and Perry, A. (1991). Genus milkminder, Annual report. Genus Management; Wrexham.

Titchen, N.M. and Scholefield, D. (1992). The potential of a rapid test for soil mineral nitrogen to determine tactical applications of fertiliser nitrogen to grassland. *Aspects of Applied Biology*, **30:** 223-229.

UKROFS (1995). Standards for Organic Food Production. UK Register of Organic Food Standards, Food From Britain; London.

van der Werff, P.A., Baars, A. and Oomen, G.J.M. (1994). Nutrient balances and measurement of nitrogen loss on mixed ecological farms on sandy soils in the Netherlands. Biological Agriculture and Horticulture, **11:** 41-50.

Webster, J. (1993). Understanding the dairy cow. Blackwell Scientific Publications, Oxford.

White, R.E., Haigh, R. and Macduff, J.H. (1987). Frequency distributions and spatially dependent variability of ammonium and nitrate concentrations in soil under grazed and ungrazed grassland. *Fertilizer Research*, **11:** 193-208.

Wilson, J. (1993). The BTO Birds and Organic Farming project one year on. *Newsletter of the British Trust for Ornithology*, **185:** 10-12.

Younie, D. and Watson, C.A. (1992). Soil nitrate levels in organically and intensively managed grassland systems. *Aspects of Applied Biology*, **30:** 235-238.