RESEARCH TOPIC REVIEW: Management & sustainability of stockless organic arable and horticultural systems

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1 SCOPE & OBJECTIVES OF THE RESEARCH TOPIC REVIEW

Traditional organic systems of mixed farming with alternate husbandry rely on fertility building leys and livestock manures to provide break crops and fertility building.

The trend within agriculture has been a move away from mixed farming systems to specialist units.

The infrastructure costs (fencing, water and buildings) of introducing livestock into an all arable farm are often prohibitively expensive and preclude conversion to a mixed organic farming system.

A stockless organic system allows conversion to organic farming without the requirement to introduce livestock and their associated infrastructure costs.

Totally stockless systems do not import livestock manures but some utilize green wastes.

The challenges of stockless organic systems are:

Conversion planning
Rotation design
Maintaining soil nutrient status
Weed control
Pest control
Economic return

The aim of this review is to address these issues and the main problems faced by producers. The study includes a review of the available research results from Defra and other research programmes, summarises the findings and provides analysis of the results together with a summary of the practical implications for organic farming. It covers the following:

i) Conversion

Farmers seek to establish a long-term sustainable system.

Does the conversion strategy have a long-term impact on yield?

High risk conversion strategies may increase short-term income but do they have a long-term impact on weed levels, soil fertility and rotation performance?

ii) **Rotation**

The balance between fertility building and cash cropping influences the financial viability and long-term sustainability of the system.

What is the optimum rotation?

iii) **Maintaining Soil Nutrient Status**

Soil health and nutrient status is critical to a sustainable system.

What is the influence of conversion strategy on soil nutrient status?

iv) **Weed Control**

What are the best strategies? How does varietal selection and cultivation technique influence the weed burden?

Are wide rows and inter-row hoeing the solution?

v) **Pests**

Pest control strategies to avoid yield loss are an integral part of an organic system.

vi) **Economic Returns**

The grower requires an economic return from the farming system.

Can a stockless system deliver a sustainable and financially viable production system?

vi) **Stockless Vegetable Systems**

Stockless organic vegetable production produces its own challenges. Demand is increasing for organic vegetables and a large proportion of the vegetables consumed are imported which provides considerable scope for new growers.

Diseases pose a threat to both quality and yield and both must be managed if organic vegetable production is to be sustainable. The end market also influences the impact of quality defects on financial performance. Vegetable box schemes and local sales are not as sensitive to cosmetic quality standards as the sales through the multiple retailers.

2 SUMMARY OF RESEARCH PROJECTS AND THE RESULTS

The HGCA funded project no. 389 "*Investigating the long-term impact of stockless organic conversion strategies*" (Sparkes, D.L. *et al.*, 2003)[1] is a three-year trial which investigated the impact of conversion strategies on subsequent yields on two soil types. The strategies were:-

1. Two years red clover rye grass green manure.
2. Two years hairy vetch green manure.
3. Red clover for seed production followed by red clover rye grass green manure.
4. Spring wheat undersown with red clover followed by a red clover green manure.
5. Spring oats followed by winter beans.
6. Spring wheat followed by winter beans.
7. Spring wheat undersown with red clover followed by a barley pea intercrop.

The two-year conversion period was followed by organic wheat, bean and oat crops.

The choice of crop rotation and in particular the ratio of fertility building to fertility exploiting crops has a major influence on the success of an organic system (Younie, Watson & Squire, 1996) [2].

Conversion strategy had a significant impact on organic bean yield, which ranged from 2.8-3.6 tonnes per hectare (1.13-1.46 tonnes per acre) and organic oat yields which range from 3.2-4.2 tonnes per hectare (1.3-1.7 tonnes per acre). 70% of the organic bean yield variation was the result of weed levels and soil texture. 72% of the variation in the oat yield was the result of weeds in April and soil mineral nitrogen in November. The impact of conversion strategies on soil mineral nitrogen levels was still detectable three years post-conversion.

A Land Quality Index (LQI) was developed which linked crop yield, through regression analysis, with crop price. Calculation of the LQI for the two organic crops showed that the spring wheat undersown with red clover had the highest index value, but when the gross margins for the entire rotation was calculated, the red clover for seed production was ranked as the top strategy. However, this strategy relies on securing specialist markets and is unlikely to be appropriate for all growers. The two years red clover strategy would suit the risk averse grower due to the high levels of soil mineral nitrogen and good weed control afforded by this strategy and the overall gross margin derived over the five year period from conversion until the end of the first three years organic crops. The result highlights the importance of the fertility building conversion period in terms of its effect on soil nutrient levels, weed abundance and economic viability.

Significant differences in crop yields were recorded in both winter bean and winter oat crops. Beans were not responsive to soil mineral nitrogen levels (SMN), however, winter oat yields were higher from the plots with the fertility building conversion periods (those strategies with the most SMN) than from those with the higher proportion of cash cropping. The differences in SMN were still apparent after the third organic crop which suggests that the conversion strategies had long-lasting consequences.

Conversion strategy differences in the weed population and community had an important influence on crop performance. The differences in weed numbers originated in the conversion period and was maintained throughout the rotation by changes in the weed seed bank, together with the vegetative spread of weed species such as thistles. Regression analysis showed that weed abundance had an important influence on the yield of both winter beans and winter oats. The project concluded, in agreement with the (Sparkes *et al.* 2006)[3], that a risk averse grower would find a red clover conversion period the most suitable. However, this strategy had the lowest bean gross margin and was only ranked fifth when gross margins for just the second and third organic crops were considered. As a result, it may not be suitable for growers requiring a stable income throughout the rotation period, but weed control and SMN levels from this strategy are among the best of the seven strategies. The findings from the study supported the recommendation, to the risk taking individual, of the clover seed/red clover strategy. This produced an average gross margin over the five year period of £459 per hectare over £100 per hectare more than any other strategy. It also had a relatively stable income distribution throughout the five year period as well as good soil structure, SMN levels and weed control. It confirmed the conclusion of previous research that the undersown wheat red clover would not be recommended to the risk averse grower, although it may be a suitable strategy for the risk taking individual.

Olesen & Askegaard, Margrethe & Rasmussen (2000)[4] considered crop production during the first course of an organic crop rotation in Denmark. They found that the positive effect of a grass clover green manure crop could not substitute for the yield decrease from leaving 25% of the area out of production. The trial was carried out over three years and the initial results of the crop rotation experiment showed large differences in response between different sites. Further effects are expected to be caused by long-term effects on soil fertility and would take longer to be manifested. A ten year experiment would be required to provide adequate information of the long term sustainability of crop rotations for organic cereal production.

Two long-term experiments were established with the aim of evaluating the agronomic and economic performance of organic stockless rotations (Welsh, Phillips & Cormack. 2002)[5]. In total four different rotations were evaluated in two sites. All of the rotations included either a one or two year red clover green manure crop to provide nitrogen for subsequent crops and it was found that this was sufficient to support three or four years of arable cropping. Over a period of 11 years at EFRC and five years at ADAS Terrington, there was no evidence of declining crop yield, although there was significant year-to-year variations. Crop yields were generally equivalent to or greater than the average organic yields. Levels of soil available phosphate and potash were maintained at both sites at non-limiting levels by the use of permitted organic fertilizer. Pest and diseases were not problematic but perennial weeds posed the most significant problem.

The red clover crops were cut and mulched approximately three to four times per season. On average the red clover accumulated approximately 275 kgs of nitrogen per hectare with significant year-to-year variation. At ADAS Terrington, the red clover accumulated 682 kgs of nitrogen per hectare on average over its two year duration. Stem nematodes were not a problem at EFRC but caused poor clover growth in patches at ADAS Terrington.

Soil organic matter levels reduced from 3.2% to 2.5% at EFRC and remained at this level for the last eight years of the project. Soil organic matter levels at ADAS Terrington grew slightly to 2-2.5% over the course of the experiment.

Applications of rock phosphate were made at EFRC to maintain the available soil phosphate levels. Aluminium calcium phosphate was applied at Terrington to maintain the soil phosphate levels.

In general, pests and diseases were not problematical. However, there has been some concern at Terrington regarding the build up of the potato system nematode and to avoid this problem vegetables were introduced as an alternative to the potatoes. Weeds have been more problematic for the intensive arable rotations. The levels of annual weed species has increased in both experiments, although these have been adequately controlled by mechanical weeding techniques. A more serious problem is perennial weeds. The level of perennial grasses such as couch have increased at both sites and creeping thistle has been a particular problem at ADAS Terrington.

Rasmussen, Askegarrd, Olesen and Kristensen (2006)[6] reviewed the effects on weeds of management in newly converted organic crop rotations in Denmark. They investigated the effects on annual weeds of location, weed control, manure application and catch crops and their inter-action in a crop rotation with cereals and pulses for grain during conversion to organic farming in order to understand the combined effects of management. A four year rotation was utilised with four treatments with and without catch cropping, with and without manure. Mechanical weed control was reduced or absent in cereals or pulses with undersown catch crops or grass clover. The effect of catch crops on weed biomass was linked to weed control, while direct effects of catch crops on weed biomass were of minor importance. At the location with the most intensive weed control weed biomass decreased in all crops over the years. At the other two locations weed biomass was stable or increased slightly in the winter wheat, pea and barley crops which received some weed control, but increased in spring barley where no weed control was performed. Catch crops reduced weed density. The crop at the start of the rotation had a significant influence on mean weed biomass but it differed between location and could mostly be explained by differences in weed biomass between years and crops. This suggests that experiments that do not include all crops in the rotation every year may give biased results. The effect of management practices (manure, catch crop and weed control) was site specific but with similar effects on different crops at each location.

Younie *et al.* (2002)[7] monitored changes in the weed seed bank between 1991 and 1998 at two sites in North East Scotland. There were minor changes in weed species diversity over time but major changes in seed bank abundance. Weed seed numbers were relatively low in rotations with a high proportion of grass clover leys. Weather and its influence on the effectiveness of weed control operations affected the seed bank.

Bulson and Welsh (1996)[8] examined the effect of weeding intensity and aggressivity on weed numbers and crop yield. The intensity was examined by comparing one or two passes through the crop. The angle of tines in relation to the ground was varied to provide a comparison between steep, medium and shallow to examine the impact of aggressivity. Aggressivity had no statistical significant effect on grain yield or ear numbers. However, all the treated plots produced lower yield than the unweeded control. This suggests that weed numbers in the trial were not at yield threatening levels and in this situation the weeder disadvantaged the crop.

The advantages and disadvantages of different break crops in an organic grass/arable rotation (Anon. 2002)[9] have been investigated. The choice of break crops to grow in addition to cereals in the fertility building phase is crucial to the agronomic and economic success of organic arable rotations. The break crop yields were strongly correlated with soil nutrient concentrations.

Improving end use and performance of arable crops on organic arable farms using an expert group DEFRA project (2002)[10] selected nine farms to study and identified that seven had positive nitrogen balances, six a positive phosphate balance and three a positive potash balance. The degree to which a particular nutrient was in surplus or deficit appeared to be independent of the balance of other nutrients within the rotation. Stockless systems without fertiliser had a large phosphate deficit.

Stockless Organic Field Vegetables

Rayns, Harlock and Turner (2002)[11] and Schmutz, Rayns, and Sumpton, (2006)[12] assessed the impact of fertility building strategies during the conversion period and subsequently in the rotation on stockless vegetable production. Effective rotation design is essential to balance fertility building crops and cash crops. In stockless systems fertility building crops are expensive as there is no direct economic return other than support payments. Long-term grass clover leys provide additional benefits of weed, pest and disease control and adding organic matter to the soil.

Stockless vegetable production presents its own challenges. Companion cropping for organic field vegetables, (Wolfe and Cormack. 2002)[13] recognised that organic crop rotations are extensive with at least one year in four as a fertility building crop. To address this lack of income the use of permanent beds of companion crops grown alongside the vegetable crops has been developed. The project concluded that companion cropping has the potential to improve the economic viability, and pest, disease and annual weed control in organic cropping systems, particularly in field vegetables. However, in practice the project did not realise these benefits.

Bending studied changes to soil quality indicators following conversion to organic vegetable production (Bending, G. 2002)[14]. The one year study examined how key functional indicators of soil quality are affected by contrasting organic and conventional management regimes. It investigated the impact of contrasting fertility building regimes on soil quality, focusing on the initial five year period following conversion from conventional to organic production. Contrasting organic management regimes had different effects on soil quality. There was evidence that organic management promoted a microbial community that was distinct in composition and functional attributes to that in conventional soil. The productivity of newly converted organic systems could be limited by a low innoculum and diversity of arbuscular mycorrhizal fungi inherited following conventional management. The clearest effect of soil structure was with regard to the detrimental effect of vegetable production rather than to any benefit associated with organic management. Wheeling lines cause compaction that resulted in poor growth of subsequent crops. However, it is likely that increased levels of organic matter may result in soil better able to cope with damaging operations.

Gladders (2002)[15] Development of disease control strategies for organically grown vegetables, reviewed the literature and found little quantitative information on diseases in organic vegetables. Late blight was the most important single problem. Stringent standards for seed and propagation are required to prevent disease being introduced. Collated records from 489 crops (156 on large farms, 333 on small farms) over a two year period illustrated that there was a greater diversity of cropping on small farms, but the diseases recorded were similar to those found in conventional cropping. Diseases were often present at low incidence of low severity in organic crops and severe infections were recorded in only 8% of crops on small farms and 16% of crops on large farms. Although these groups of farms grew different ranges of crops, these results provide new information to suggest that large scale production is more prone to disease problems. This observation is consistent with other epidemiological studies, including the mixture effect, which suggests that increasing diversity of potential disease hosts per unit area tends to reduce the probability of infection. The systemic analysis of disease problems allowed the main sources to be identified. It would appear that celery leaf spot, septoria, in lettuce and alternaria blight in carrots are primarily seed borne problems which can be managed by testing seed stocks and using seed treatments. Club root, allium whiterot and rhizoctonia disease are soil borne diseases which can be managed by rotation and avoiding known problem areas. Forward planning is critical for organic production and simple cropping schemes which avoid year round production of planting of successive crops next to each other may have helped reduce the impact of borassic foila disease and leek rust. Diseases pose a threat to both quality and yield, both must be managed if organic production is to expand and remain viable. Diseases are common in organic vegetables but severe infections leading to significant losses of yield or quality affected only 11% of crops. Seed borne diseases are important and the availability of healthy seed would reduce losses in vegetables. Soil borne diseases can be managed through rotation or avoiding badly infested areas. Disease management using organic conditioners, biological control agents and soil amendments merit investigation in farm scale experiments.

Organic crops tended to be more weedy than conventional crops and the weeds themselves can become diseased. The majority of parasites involved are not adapted to crop plants. However, the presence of weed parasite spores and semiochemicals released from the weeds could have some influence in restricting disease development in crops through the introduction of resistance.

3 ANALYSIS AND CONCLUSION

Conversion

The evidence from the research is that conversion strategy influences rotational performance both financially and physically.

Fertility building crops reduce the rotational return but provide a sustainable cropping sequence.

The use of the Organic Entry Level Scheme (OELS) conversion grant provides an income during the fertility building phase and removes the cashflow driven requirement to introduce in conversion cropping.

The introduction of clover seed crops increases the return but there is a limited but expanding market. The harvesting of clover seed for use on the farm reduces seed costs but does not increase income.

Rotation

No direct income is derived from the grass clover leys under a stockless system but support payments continue. Alternative fertility building crops have not been fully explored experimentally. Current trials are examining the impact of cutting regimes on fertility building.

The optimum rotation is influenced by the inherent soil fertility levels and weed burden.

Short-term financial gain can be increased by minimising the fertility building phases but the limited evidence available suggests that soil health and fertility will decline long-term if the rotation is too exploitative.

A reduction in the non-organic portion of the rations for organic livestock now provides a premium outlet for organic pulses. Pulses are becoming a profitable break crop.

The optimum rotation is both site and soil specific.

Maintaining Soil Nutrient Status

Experimental evidence is weak as experiments tend to be short-lived and are therefore unable to monitor more than one rotation and few even monitor an entire rotation.

A stockless system is probably more vulnerable to the removal of mineral resources although only the grain is removed each year. No livestock manure is brought back into the system but green wastes are available. Ultimately the net offtake from a rotation is dependent on the balance of fertility building to cash cropping and animal product sales, rather than whether the system is stockless or stocked. There is a tendency for stockless rotations to be more intensive, partly because of the lack of income from the green manure. However the real challenge is to ensure that the rotation and system is appropriate to the particular soil type and other farm conditions.

Soil mineral nitrogen levels vary according to the rotation. It is generally available mineral nitrogen which limits yield potential and those crops which follow a fertility building grass clover ley or green manure are always the highest yielding. Maximising N fixation requires careful management.

Ploughing down grass clover green manures in the autumn can lead to an increase in nitrate leaching. Delayed ploughing until soil temperature is reduced is an effective strategy for reducing the losses.

The use of composted green waste to supplement the nitrogen fixed by the leguminous crops is one option. However, most of the green waste has been derived from non-organic systems and it could be argued that it undermines the integrity of the system for organic farmers to use material produced from chemical based systems.

There is some evidence that the lack of manures reduces mycorrhizal activity, otherwise there is no evidence of reduced soil microbiological activity in stockless systems.

Weed Control

The financial pressure in stockless systems to produce the maximum number of cash crops per rotation can lead to problems with annual and perennial weeds. Extending the ley or green manure period reduces weed pressure but also returns. Stock based systems tend to have longer fertility building phases which improve weed control.

A number of cultural and mechanical techniques can be used:-

<u>Stale Seed Bed</u>
Stubbles can be cultivated post-harvest to stimulate weed seed germination and then remove the seedlings by mechanical cultivation. This helps deplete the seed bank. Attempts to use minimal cultivations only have rarely been successful and the land is generally shallow ploughed prior to drilling. The plough creates a cleaner seed bed but can bring previously dormant seeds back up into the germination zone.

<u>Seed Rate and Variety</u>
Autumn establishment allows more stale seed bed cultivation and can reduce weed germination at the time of sowing as a result of lower soil temperatures. Higher seed rates produce a competitive crop which helps to suppress the weeds. The selection of tall varieties reduces the impact of the weeds on yield.

<u>Photo Control of Weeds</u>
German research has shown that some weeds must receive exposure to light to act as a trigger to germinations. Trials carried out in which crops were sown at night or under the cover of a shroud or a combination of both to reduce weed germination failed to fully replicate the greenhouse pot results. Chickweed, Mayweed and annual grass were reduced but the other non-light responsive weeds prevented any yield benefits being realised and the technique has no practical field scale application.

<u>Inter-row Cultivations</u>
Precision drilling of the crop enables steerage hoes to be utilised to remove the inter-row weeds. It is a useful technique against grass weeds and wild oats but weeds still grow between the plants within the rows. Accuracy is required in both drilling and hoeing although self-steering hoes are now available. The technique is only effective in high value crops or where weed burdens are severe.

Harrow Comb Weeding

Harrow comb weeders offer a cheap weed control measure. The effectiveness depends on timing, weather conditions and the differential rooting habits of the crops and weeds. Early removal or burial of weed seedlings is generally the most effective but this usually needs to be carried out in the autumn when soil conditions tend to be unsuitable. In the absence of a high weed population cultivations have an adverse effect on yield.

Pests and Diseases

Organic systems rarely suffer from yield reducing diseases as the lower fertility levels reduce the pressure on the plant's system.

Pests can cause problems with slugs, leather jackets and aphids occasionally leading to crop loss. Cultural techniques and timing are the only defence.

Nematodes can cause problems and only tested clover seed should be sown.

Correctly designed rotations minimise the risk from soil borne diseases.

Economic Return

Long-term experiments at Terrington, CWS Agriculture and Rodale in America have examined the financial viability of stockless systems.

The Terrington results compared stockless organic and conventional farms and although the sample used was small, the stockless organic produced the highest margin and out-performed the conventional farms.

The CWS Agriculture experiment compared two organic systems, mixed farming and stockless, over a number of years. The results from 1989 to 1996, two years of conversion and five years of cropping, were published in the RASE Journal (1999)[16]. The stockless rotation produced an additional 27% net margin compared to the mixed farming system and only 2% lower than the standard data for conventional farms. The growing of in conversion crops was found to produce low yielding crop sold at conventional prices and was less successful than utilising green manures for fertility building. The basic crop rotation was red clover grass ley/red clover grass ley/wheat/oats/beans/wheat/oats. Beans were found to be a more successful fertility building break crop than peas.

Over the full seven years of the rotation only two crops suffered severely from pests, a crop of peas to an attack of aphids and a crop of wheat to slugs.

The Rodale Institute in Pennsylvania has been studying organic systems, including stockless, since 1981 (Peterson *et al.* 1999) [17]. The results show that after a conversion period during which yields are likely to be lower than those on conventional farms, organic stockless farms can compete economically with conventional farms. However, the costs of conversion is likely to affect the farm's overall financial performance for a number of years.

The profitability of organic stockless systems at gross margin level will be less than a mixed farming system where the fertility building phase of the rotation derives income from livestock sales.

Data from the 2007 Organic Farm Management Handbook (Lampkin. 2006)[18] demonstrates the returns from a stocked and stockless system.

Table 1
Organic Stockless Farming System Gross Margin

Crop		**Area / number**			**Gross Margin excl. subsidies** Unit Gross Margin			Farm Gross Margin
Stockless								
		ha	*acre*		*£/ha*	*£/acre*		
Winter Wheat		40	99		505	204		20,200
Spring Wheat		30	74		337	136		10,110
Winter Oats		40	99		378	153		15,120
Spring Barley		10	25		417	169		4,170
Spring Beans		40	99		379	153		15,160
Red Clover GM year 1		40	99		-182	-74		-7,280
Red Clover GM year 2		40	99		0	0		0
Total		240	593					57,480
whole farm survey data *								
2004		240	592		282	114		67,598
2001		240	592		410	166		98,281

To Table 2>

Table 2
Organic Mainly Arable Farming System Gross Margin

			Gross Margin excl. subsidies		
Crop	**Area / number**		**Unit Gross Margin**		**Farm Gross Margin**
Mainly arable					
	ha	*acre*	*£/ha*	*£/acre*	
Winter Wheat	40	99	505	204	20,200
Spring Wheat	15	37	337	136	5,055
Winter Oats	21	52	378	153	7,938
Spring Barley	8	20	417	169	3,336
Spring Beans	21	52	379	153	7,959
Total	105	259			
	ha	*acre*	*£/ha*	*£/acre*	
Short term leys	46	114	-109	-44	-5,014
Medium/long term leys	69	170	-98	-40	-6,762
Permanent Grassland	20	49	-55	-22	-1,100
Total	135	334			
Farm Total	240	593			
	head	*LU*	*£/head*	*£/LU*	
Beef finishing, 18 month	58	143	288	117	16,704
Single suckler cows	61	151	188	76	11,468
Lowland sheep	600	1483	41	17	24,600
					84,384
whole farm survey data *					
2004	250	618	456	185	11400
2001	250	618	546	221	136500

* *includes potatoes and carrots.*

At a farm gross margin level the mixed farming system produces an additional income of £26,904. However, the extra gross margin requires investment in buildings, forage and effluent facilities, fencing and water supplies. Additional labour is required to produce the livestock and using standard data from The Farm Management Pocket Book (Nix. 2006)[19] an extra two men with additional casual labour are required. (Appendix 1)

In the absence of an existing infrastructure suitable for livestock production, a stockless system provides the highest return after allowing for overheads.

Vegetable Production

Stockless systems, with no reliance on livestock or imported wastes, often referred to as stockfree, have been successfully operating over a number of years. Anecdotal evidence from a closed system which has been relying on internally produced compost for 12 years is that yields are improving. Red clover/lucerne is cut and mulched for two years to support a five year cropping. Cover crops are used between cash crops to prevent nutrient losses.

Conclusion

The essential difference between stockless and stocked systems is that the fertility building clover ley and other "forage crops" are not processed through an animal but instead are grown as green manures which are returned directly to the soil by mulching, incorporation or occasionally through composting of the green manure. Stockless systems provide no opportunity for the creation of straw and animal manure based farm yard manure or compost.

While there is no research evidence that the lack of animals or manure based compost affects overall soil fertility and crop yield, there is some research evidence that animal manure enhances soil mychorrizae populations and soil organic matter accumulation. This effect might also be seen from the use of plant based compost, sometimes sourced off-farm as "green waste" in stockless systems, but there is no comparative work available. While the use of manures has the advantage of allowing movement of fertility around the farm within a rotation, grazing animals have the drawback of uneven dispersal of manure and urine and manure storage is liable to poor management and loss of nutrients. Green manures are fundamental to stockless systems, both as one or two year crops which are either mulched or incorporated or grown as short term catch crops or undersown crops. With appropriate selection and management of green manures there is potential for enhanced fertility building over that which is possible with grazed leys.

The practical commercial experience of farmers using stockless rotations is stronger than the research would suggest in terms of supporting its technical success and viability. Weed control remains a serious problem for arable farms which requires very high standards of management.

The demand for organic livestock products is increasing and the area of organic land producing feed grains is insufficient to support the required expansion. World demand for organic grains is increasing. The introduction of livestock on to specialist conventional cereal producing farms in many instances requires prohibitively expensive infrastructure costs. Stockless rotations utilising green manures to fix nitrogen as part of the rotation provide a technically feasible and profitable alternative.

Stockless horticultural systems operated with or without the use of imported manure or compost offer potential for technically and financially viable systems provided that there is an appropriate balance of fertility building green manures and cash crops.

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Defra OF0145. *Testing the sustainability of stockless arable organic farming on a fertile soil.*

Appendix 1
Labour requirement for Stockless and Stocked Systems

Gross margin analysis provides details of the performance at enterprise level. However, it ignores the impact of overheads on enterprise mix. The labour, power, machinery, building and infrastructure costs of different combinations of enterprises vary widely and have a major input on farm profitability.

Overhead costs tend to be farm and site specific. The labour requirement of a stock based system is significantly higher than for a stockless system.

Data on labour requirements from the Farm Management Pocket Book has been utilised to analyse the labour requirement of the systems costed to gross margin level in the Organic Farm Management Handbook.

Figure 1
Stockless Organic System Labour Profile
(240ha Arable cropping)

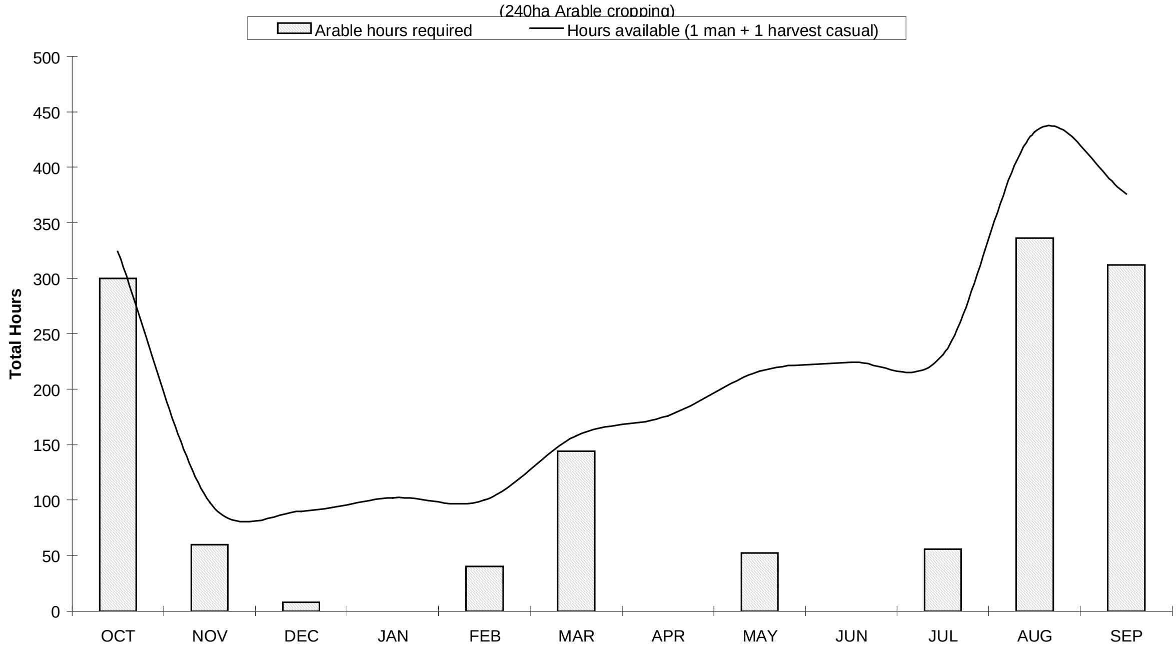

Figure 2
Mainly Arable Organic Farming System Labour Profile
(105ha Arable, 600 sheep, 58 beef finishers and 61 single suckler cows)