Aspects of Applied Biology 79, 2006
What will organic farming deliver? COR 2006

10-year interdisciplinary monitoring of organic stockless, vegetable rotations at Warwick-HRI, Kirton, South Lincolnshire, UK

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Summary

Interdisciplinary monitoring of an organic stockless farming system has been carried out over ten years on a fertile silty clay loam in the main vegetable production area of the UK. The results draw together economic outcomes with agronomy, soil science and agro-ecology. Organic management has been used at the Kirton research site since conversion of a 3.2 ha unit in 1997. There is great variability in crop yields and marketing results but overall a successful ongoing vegetable production system has been established. Soil fertility, weeds, pests and diseases have been managed successfully without imports of animal manures or green waste compost. Production costs are well controlled and marketable yields are good. However, because the site is a research farm, the actual marketing of produce was sometimes weak and caused a low farm net margin. The site contributes valuable information to the European network of long-term field experiments in organic farming for this particular farming system.

Keywords: Organic vegetables, long-term experiments, crop rotations, farm economics, N dynamics, fertility building, interdisciplinary modelling

Introduction

Warwick-HRI Kirton, near Boston in South Lincolnshire, is a horticultural research station with 46 ha of deep, stoneless, well-drained grade-one land (silty clay loam) situated in the UK's premier vegetable producing area. The site is flat, 7 m above sea level with an average rainfall of 630 mm and temperature of 10.4°C during the monitoring period 1997-2005. In 1996, the decision was taken to convert a 3.2 ha field (Lane Field) from conventional intensive vegetable and cereal production to organic field vegetable production. The site was continuously monitored during conversion (Defra-funded projects OF0126T, OF0191, OF0332) collaboratively by HDRA, University of Warwick-HRI, Organic Advisory Service at Elm Farm Research Centre, and the IRS at the University of Wales, Aberystwyth. The overall aim was to monitor the economic and agronomic performance of an intensive organic vegetable system.

Material and Methods

The 3.2 ha field is split into eight equal areas (numbered A-H) for cropping and monitoring purposes. It was converted in two stages beginning in 1997 (E, F, G and H) and 1998 (A, B, C and

D). A beetle bank was established between the two blocks of land. The basic rotational principle planned was two years of fertility building grass/clover leys followed by four years of vegetables cropping: potatoes - brassicas - alliums – carrots (Fig. 1). The site is completely stockless; no animal manures or green waste compost have been used. The original cropping plan was adapted due to marketing issues; additionally site problems with white rot (*Sclerotium cepivorum*) means onions were impossible to grow organically. New crops have also been introduced (lettuces, sweetcorn and courgettes). The actual cropping history of the site is given in Fig. 1.

Soil fertility monitoring

Soil nutrient status was monitored annually in late February/March. Samples (0–30 cm) were analysed for particle size distribution, organic matter content, pH, available P, K and Mg, Ca, and trace elements (iron, manganese, zinc, and copper). Methods are described in full by EFRC (1985). Soil mineral nitrogen was also measured at key points in the season/rotation. Samples (0-90 cm) were taken, extracted with 1 M KCl, mineral N was determined in the extracts.

Pest and disease monitoring

Pest and disease management for each crop and the farm system as a whole were documented. The incidence of pests and diseases and the success/failure of the strategies used were recorded. Basic assessments of pest and disease incidences were made during the growing season. Ten quadrats (0.25 m^2) in a 'W' shape were used in each field, or each crop as appropriate. Pest and disease symptoms and their severity were noted, including number of plants and percentage leaf area affected. The presence of predators and parasitised pests were also noted.

Weed monitoring

The weed control programme for each crop and the farm as a whole was documented. Weed assessments were made at the same time as pest and disease assessments. Percentage crop, weed and bare ground were recorded in quadrats; the weed species present were also recorded.

Economic monitoring

Staff at Kirton kept a computerised field diary of operations and recorded marketable produce sold. Variable costs and allocated fixed costs were extracted, including costs of machinery, seed, crop protection, transport and packaging. Missing data and casual labour rates were taken from the Organic Farm Management Handbook (Lampkin *et al*., 2004). From the costs and the prices achieved, gross and net margins were calculated for each crop (cash and fertility building); rotational and farm gross or net margins were also calculated.

Table 1. *Marketable yields of organic vegetable cash crops grown in more then 3 years. Yields are shown in tonnes per ha^{-1}, cv% is coefficient of variation and %-OFMH percentage provides a comparison with Organic Farm Management Handbook standard data (Lampkin* et al.*, 1996–2004)*

Crop	t ha^{-1}	cv%	% of OFMH
Potatoes	29.3	39%	105%
Carrots	28.8	94%	78%
Cabbage (Dutch white)	30.6	50%	102%

Year/Plot	A	B	C	D	E	F	G	H	% veg
1996	Veg	Veg	Veg/Barley	Barley	Barley	Barley	Cauliflower/	Cauliflower	50%
1997	Barley	Barley	Barley	Barley	G/C ley	G/C ley	G/C ley	G/C ley	0%
1998	G/C ley	G/C ley	G/C ley	G/C ley	Cabbage (D	G/C ley	G/C ley	Potatoes	25%
1999	G/C ley	G/C ley	G/C ley	G/C ley	Carrots	Cabbage (D	Potatoes	Onions	50%
2000	Cauliflower	Potatoes	Cabbage (D	Potatoes	G/C fallow	Carrots	Calabrese	Carrots	88%
2001	Potatoes	Lettuce	Potatoes	Lettuce	Carrots	G/C ley	Carrots	G/C ley	75%
	rye/vetch	rye/vetch	rye/vetch	rye/vetch					
2002	Lettuce	Sweetcorn	G/C fallow	G/C fallow	G/C fallow	Cabbage Sa	G/C fallow	Cauliflower	50%
	G/C	G/C	G/C	G/C	G/C	G/C	vetch	G/C	
2003	Sweetcorn	G/C ley	G/C ley	Beans & Pe	Cabbage Sa	Lettuce	Cabbage Sa	Lettuce	75%
	trefoil (failed)			vetch	vetch	vetch	vetch	vetch	
2004	G/C ley	Cabbage Sa	G/C ley	Cabbage Sa	Lettuce	Sweetcorn	Lettuce	Sweetcorn	75%
		vetch		vetch		red clover	vetch	trefoil	
2005	Cabbage Sa	Courgettes	Cabbage Sa	Courgettes	Sweetcorn	Red Clover	Sweetcorn	Trefoil	75%
	vetch	vetch	vetch	vetch	red clover		trefoil		
% veg 97-02	60%	60%	40%	40%	50%	50%	50%	67%	52%
% veg 97-05	63%	63%	38%	63%	67%	56%	67%	67%	60%

Fig. 1. Crop rotations at the 3.2 ha organic research site at Warwick-HRI, Kirton. In-conversion years are shown in grey and %-vegetable cropping is shown for each year and each rotation. From 2001 onwards, short-term fertility building crops were used where possible and are shown in an extra line.

Weeds, pests and diseases

The weed pressure was at a medium level (1997–2005); weeds between the rows were managed effectively with inter-row hoe and brush-weeders. Due to labour shortage, hand weeding was neglected, marketable yield of the particular crop was affected but not overall weed pressure. Weeds were topped to prevent seeding; perennial weeds occurred sporadically, there was no evidence of increase. Pests and diseases caused problems in particular crops but were largely successfully managed, e.g. high background levels of brassica pests on this site led only to low levels of damage. Caterpillars caused problems in conversion cabbage but use of Bt, fleece and good predator levels meant they were not subsequently a problem. However there were losses of Dutch white cabbage in store to rots. Late blight (*Phytophthora infestans*) in potatoes was managed through varietal choice after Nicola performed poorly; approved copper treatments were also applied. Carrot fly (*Psila rosae*) damage was minimised by late sowings but some problems were experienced when the crop was left in the ground when the market was slow.

Soil fertility

There were few consistent differences seen in annual soil samples. Area H has twice as much available P on average compared to the other plots. This area is closest to the road and may have been spread with material from the ditch or received other inputs in the past. Organic matter levels have remained around 2.7% despite the introduction of leys into the rotation. This is on the borderline of acceptability for this soil type (according to EFRC recommendations). Calcium and pH levels are naturally high in this soil (pH 7.7). Crop observation showed that in most cases adequate nitrogen was available – although there were occasions when the preceding fertility-building crop was not adequate to supply crop demand. Available phosphorus showed a slow but steady decline since conversion (from 51 to 31 mg L^{-1}); in 2005, levels were still satisfactory for horticultural production. For potassium, there has been a steady decline in available K since conversion began (from 131 to 88 mg kg^{-1}) and levels are considered low. Mg levels have remained relatively high and stable. The slight decline in P and K levels mirrors that of other stockless systems in the UK (Cormack, 1999; Rayns & Sumption, 2004).

Economics

Before conversion, in 1996, the average annual farm net margin was 1100 € ha^{-1} (£770). During conversion in 1997 and 1998 the annual farm net margin decreased to 350 € ha^{-1} (£245) and in the four years following the conversion period it averaged 1000 € ha^{-1} (£700). A high of 4100 € ha^{-1} (£2870) in 2000 and a low of -1500 € ha^{-1} (-£1050) in 2001 indicates the great variability in this system. Rotational net margins showed that the two rotations with in-conversion vegetables produced lower net margins of -430 € ha^{-1} (£300) after six years. Where two years of grass/clover ley was used for conversion rotations had net margins of 1400 € ha^{-1} (£980) and hence "paid" for the fertility delivered and the reduced cropping risk in subsequent vegetable crops. Problems with marketing have led to low net margins. Further analysis will assume that all marketable yield was actually sold at a standard price and incurring standard harvesting costs.

Conclusions

Organic vegetable production is economically and agronomically viable without animal manure or green waste compost. There is high variability in yields and marketing results and therefore various adjustments to the rotation have been made. It is possible to maintain yield levels with 67–75% vegetable cropping in the rotation and a mixture of long and short-term fertility building crops. Although designed as a case study and demonstration with no replications or a fixed rotation, the site provides a valuable resource to growers and scientists alike. Data is used in the European network of long-term field experiments in organic farming (Raupp *et al*., 2006) and in modelling of crop rotations and N dynamics (Schmutz *et al.*, 2006).

Acknowledgements

We gratefully acknowledge funding by the UK Government (MAFF/DEFRA) for the Kirton Organic site as part of the projects OF0126T, OF0191 and OF 0332.

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