ORGANIC FARMING - NOW AND THE FUTURE

C.M. Penfold and M.S. Miyan

University of Adelaide, Roseworthy Campus, Roseworthy, SA 5371

Abstract

Over an eight year period, organic, biodynamic, integrated and conventional broadacre farming systems have been compared on a 16 ha. site at Roseworthy Campus. Under scrutiny were soil biological, physical and chemical characteristics, financial outcomes, productivity and product quality parameters.Soil carbon increased on the conventional treatment over the eight year period of the trial, while extractable phosphorous was lowest on the biodynamic treatment. When compared to the other three treatments, there was lower microbial biomass carbon on the integrated treatment; microbial activity on the biodynamic treatment; and mycorrhiza infection of medic roots on the conventional treatment. The soil aggregate stability was less in the integrated system. While the conventional and integrated systems had higher costs, their financial returns were also considerably higher, resulting in higher gross margins than the two alternative treatments. Overall, it was apparent that weed control was the major productivity constraint on all treatments, due to *Oxalis* spp. and herbicide resistant ryegrass.

Key Words: organic, biodynamic, productivity, weeds, soil biology.

During the last decade, there has been considerable interest in broadacre organic farming. Several European governments are now actively supporting farmers to move from conventional to organic practices. The United States has witnessed an annual 20 % growth in organic farming for the last 7 years. In Japan, the market for organically produced foods is now estimated at 40 billion dollars. Australian farmers are well placed to supply a substantial portion of this developing market. Despite these opportunities, broadacre organic farming is not being widely adopted, far short of projections of 1990 that 2.5% of the agricultural land would be farmed organically by 1999 (2). Research in Australia over the last ten years provides some of the reasons why broadacre organic farming remains a system for those committed to a production system without synthetic pesticides and fertilisers. This paper will describe the results of a long-term trial where organic and conventional farming systems were compared for issues of sustainability, its implications for further research and the future for organic farming in Australia.

Materials and methods

In 1989 a long-term trial was established at the Roseworthy Campus ($34^{o}34'S$, 138^{o} 45'E) to investigate the sustainability of four broadacre farming systems: *viz* organic, biodynamic, integrated and conventional. The organic and biodynamic treatments abided by the requirements of the National Association for Sustainable Agriculture Australia (NASAA) and the Biological Farmers of Australia grade A certification standards.? These standards require strict adherence to allowable inputs, and exclude the use of synthetic fertiliser and pesticides. The integrated treatment combines minimum tillage/direct drilling with the use of municipal sludge as the principal fertiliser input. As with the conventional treatment, pesticides are used for weed, insect and disease control, but absolute control is not seen as essential. The conventional system utilises recognised 'best practice' minimum tillage/direct drilling, synthetic fertilisers and pesticides as required and rotations which include a pasture component when necessary for the control of herbicide resistant weeds.

The 16 hectare site consists of duplex alkaline soils (pH $CaCl_2$, 7.4), and basal available phosphate (Colwell) of 37 mg/kg and organic carbon (total - inorganic) of 1.32%. Each system was replicated twice, providing a plot size of 2 ha. Electric fencing and water troughs enabled the grazing of individual treatments when required. Overseeing the trial and advising on the individual treatments was a management committee consisting of farmers and scientists with experience covering each of the four farming systems.

Each system had individual management practices for soil fertility, pest and disease control, tillage and rotations, each designed to achieve sustainability as measured by the criteria shown below. Every four years, all systems are planted to a wheat crop (Table 1), enabling more rigorous assessment of the systems impact on the criteria under investigation. A broad based approach to measure sustainability was taken. Soil chemical, physical and biological status, and the productive and economic performance of each treatment were the principal parameters investigated over the eight year period.

Table 1 : Crops rotations as used on the Biological Farming Systems Trial, 1989 - 1996

	Organic	Biodynamic	Integrated	Conventional
1988	regenerated pasture	regenerated pasture	regenerated pasture	regenerated pasture
1989	oats/medic for hay	oats/medic for hay	oats/medic for hay	Wheat
1990	wheat crop mulched	legume based pasture	legume based pasture	peas
1991	green manure	oats/vetch for hay	legume based pasture	legume based pasture
1992	wheat	wheat	wheat	wheat
1993	chick peas	safflower	faba beans	faba beans
1994	cereal rye / vetch grazed	oats / vetch	wheat (hard)	wheat (durum)
1995	faba beans	oats/vetch grazed	faba beans	canola
1996	wheat	wheat	wheat	wheat

Results

Soil chemistry

Soil organic carbon did not differ between treatments.? The conventional treatment, however, displayed an increase ($P<0.05$) in carbon over the eight year period (1990, 1.26%, 1997, 1.64%). Extractable P on the conventional, organic and integrated treatments was higher (Con, 50.1; Org, 30.4; Int, 37.0 mg/kg) than the biodynamic treatment (BD, 19.1), and extractable P on the conventional treatment was greater than all other treatments ($P<0.05$).

Soil biology

There were no significant differences between treatments of wheat root infection by mycorrhiza, microbial biomass, microbial activity or earthworm populations.? However, some trends were apparent. Mycorrhiza infection of medic (*Medicago truncatulata*) roots were significantly less on the conventional treatment (20% of root length colonised) in 1996 compared to other treatments (org. 37%, BD. 34%, Int. 35%, $P<0.05$). Microbial biomass increased on the organic treatment with the first rains in the year following a green manure crop, and the integrated treatment had consistently less microbial biomass throughout the 1996 growing season. Cotton strip decomposition, used as a measure of microbial act- ivity, was also considerably less on the integrated treatment.

Soil structure

Soil aggregate stability, measured using simulated rainfall in the field (1992) and the laboratory (1996), showed the organic, biodynamic and conventional systems to trend towards more water stable soil aggregates than the integrated system.

System productivity

Productivity on all treatments was governed principally by weeds. Herbicide resistant ryegrass (*Lolium rigidum*) was prolific by 1993, requiring a change in weed management on the integrated and conventional treatments, while soursob (*Oxalis pes-caprae*) restricted yields on the organic and biodynamic treatments, delaying crop planting and presenting in-crop competition.

In 1996 wet winter conditions hampered mechanical weed control on the organic and biodynamic systems, delaying seeding and reducing seedling emergence, resulting in poor subsequent yields. Wheat protein measured in the common cropping years, 1992 and 1996, showed no significant differences between treatments (Table 2).

Table 2: Wheat yield and protein for the two common planting years, 1992 and 1996.

	Organic	Biodynamic	Integrated	Conventional
Wheat yield 1992 (t/ha.)	2.9	2.3	2.7	3.5
Wheat protein (%)	10.4	8.9	10.7	10.2
Wheat yield 1996 (t/ha)	1.4	1.8	3.8	4.3
Wheat protein (%)	11.2	11.3	11.5	12.1

Table 3. Total gross margins of 4 farming systems, 1989-1996

	Organic	Biodynamic	Integrated	Conventional
Gross income ($/ha)	1507	1901	2610	2833
Costs ($/ha)	612	597	1166	1099
Gross margin ($/ha)	895	1304	1444	1734

Economic performance

The most reliable income generating crop on the organic and biodynamic treatments was hay. For both wheat crops, a 20% premium above the standard market price applied to the organic and biodynamic systems.? Despite this, and considerably lower input costs, the higher production on the conventional and integrated systems resulted in higher total gross margins over the trial period (Table 3).

Discussion

Despite contrasting rotations, soil and tillage management being imposed on the four treatments, including a green manure crop, up to 5 tillage passes in 1 year for weed control and direct drilling on the conventional and integrated treatments, soil carbon was not affected. The result seems incongruous with those of Schultz (5) and Rovira (4) where frequent cropping coupled with conventional tillage practices led to significant declines in soil organic carbon. A difference may be that their "worst practice" treatment involved removal of all crop residues each year to simulate the burning of stubbles.? On this trial no treatment has been burnt over the 8 year period. However, the biodynamic treatment has produced two high yielding hay crops, removing 10.5 t/ha of organic matter from the system.

The reason for the significantly different soil available P levels is apparent in an audit of phosphorous applied compared with extracted from the soil as produce. The biodynamic (-10 kg/ha) and the organic plots (+16 kg/ha) both have considerably less net P than the integrated (+57 kg/ha) and conventional (+45 kg/ha) treatments.

The investigations of soil biology revealed reduced levels of microbial biomass and microbial activity on the integrated treatment. Rainfall simulation studied in 1992 measured 20% less infiltration on the integrated treatment. It is therefore expected this soil would have less air filled pore space, which is likely to reduce microbial activity and biomass.

Organic and biodynamic farming systems place a strong reliance on soil micro-organisms to transform and transfer plant nutrients from the soil to the plant roots (3). However, in this environment these systems did not make a significant impact on the soil biota measured in this study. Possibly, with a greater emphasis on pastures and green manures, improvements in the soil biology may have occurred, but the financial returns to pastures dictated otherwise.

Productivity was linked closely to weed control. Despite numerous non-chemical weed management strategies being employed on the organic systems, this remained a major yield constraint. Input costs were also considerably less without the use of herbicides, but the yield penalties did not offset this.

Conclusions

This research trial has shown the main difference in sustainability between organic and conventional systems is the increased productivity of the latter, which resulted in higher profitability. However, experience gained from this trial has provided insight into improving organic systems. Ley periods are essential in organic farming systems for weed control and nitrogen fixation. However, while the premiums for organically produced meat and wool remain elusive, pastures can be a financial liability. To overcome this it is suggested that green manures could take a much larger role in the rotation.? In addition, novel tillage, rotation and weed management systems will need further investigation and implementation to overcome present problems in weed control.

Nutrient supply, particularly P, remains a concern for organic farming. The potential of microbial activators, including some which are commercially available, to assist in increasing the plant uptake of non-acidulated phosphorous, requires further investigation.

Organic farming in Australia is unlikely ever to be adopted at the level of countries such as Denmark, Sweden and Germany although the opportunity exists to increase the market share for organic product to countries such as Japan and much of Europe. Surveys have shown farmers are requesting information about organic farming practices, because they recognise their incorporation into conventional systems may enhance the sustainability of those systems. To cater for this spectrum of clients, research into organic farming practices should be strongly supported.

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