Sustainability of organic broadacre cropping systems with respect to aspects of nutrient and energy flow

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Summary. There is currently widespread debate about the sustainability of Australian agriculture. Alternative systems such as organic farming have been suggested as one method of achieving sustainability. Much of this debate has centred upon defining sustainable Agriculture but definitions are of limited value in assessing agroecosystem sustainability. This paper proposes a number of criteria which could be used for the assessment of sustainability. Data were collected on the management systems of 18 organic broadacre farmers in south-east Australia. These data are used to assess the management systems with regard to two important characteristics of ecosystem and agroecosystem function, namely nutrient and energy flow.

Introduction

Debate over the sustainability of Australian agriculture has now become widespread including both agricultural scientists and the community at large. Much of this debate has centred on defining sustainable agriculture and a range of definitions has been offered. These range from prescriptions on the use of farm inputs, for example, no synthetically compounded fertilisers (9), through those highlighting the environmental, soil and socio-economic impacts (11) of the systems to very generalised aims for any agricultural system relating to maintenance of resource base and avoidance of damage to other ecosystems (15). While these definitions address some aspects of agroecosystem function and sustainability they ignore others. None offer methods for assessing the sustainability of agroecosystems.

Nutrient and energy flow are of central importance to the sustainability of any ecosystem. The management of these is critical to the sustainability of any agroecosystem. Plants in stable, mature ecosystems typically retain a large proportion of their nutrients within their living tissues by redistribution and reuse, thus preventing their loss from the ecosystem (16). This is in marked contrast to most agroecosystems. One feature of persistent agroecosystems (1), is their maintenance of cycles of materials and wastes through effective recycling practices. Auxiliary energy sources are one of the four key areas in which agroecosystems differ from natural ecosystems (10). These auxiliary energy sources, in the form of fuel, fertilisers and pesticides used in conventional farming ecosystems, are critical for achieving increased productivity.

Any assessment of sustainability of a particular agroecosystem will need to address the following criteria in detail: (i) the characteristics that are used as the basis for judging sustainability, for example, nutrient replacement; (ii) the boundaries or limits of the system or practice under examination, for example, a trial plot, an individual paddock, the whole farm, or the industry; (iii) the period of time over which the system or practice is to be judged, for example, the annual cropping cycle, over a rotation, period of debt repayment, or for future generations. This is necessary because a change in any of the above three factors can cause the assessment of a system or practice to change from sustainable to unsustainable or *vice versa.* Debate about the sustainability of any system is meaningless unless these criteria are specified.

Methods

A survey of organic, broadacre cereal and livestock producers was conducted in 1990 and 1991. The farmers wee located using organic certification organisations, the personal knowledge of the researchers and from referral by other farmers. The survey consisted of a farm visit and structured interview with the farmer to obtain information on the farming system. Each farmer was then left a questionnaire for completion which provided details of the farm resources.

Detailed information was provided on resources such as farm area, machinery available to each farmer and how these resources were used to operate the farm. Assessments of the sustainability of these farms was based on these data.

Results and discussion

Eighteen farms were surveyed. Six were located in northern NSW, three in central NSW and three in southern NSW. The remaining six were located in the Wimmera district of Victoria using regional definitions (2,8). A wide range of data was collected but only information relevant to the aims of the review is used here.

Table 1. Data for sixteen organic, broadacre farms.

State, region and farm no.	Farm area (ha)	Arable area (ha)	1990 crop (ha)	Last use of super-phosphate	Largest tractor (kW)	Sheep mob	Cattle numbers
New South Wales							
Northern 1	1215	810	363	Never	242	600	179
Northern 2	445	283	109	Never	75	450	Nil
Northern 3	2024	2024	1619	Never	147	Nil**	Nil
Northern 4	2496	1619	607	Never	234	Nil	Nil
Northern 5	1203	729	81*	1974	128	Nil	557
Central 1	3441	1822	777	Never	126	2000	Nil
Central 2	1073	1012	186	1988	75	5570	39
Southern 1	1093	749	194	1962	82	2700	134
Southern 2	405	389	48	1970	72	908	31
Southern 3	891	630	197	1954	90	1384	Nil
Victoria							
Wimmera 1	377	363	199	1980	75	1600	3
Wimmera 2	255	235	102	1987	57	720	Nil
Wimmera 3	520	508	287	1982	90	1415	Nil
Wimmera 4	696	623	129	1986	97	1500	Nil
Wimmera 5	781	727	274	1990	75	2822	Nil
Wimmera 6***	652	642	196	1986	75	1100	Nil

* Only 40% of usual crop area.
** Cropping enterprise only.
*** Cropping not all organic; sheep not organic.

Data for farm areas, arable area, stock numbers and previous fertiliser use are representative of broadacre stock/cropping enterprises found in south-eastern Australia. Date of last use of soluble fertiliser gives some indication of the time of conversion to organic farming. Nine of the farms now use fertilisers sourced from off-farm and include: rock phosphate; custom mixtures that include ground minerals, blood and bone, and manures; composted chicken manure; lime; dolomite; gypsum. Some recorded fertiliser rates are: chicken manure 240, 360 and 480 kg/ha; rock phosphate 50 to 180 kg/ha; mineral mixes 110 to 160 kg/ha. Two farms make no use of off-farm fertilisers, but both use green manure crops extensively in their rotations. One of these farms has parallel production of organic and conventional crops and uses a range of conventional fertilisers on some of the conventional crops. The main crops grown are cereals, predominantly wheat, but also barley, oats and rye.

Research on organic farming in Australia is hampered by the lack of information on the number of organic farms and details of their farming methods. Information on organic farms is not available from the usual sources of information such as ABARE and ABS. The exact numberof organic broadacre farms in Victoria and NSW is therefore unclear. Many of the problems of assessing the scale of organic farming have already been detailed (12). However, in the opinion of the authors, the 18 farms surveyed are likely to represent a large proportion of the organic broadacre farms in the regions surveyed.

The sustainability of these farms with respect to their nutrient and energy flows can be assessed with respect to their use of fossil fuel, fertilisers and system boundaries.

Fossil fuel use

All the surveyed farms depended on a finite fossil energy resource by operating diesel and petrol powered machinery. This dependence means that these farming systems are ultimately unsustainable in their present form. Conventional farms are equally as dependent on this finite fossil fuel, but an important difference between conventional and organic farming may be the rate of use of this resource. A system with reduced dependence on fossil fuel will deplete this resource more slowly. This will provide more time for the generation of alternative technology and such a system is likely to be more amenable to conversion to alternative technology.

No data were collected on individual farm fuel use but some assessments can be based on the area cropped on each farm and the size of the largest tractor (Table 1). Information from local agronomists indicated that the surveyed farms had below average areas of crop and, in general, smaller tractors. The reduction is most likely to be due to the reduced area of crop. On a per hectare basis the direct fuel use of organic farms is likely to be similar or higher than that of conventional farmers due to the reliance of organic farms on cultivation for weed control in the cropping phase of the rotation. None of the organic farms used herbicides for weed control. If the energy cost of pesticides used by conventional farmers is considered then the difference may be reduced. The use of legume fixed nitrogen by the organic farms represents a major energy saving given the high energy cost of nitrogenous fertilisers (6). The surveyed farms, in common with all farming systems in Australia are dependent on fossil fuel based transport systems for the supply of inputs and the export of produce.

Fertiliser use

Most of the farmers are using some form of fertiliser and this is contrary to views sometimes expressed (13,14). From the data collected it was impossible to establish if the loss of nutrients in produce exported from these farms was matched by the inputs of fertiliser. On the basis of a nutrient budget those farmers not using fertiliser must be depleting their soil nutrient levels and are hence unsustainable. It should be noted, however, that these farms are in areas and generally, with one exception (Kneipp, pers. comm.), on soils where the practice of cropping without the use of fertiliser is commonplace. The direct use of rock phosphate by some organic farmers and its indirect use by conventional farmers in the form of manufactured fertilisers such as superphosphate is another example of reliance on a finite resource. The organic farmers with their low levels of cropping are likely to be depleting this resource more slowly and are certainly saving some of the energy cost of manufacture. The sustainability of the sources of fertilisers and the maintenance of nutrient levels for all farmers leads to consideration of system boundaries.

System boundaries

Conway (3) proposed a hierarchy of agroecosystems ranging form the simplest such as an individual plant through to crop paddocks, regions, nations and ultimately the world. Conway points out that the behaviour of a farming system cannot easily be determined from the study of smaller component systems and *vice versa.* In discussions of sustainability, systems boundaries and positions in larger systems need to be carefully defined. In assessing the surveyed farms the appropriate system boundary is the farm, as this unit was the basis for data collection. If the maintenance of soil nutrient levels is used as a characteristic, then, those farmers not using fertilisers are unsustainable because they are not replacing nutrients exported in produce. Those farmers using fertiliser may be sustainable at the farm agroecosystem level. However, if the boundaries of the system are expanded and Australia is considered as the agroecosystem under scrutiny, a different conclusion may be drawn. Most of the Australian wheat crop is exported and the nutrients in these exports are lost from the agroecosystem. In addition, most of the nutrients contained in domestically consumed wheat are lost in urban waste disposal. It can therefore argued that on the basis of soil nutrient maintenance, Australia is not a sustainable agroecosystem as the level of nutrients lost is not restored by those imported as fertiliser (7). Thus it is possible for smaller agroecosystems such as individual paddocks or farms to be considered sustainable within larger agroecosystems which can be considered unsustainable. This argument can be extended by considering the world as an agroecosystem. On the basis of soil nutrient maintenance it could be argued that the nutrients have not been lost but merely redistributed and will ultimately be recycled. This, of course, is of little consolation if it is intended to maintain Australia as a sustainable agroecosystem and leads to a consideration of the time periods involved.

Time period used

The period for which sustainability is required can change according to individual circumstances. For example, a farmer hoping to sell a property and retire within a few years may well be happy with farming techniques unacceptable to one intending to pass the farm onto children and grandchildren. Anticipation of new technology could also influence the assessment of sustainability. For example, technology based on finite fossil fuels is unsustainable but may be considered sustainable if it is believed an alternative such as ethanol can be implemented before fossil fuels run out.

Where a new technology is assured a short time period may be acceptable. However, in general, the most appropriate time period is the indefinite future. On this basis the surveyed farms, along with most Australian agriculture, have to be considered unsustainable given their reliance on finite fossil fuel and mineral resources.

Conclusion

It is, of course, impossible to be absolutely certain of the sustainability of a particular system. A more correct claim would be that a system can only be considered sustainable in the light of the best available information. It is clear, from the data presented and on the basis of the chosen criteria, that the surveyed organic farming systems are not sustainable. However, this is not a reason to dismiss them as they are certainly no less sustainable than conventional farming systems and are probably using finite resources at a slower rate. They may well be both easier to make sustainable and already have some of the features, such *as* increased reliance on natural biological systems for nutrient supply, that will be part of sustainable systems. It must be noted, however, that the achievement of sustainability will not be possible by focussing attention solely at the level of the farm agroecosystem. Sustainable agriculture will only be possible when Australia as a whole is considered as a system. Many of the causes of agricultural unsustainability are related to the structure and demands of society itself. In an industrialised system like Australia, this will apply to any type of farming system, alternative or conventional, subsistence or market orientated (4,5).

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