Organic Farming: Should Government Give it More Technical Support?

Graham Marshall*

1. Introduction

The recent focus on sustainable development appears to have given organic farming a legitimacy in public debate it had previously lacked. In this paper, consideration is given to whether more of the research, extension and education services provided to agriculture by governments in Australia should be directed towards assisting farmers to profitably apply organic farming methods. The significance of this issue was highlighted by attendance at the 1990 Australian Organic Agriculture Conference, where on a number of occasions the view was stated that government is providing less technical support to organic agriculture than justified by its economic and environmental benefits. Wynen and Edwards (1990, p. 54) provide some support for this view. They concluded "there is reason to think economic efficiency would be increased by the allocation of extra resources to research and extension activities helpful to 'chemical-free' (ie. organic) farming".

2. The Characteristics and Significance of Organic Agriculture

As applied to a farming system, 'organic' means management of the system as a living organism, all components of the system being recognised as strongly interdependent (International Federation of Organic Agricultural Movements 1986). Advocates of organic farming systems argue the necessity of following ecological principles in the design of agricultural systems. The primary emphasis is on management of the fertility of the soil, defined broadly to encompass its physical, chemical and biological features. Considerable emphasis is placed on maintaining active biological systems in soil which perform important functions such as nutrient recycling (Williams 1989). Proponents suggest that the increased 'health' of plants grown on a fertile soil reduces their susceptibility to predation by pests and increases their nutritional value (Haupt 1990). There is some evidence from feeding experiments that organically-produced food is preferred by livestock and is associated with greater weight gain and faster recuperation after illness (Plochberger 1989). Organic methods of soil management, and complementary cropping and livestock husbandry practices, are also claimed to control populations of weeds, pathogens, insects and parasites which would otherwise reduce agricultural productivity (Haupt 1990). (The aforementioned problems will hereafter be summarily referred to as pests.)

Application of artificial chemicals is precluded from organic agriculture, at least for farmers seeking to have their farms certified by one of the organic groups (Organic Produce Advisory Committee 1991). Proponents of organic agriculture stress that it is not only absence of use of artificial chemicals that signifies an organic system but rather the presence of farming techniques that facilitate successful pest and soil fertility management without recourse to artificial chemicals.

Hassall and Associates (1990) estimated that there were 1,513 commercial organic producers operating in Australia at the end of 1989 (ie. 0.8 per cent of all farmers) and that the total area farmed organically was between 117,000 and 340,000 hectares (ie. between 0.1 and 0.2 per cent of total farm area

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excluding the pastoral zone). The rate of increase during the 1980s of the number of organic farmers in Australia was estimated to have been 22 per cent per annum. It was also estimated that 71 per cent of current organic producers were predominantly involved in horticulture, 15 per cent in livestock and 14 per cent in broadacre cropping/livestock. Of the total area farmed organically, 68 per cent was estimated to be accounted for by broadacre cropping/livestock farms, 22 per cent by livestock farms and 10 per cent by horticultural farms. Total domestic market sales of organically produced food in 1989/90 were estimated to be between $35 million and $45 million (not including 'informal' sales which could be 30 per cent of the organic produce market). This represented 0.2 per cent of total domestic food sales at that time.

Organic agriculture can be viewed as lying at one end of an array of 'alternative' farming systems defined as "alternatives to current farming systems that tend to have a high degree of specialisation. The current systems emphasise high yields which are achieved by major inputs of fertilisers, pesticides and other off-farm purchases" (United States Secretary of Agriculture quoted in O'Connell 1990, p. 456). Hence, farmers choose not only between organic farming systems and systems highly dependent on agricultural chemicals, but from a range of farming systems varying in the extent to which use of agricultural chemicals is integral to system productivity. Not only those fully adhering to organic farming principles use techniques allowing reduced use of agricultural chemicals. For instance, a study by the Victorian Department of Agriculture and Rural Affairs (cited in Hassall and Associates 1990) found that five per cent of respondents believed they used organic farming practices 'a great deal', 17 per cent 'a fair amount' and 46 per cent 'a little'. This parallels the finding of Buttel *et al* (1986, p. 60) that "significantly more US farmers than those self-identified as 'organic' farmers or 'alternative agriculturalists' manage to get along without relying heavily on agrochemicals". Thus the use of 'conventional' in previous studies to classify all farmers other than those practising organic systems has little value in framing analysis or policy debate regarding changes that are, or should be, occurring within Australian farming practice.

3. The Optimal Size of Organic Agriculture

An economic efficiency perspective

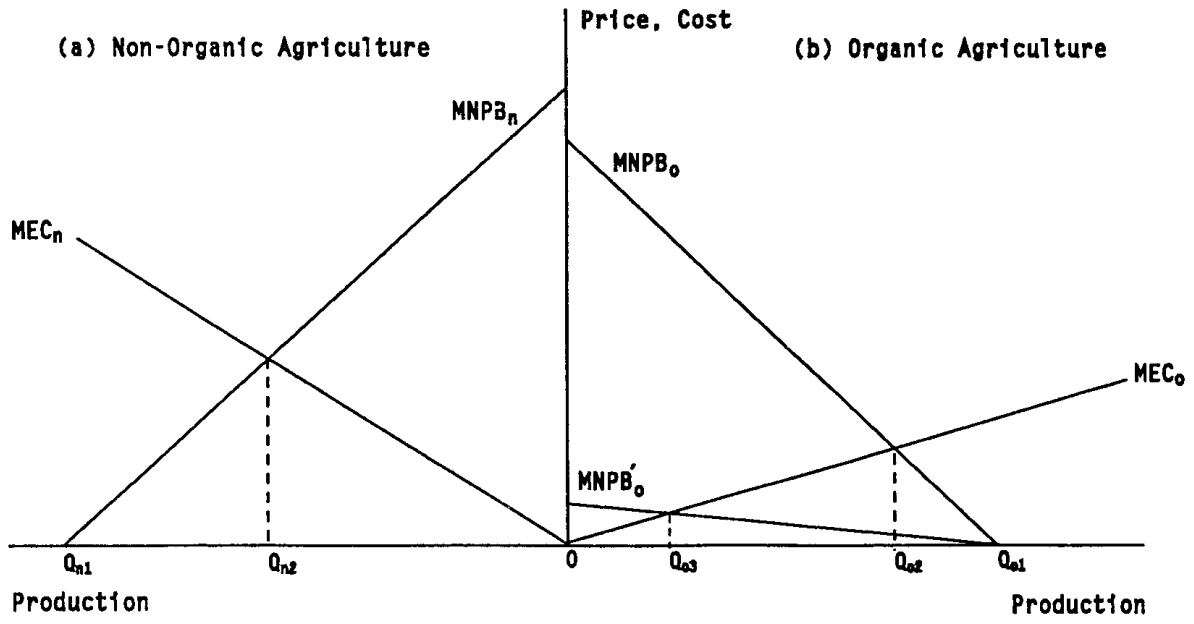
Wynen and Edwards (1990, p. 39) concluded that "a favourable change in net externalities could be expected from a movement towards chemical-free (organic) farming". This raises the question of whether successful government intervention to internalise externalities would result in an increase in the share of total agricultural production accounted for by organic agriculture.

The economically efficient pattern of production is that in which the net social benefits of production from each farming system, at the margin, are equal. Farmers, however, are likely only to consider net private benefits when choosing between farming systems and to ignore externalities. The implications of this for the pattern of production from organic and non-organic farming systems are demonstrated using Figure 1.

The marginal net private benefit schedules for organic and non-organic agriculture are shown respectively as $MNPB_o$ and $MNPB_n$. Farmers in aggregate increase production from each farming system until marginal net private benefit declines to zero. Hence the market-determined levels of production from organic and non-organic agriculture are Q_{o1} and Q_{n1} respectively. The marginal external cost schedules for organic and non-organic agriculture are shown as MEC_o and MEC_n respectively. Note that organic agriculture is assumed to have lower external costs than non-organic agriculture at equal levels of production. The marginal net social benefits of organic and non-organic agriculture are equal, and thus economic efficiency is attained, when the marginal net private benefit of production from each equals marginal external cost (Pearce and Turner 1990). Hence social welfare is maximised by reduction of organic production from Q_{o1} to Q_{o2} and reduction of non-organic production from Q_{n1} to Q_{n2}.

Note that these marginal net private benefit schedules have been drawn with the same slopes. Thus equal production declines result in equal losses of net private benefits from organic and non-organic

Figure 1: Optimal Levels of Organic and Non-Organic Production



agriculture. Hence the economically efficient production decline (in absolute terms) is greater in the case of non-organic agriculture due to the associated greater saving in external costs. Although internalisation of external costs here results overall in reduced production, it results in an increase in the proportion of overall production derived from organic agriculture.

It is theoretically possible, however, that the relative slopes of the marginal net private benefit schedules may be such that equal production declines for the two classes of agriculture result in non-organic agriculture experiencing a sufficiently greater loss of net private benefit compared with organic agriculture that it outweighs the greater saving in external costs from reducing non-organic production. In that case, internalisation of external costs results in the absolute production decline being greater for organic than non-organic agriculture. This scenario is illustrated in Figure 1 by changing the marginal net private benefit schedule for organic agriculture to MNPB$_o'$. Internalisation of external costs now causes a greater reduction of organic production (from Q_{o1} to Q_{o3}) than of non-organic production (again from Q_{n1} to Q_{n2}).

Given a perfectly competitive market (so that marginal net private benefit equals output price minus marginal private cost), this possibility arises only if the slope of the marginal private cost schedule for non-organic agriculture over the relevant production range is sufficiently steeper than that of organic agriculture. In the absence of any empirical evidence that this is the case or of a theoretical basis for expecting it to be so, it is reasonable to conclude that, if external costs are indeed lower for organic than non-organic agriculture, internalisation of external costs would increase the share of total agricultural production accounted for by organic agriculture. However, for this shift to be optimal in the sense of increasing social welfare, the marginal social benefits from the shift must exceed the marginal social costs of effecting the shift, includ-

ing transaction and enforcement costs and any costs arising from government failure.

A sustainable development perspective

The conventional definition of economic efficiency relates to an aim of maximising the welfare of current generations. In contrast, advocates of sustainable development include the welfare of future generations as one of their major concerns. Resource depletion by current generations can be viewed as imposing negative externalities on future generations, for example by increasing future extraction costs or by requiring more expensive substitutes to be used. Investment by current generations of financial surpluses accumulated from resource depletion can equivalently be seen as bestowing countervailing positive externalities on future generations.

Net externalities incurred by future generations could hypothetically be represented in Figure 1 by pivoting the respective marginal external cost schedules appropriately. Whether organic agriculture (through, perhaps, conserving natural resource stocks to a greater extent) or non-organic agriculture (through, perhaps, generating greater financial surpluses to be invested in man-made resource stocks) is likely to yield the greater (or less negative) net externalities for future generations is an empirical question unable to be addressed here. If, for the sake of illustration, the net externalities for future generations were expected to be greater from organic than non-organic agriculture, their inclusion would result in an increase of the slope of MEC_n relative to MEC_o. Internalisation of externalities for both current and future generations would then result in organic agriculture increasing its share of total agricultural production to a greater degree than if only those externalities for current generations were internalised.

4. Economic Efficiency and Government Provision of Technical Support to Organic Agriculture

Wynen and Edwards (1990, p. 51) suggest that organic farming may be 'under-researched' relative to the mainstream farming systems. This is based on their observation that mainstream (chemical-using) types of farming rely to a greater extent on purchased physical inputs than does organic farming which relies to a greater degree on inputs of knowledge (know-how). A more general observation can be made: organic farming relies on self-regenerating 'inputs' (including know-how and ecosystem service flows) to a significantly greater degree than mainstream farming systems which rely to a greater extent on non-self-regenerating inputs (including agricultural chemicals). While the likelihood of being able to gain enforceable property rights over non-self-regenerating inputs resulting from research is high, this is less likely to be true for self-regenerating inputs resulting from research. Non-exclusivity of many types of self-regenerating inputs means that the private sector will undertake less research to generate these types of inputs than is economically efficient.

However, while it is clear that government intervention is necessary to ensure an economically efficient level of research directed at producing self-regenerating inputs, it does not follow that the degree of reliance of a farming system on this type of input should govern the allocation of public research resources between different types of farming systems. Economic efficiency requires that available public research resources be allocated between farming systems such that the expected net social benefits from the allocation to each system are equal at the margin. The hypothesis that organic farming is 'under-researched' relative to the more mainstream farming systems is based then on a presumption of government failure to allocate an economically efficient level of research resources to research directed at generating self-regenerating inputs of the type used in organic agriculture. This presumption requires empirical evaluation.

Wynen and Edwards (1990) argue that the resource misallocation effects of externalities arising from use of chemicals in agriculture and underpricing of health services should preferably be corrected by policies directly removing the cause of the externalities. They argue that if this is not possible, additional research directed at reducing externalities in mainstream farming systems as well as at increasing the productivity of organic farming sys-

tems may be justified on second-best economic efficiency grounds. However, the economically efficient allocation of these additional research resources between attempting to reduce externalities from chemical use and attempting to improve the productivity of organic agriculture would again be according to the expected marginal net social benefits from each.

In any case, research resources are allocated to solving specific problems rather than to particular farming systems. Given the virtually infinite range of problems apparent at any time, the task is to allocate available research resources between problems, as well as between possible solutions. The expected net social benefit from allocating research resources to solving a particular problem depends on a range of stochastic factors including cost of research and size and timing of net private benefits and net external benefits from a solution. It is apparent therefore that there is no a priori case, on either first or second best economic efficiency grounds, for governments increasing allocation of research resources to problems of particular significance to organic farmers. An empirical approach is required for each allocation decision.

The above arguments apply equally to the question of whether government should provide greater levels of other types of technical support (eg. extension and education) with respect to problems of particular significance to organic agriculture.

5. Predicting the Future of Organic Agriculture

Altieri (1990) proposes that economics can provide an understanding of why certain agricultural systems become predominant and why they are replaced over time by other systems. Prediction of the future level of adoption of a type of farming system is integral to estimating the expected net social benefit from allocating public technical support resources to a problem of particular significance to that farming system. Hence an overview of some socio-economic and technological trends considered relevant to future adoption of organic agriculture is presented in this section.

Increasing understanding of agricultural ecology

Understanding of ecological processes has improved greatly since chemical-reliant agricultural systems began to predominate, and seems likely to continue to do so. Hence, ecological methods of pest control and soil fertility management are becoming increasingly feasible. James (1991, p. 52) claims, however, that the rate of progress in ecologically-based pest control programs "will be slow unless research resources are substantially increased". Pimentel (1985) claimed that the estimated average return per dollar invested in biological control in the United States was about $US30. If rates of return in Australia are of a similar magnitude, it may be expected that public funding in Australia of ecology-based pest control will expand significantly in the future. Opportunities for profitable organic farming will thereby be enhanced.

Development of new weed management options

Strategies for weed management are increasingly being developed which do not require application of herbicides, and which also avoid the problems of soil structure decline often associated with tillage (Morgan 1990; Geier 1990). Tillage technology has been developed which causes considerably less soil disruption. Alternative techniques are also available, such as those applying heat or electrical pulses to weeds. Use of rotations, mulches and allelopathic relationships between different plant species are among the other non-chemical weed management strategies available.

Increasing pest resistance to biocides

Pest resistance to herbicides, insecticides, veterinary chemicals etc. (biocides) has become a substantial problem for farmers relying on them. The resultant shortening of the economic life of agricultural chemicals means that the fixed costs of developing, registering and marketing a product are spread over less aggregate units sold, so that farmers must be charged a higher price than if onset of pest resistance were less of a problem. An option for farmers experiencing pest resistance is to rotate their use of biocides, and their application of other pest management techniques, in order to prevent a

build-up of pest resistance. However, this is likely to entail increased time and/or cash costs for farmers (for example in monitoring pest and predator numbers if integrated pest management is used) and increased investment of their time in learning the more complex chemical-control strategies.

Increased interest in maintaining agricultural productivity of soils

From an examination of historic trends in Australian wheat yields, Williams (1989, p. 173) concluded that "gains in productivity through improved agronomy and plant breeding are barely keeping up with the deteriorating soil fertility" where the definition of soil fertility encompasses its physical, chemical and biological characteristics. He notes evidence in Murray-Darling Basin Ministerial Council (1987) that, of the various forms of land degradation, soil structural decline has been the major contributor to reduced agricultural productivity and argues that this has been due to depletion of organic matter in soils.

Farming systems which maintain organic matter levels in soils that maintain soil structural stability can ameliorate soil structural decline. The traditional means of maintaining soil structure, inclusion of legume-based pasture leys in rotations, has been identified as contributing to soil acidification (Williams 1989). Minimum tillage and stubble management has been found to make a substantial contribution to maintaining soil physical condition in some soil types, but its increased reliance on agricultural chemicals raises concerns regarding the ecological effects of these chemicals (Williams 1989). Moreover, Uren (1991) notes that, despite increased use of fertilisers and biocides in minimum-tillage systems, it has been the experience world-wide that yields are not increased relative to conventional-tillage systems. Organic agriculture, which emphasises the building-up of organic matter levels in soils and prohibits use of agricultural chemicals, therefore appears likely to attract increasing interest.

Increasing concern over off-site effects of soil erosion

Soil erosion leads to a range of off-site problems including sedimentation of stream beds and turbidity and nutrient loading in streams (Murray-Darling Basin Ministerial Council 1989). There have been a number of studies estimating the on-site costs of agricultural land degradation (eg. Murray-Darling Basin Ministerial Council 1987; Thorne and Watkins 1991; Woods 1984). However, estimation of off-site costs of agricultural land degradation has been a neglected field in Australia. In one of the few studies of this type, Russell *et al* (1990) estimated that average annual additional public expenditure on road maintenance, water treatment, dredging and railway maintenance attributable to off-site effects of soil erosion in Queensland was $31.3 million (1988 dollars). These authors considered that damage costs where no remedial action was taken, including degradation of aquatic ecosystems, were potentially greater than the above sum. However, valuation of these costs is seriously handicapped because "our depth of understanding and monitoring of ecological damages is appallingly low .." (Russell *et al* 1990, p. x).

Studies in the United States indicate that soil erosion from agricultural land is much more of an economic problem in terms of its contribution to off-site surface water pollution (sediment deposition and nutrient loading) than in terms of its impact on agricultural productivity. It has been estimated that in the United States the former cost exceeds the latter by two to eight times (United States Department of Agriculture 1987). Crosson and Brubaker (1982) found that soil erosion was the major threat to the United States environment posed by projected levels of crop production and land use. The extent to which this is also true in Australia, with a much lower population density, is unclear.

Reganold (1991) demonstrated that rates of soil erosion on organic farms can be considerably lower than on chemical-using farms. Increasing community recognition of the soil erosion problem is therefore likely to further encourage interest in organic farming practices.

Increasing concern over environmental and health effects of agricultural chemical use

A significant proportion of chemicals applied for agricultural purposes are transported from farms

by processes including soil erosion and surface and sub-surface drainage. For example, Phipps and Crosson (1986) estimated that in the United States between 50 and 70 per cent of all nutrients, principally nitrogen and phosphorous, reaching surface waters, originate on agricultural land in the form of fertiliser or animal waste. There is Australian evidence that in areas of high nitrogen application, as much as 25 per cent is lost through deep drainage and leaching to groundwater, streams and water storage reservoirs (Williams 1989).

Little research has as yet been directed to levels of pesticide residue accumulation in the Australian environment (Bureau of Rural Resources 1989). The Australian Science and Technology Council 1989, p. 1) found that ".. chemical residues in agricultural produce are not an undue health hazard to consumers of Australian agricultural produce..". Regardless of the state of scientific evidence, however, a considerable proportion of Australians is concerned over the use of agricultural chemicals. It has been suggested that this is due to increased availability and improved dissemination of information regarding the long term adverse effects on consumer health of some agricultural chemicals (Australian Bureau of Agricultural and Resource Economics 1989).

In a recent Australian survey, 82 per cent of those interviewed stated they would prefer to buy food which had no chemicals used in its growing or preparation, even if it cost more (Irving Saulwick and Associates 1989). If consumer research in Europe is used as a guide, the early concern of consumers is with health aspects of food including levels of chemical residues. However, over time the concern for how the production of food affects the environment and the quality of life for livestock increasingly influences product choice (Holden 1990). It is likely that the finding of Clarke (1988) that the Victorian market for organically-produced food appears to be expanding rapidly can be attributed to such concerns.

The willingness of consumers to pay substantial price premiums for organic produce is further evidence of community concern regarding chemical use in agriculture. Hassall and Associates (1990) found that the size of price premiums depended on the degree of difficulty, given existing technology, in producing various items organically. Typical retail price premiums for organic produce sold in Sydney were found to be 30-40 per cent for fruit and vegetables, at least 25 per cent for wholefoods (grains, flours, nuts, pulses etc.), 30-50 per cent for beef and lamb and 80-100 per cent for chicken meat. The size of these premiums may also reflect the infancy of the organic produce industry, and particularly lags in supply response because of the need for farmers to learn organic farming methods and become certified as organic before they can take advantage of existing premiums.

These concerns are also reflected by increasing political pressures for policies taking greater account of environmental and health costs of chemical use in agriculture. Pressure is increasing for deregistration of agricultural chemicals containing ingredients associated with health problems. A referendum was held in 1990, (the 'Big Green Initiative') which if successful was likely to have resulted in over 50 per cent of agricultural chemicals being banned in California within five years (Pollock and Fowler 1990). Closer to home, the Australian Democrats (1990) have committed themselves to reducing use of agricultural and veterinary chemicals.

Application of the 'polluter pays principle' with regard to agricultural chemical use has also been receiving increasing attention. The economic efficiency implications of taxing artificial fertilisers and pesticides are discussed by Wynen and Edwards (1990) and Australian Bureau of Agricultural and Resource Economics (1989). The Australian Conservation Foundation has recommended that the Federal Government "investigate the possibility of a targeted chemical herbicides and fertilisers tax, and other measures designed to reduce the use of agricultural chemicals in favour of less damaging alternatives" (Cameron and Elix 1991, p. 217). The Australian Democrats (1990) have called for an agricultural chemicals tax in order to provide funding to support farmers using chemical-free or reduced chemical farming practices.

Increases in regulatory control of agricultural chemical use have also occurred in some countries. In some states of the United States, requirements have

been introduced for farmers to be registered before being able to purchase certain agricultural chemicals and for their purchase to be on a 'prescription' basis, somewhat similar to the case for pharmaceutical products. In Denmark, additional regulation of biocide use was introduced in 1986, requiring a 50 per cent reduction in total biocide use by 1997 and compulsory 'spraying certificate' training for farmers. The Netherlands Government has stated its intention to regulate rates of fertiliser application to match the rate of plant nutrient uptake (Cameron and Elix 1991).

Possible lower investment in development of new generations of biocides

The trends identified in the preceding subsection suggest that international demand for biocides will increase more slowly than in the past, or even decline. Slower market expansion for biocides may lead to curtailment of investment in developing new generations of biocides and diversion of resources to developing pest management products perceived to have lower environmental and health impacts, especially where property rights to these products can be established and enforced. Reduced global allocation of resources to biocide innovation may thus occur regardless of Australian policies with respect to chemical registration and use. Note that this may in fact be detrimental for environmental and health improvement if opportunities to substitute new biocides for more harmful ones currently in use are foregone (Australian Bureau of Agricultural and Resource Economics 1989).

Increasing opportunity for private R & D of biological agents and natural compounds

Chemical compounds emitted by plants reducing their vulnerability to weeds, insects or pathogens (known as allelochemicals) have been identified. Similarly the potential for microorganisms to contribute to biological control programs has been realised with development of mycoherbicides. These are examples of products of biotechnology which can be harvested directly or mimicked synthetically (Lovett 1990). Since these products are non-self-regenerating and techniques of harvesting or synthesising them are likely to be patentable, the profitability of their research and development will be considerably greater than has been the case for most biological control 'products' in the past. Commercial opportunities may therefore encourage a substantial increase in private research and development regarding biological agents and natural compounds, with the result that farmers will have greater options for successfully implementing organic farming.

A related issue concerns research and development of genetically-engineered livestock and agricultural plants designed to increase their tolerance to, or competitiveness with, pests and thereby reduce the need for biocides. While it is clear how crop plants genetically-engineered to be herbicide-tolerant contravene organic principles, it is less clear where increased tolerance to or competitiveness with pests is the outcome. However, genetically-engineered material cannot be used on farms seeking to be certified in Australia as organic (Organic Produce Advisory Committee 1990). The outright prohibition on use of genetically-engineered material appears largely to stem from an observation that "the list of the top ten biotechnology companies in the world includes all the names well known for agri-chemicals ... Many of these companies are now associated with the major seed companies" (Guard and Guard 1990/91, p. 4). Rather than seek to reduce reliance on biocides, these authors' belief is that the objective of these companies is "to marry fertilisers, herbicides, pesticides and the very crops themselves, to be obtained as a package from the same company" (p. 4).

In economic terms, the argument is that economic inefficiency in biocide use will occur not only because of the existing specification of property rights, which includes the right of farmers to generate external costs associated with agricultural use, but also because of the potential for these companies to considerably increase their market power.

The implications of genetic engineering for the future competitiveness of organic agriculture in Australia will depend on a number of factors. These include the final form of regulation (by government and self-regulation) of the genetic engineering industry, the manner of government involvement in genetic engineering research and the willingness of

those determining organic certification criteria to permit use of genetically-engineered materials shown to "contribute to long-term ecological sustainability and the maintenance of biological diversity" (Phelps 1991, p. 10).

Increasing incentive for extension of solutions developed by public research agencies

As discussed in Section 4, research directed at providing self-regenerating inputs as solutions to agricultural problems has largely been the province of the public sector. To the extent that these types of solutions are substitutes for solutions involving chemical use, the public and private sectors can be viewed as competing for a share of the 'solutions market'. However, a not uncommon view is that public agricultural research agencies have traditionally 'under-marketed' the solutions they develop. This suggests that allocation by these agencies of resources between research and extension according to the equi-marginal net benefit principle would have resulted in significantly greater allocation to extension than has been the case. Moreover, the lack of a profit-imperative in these agencies suggests that the rate of adoption of marketing innovations has been lower than would have been economically efficient. It is considered likely therefore that solutions involving self-regenerating inputs would have been adopted to a greater degree if these types of government failure had not occurred.

Recent trends in Australia toward increasing commercialisation of the public sector and integration of extension into research programs may reduce this kind of government failure to some extent. In addition, the intricacy of the know-how required to effectively implement many solutions involving manipulation or supplementation of ecological processes is likely to limit the number of farmers able to apply them independently. For example, firms have been established to advise farmers regarding the fine detail required to apply Integrated Pest Management. Public research institutions may therefore be increasingly able to extract returns from educating farmers or consultants regarding the know-how required to apply solutions. This may increase the allocation of public research resources to developing ecologically-based solutions and thereby increase the scope for profitable organic farming.

Tightening export market standards for agricultural chemical residues in foods

Farley (1990) suggests that reduced agricultural chemical use in Australian agriculture is likely to become increasingly desirable for ensuring continuing access to export markets. For example, he hypothesises that if the General Agreement on Tariffs and Trade succeeds in dismantling the more visible devices the European Community uses to protect its agricultural sector from imports, a subtle shift to using chemical residue standards to discriminate against imports would occur. In this eventuality the competitiveness of organic farmers within exporting industries would increase.

Termination of fertiliser subsidies

The longstanding Australian policy of subsidising the use of phosphatic and nitrogenous fertilisers was terminated in 1988. Since organic farmers did not receive a subsidy for their alternative methods of fertilising the soil (eg. rock phosphate, compost or inclusion of pastures and livestock in rotations) they had been disadvantaged compared to other farmers during this period (Wynen and Edwards 1990).

Proposals for government assistance for farmers converting to organic farming

Government subsidisation of farmers converting to organic systems has attracted increasing interest in recent years. In Europe there has been a move toward 'extensification' of the agricultural sector to reduce surplus production and thereby reduce economic inefficiencies associated with the Common Agricultural Policy. One way of achieving this, recently applied in West Germany and in Finland and scheduled to have been introduced in the United Kingdom in mid 1991, is to subsidise conversion of farmers to organic systems of production. This is because it is expected that conversion leads to a fall in production. Locally, the Australian Democrats (1990) support the provision of incentives to farmers to convert to agricultural methods associated with lower environmental costs.

The Australian Conservation Foundation has recommended that the New South Wales Government "make grants available to farmers who have a plan for conversion to low-input farming that has been approved by extension officers with expertise in low-input farming" (Cameron and Elix 1991, p. 215). Although the economic case for conversion assistance in Australia has been stated to be weak (Wynen and Edwards 1990), the introduction of such assistance due to other rationale would be likely to increase adoption of organic farming techniques.

Evidence that organic farming can be financially competitive with other farming systems

Wynen and Edwards (1990, p. 54) concluded on the basis of a farm survey that "private financial net benefits from chemical-free (organic) livestock/cereal farming in a steady-state situation in parts of south-eastern Australia could be similar to those from conventional farming". The estimate by Hassall and Associates (1990) of a 22 per cent per annum rate of increase in the number of organic producers during the 1980s provides evidence at least of an increasing perception that organic agriculture can be financially viable.

Conclusion

This discussion of socio-economic and technological trends has indicated a number of factors contributing to increasing incentives and opportunities for farmers to adopt organic farming practices. Hassall and Associates (1990) suggest that future relative production shares accounted for by organic producers will be greater for those products which are easier to produce organically. Products identified as easy or very easy to produce organically included oats, oilseeds, citrus, stone fruit (in areas free from fruit fly), milk, grapes, nuts, bananas, pumpkins, strawberries and kiwifruit. Their mid-range forecast for the number of organic producers in Australia in 1999 was 7,801 producers (5.1 per cent of all producers excluding those in the pastoral zone), accounting for 3.2 million hectares (2.5 per cent of total agricultural area excluding the pastoral zone). Looking further into the future, however, genetic engineering is likely to have a significant influence on whether, on balance, the competitiveness of organic production will increase or decline. The direction of this influence may depend importantly on future developments in government regulation of the genetic engineering and agricultural chemical industries, on the role the public sector assumes in undertaking genetic engineering research and on the future flexibility of organic farming certification criteria with respect to use of genetically-engineered materials.

6. Research Areas for Agricultural Economists

Economists can assist public institutions to efficiently allocate their technical support resources between organic agriculture and other farming systems. In this section a number of economic research areas relevant to this issue are discussed briefly.

Benefit-cost comparisons of research into chemical and non-chemical techniques

Current public research programs are variously targeted at developing (or refining) chemical and non-chemical solutions to agricultural problems. Benefit-cost case studies of selected 'chemical' and 'non-chemical' research programs would be useful in indicating the magnitude of returns that can be expected from each type of program, and in identifying the circumstances where one type of program is likely to yield higher net returns than another.

Estimation of external costs of different farming systems

Research is required to verify the hypothesis of Wynen and Edwards (1990, p. 39) that "a favourable change in net externalities could be expected from a movement towards chemical-free farming". A useful starting point would be their categorisation of "benefits and costs of a movement from conventional to chemical-free farming" (p. 41). Measurement of external costs of chemical use in various situations also has a value in evaluating cases for government intervention intended to result in convergence of privately and socially optimal rates of chemical use.

Assessment of wider implications of a shift toward organic agriculture

A shift toward farmer adoption of organic farming practices may be associated with broader changes in the agricultural sector. An appreciation of these changes is necessary for assessing the case for government intervention, including by technical support, to influence the rate of adoption of organic agriculture. An example of a study examining the macro-implications of a shift toward adoption of organic agriculture is that of Langley *et al* (1982). Buttel *et al* (1986) provided a critique of this and similar studies.

Financial analysis of organic farming systems

Financial analysis of organic farming systems can assist public institutions to verify the viability of organic farming and thereby the likelihood of significant demand for technical support relating to organic farming practices. It can also assist identification of the types of technical support having the greatest scope to improve the financial performance of organic farming systems. The method of analysis needs to recognise that organic farming systems are designed to exploit complementary relationships between components of the system to a considerably greater degree than systems using chemical inputs. This is particularly relevant for financial comparisons of chemical and ecologically-based solutions to the same problem. A valid analysis will often require comparison of systems of techniques rather than of individual techniques.

Financial analysis of strategies for conversion to organic agriculture

During the process of conversion to an organic system yields are likely to be relatively low because farmers are unfamiliar with the new management techniques. Moreover the ecologically-based productivity benefits of an organic system can take considerably longer to materialise than the problems that arise with sudden disuse of the chemicals upon which the previous system had depended (Wynen and Edwards 1990). Hassall and Associates (1990) identified this as an area in which economic studies could contribute towards solutions for farmers. An important role would be in evaluating alternative strategies for converting to organic systems.

Modelling individual choice of farming system

As the agricultural economics profession has largely been established in a period during which technology embodied in agricultural chemical inputs considerably reduced the level of system-management skill required for farmers to operate profitably, it is perhaps understandable that the economic significance of this skill has been overlooked. Agricultural production economics has been concerned mainly with farmer choices of input and output combinations, with system-management skill taken as given. These choices are in fact influenced by choice of farming system, which is in turn influenced by farmer propensity to acquire and apply system-management skill. In this sense, the choices typically analysed in agricultural production economics are third-level choices. With the need for a whole farm systems approach to agricultural research, extension and policy increasingly being recognised, there is a corresponding need to develop a theoretical basis for analysing individual choice of farming system. This framework can then be applied empirically, for example regarding the effects of government policy changes and technological innovations on rates of adoption of organic and other types of farming.

7. Conclusions

Organic farmers can be viewed as being at one end of a spectrum along which lie farming systems differing in the extent to which agricultural chemical use is integral to their productivity. If in fact organic agriculture does result in lower external costs than types of agriculture using chemicals, then internalisation of external costs is likely to result in organic agriculture accounting for an increased share of total agricultural production. However, government intervention designed to internalise external costs will increase social welfare only if the allocative efficiency gains realised exceed the full costs of the intervention.

Government can effect a convergence toward an economically efficient pattern of farming system adoption in two main ways. Firstly, it can modify

the institutional and policy environment so that incentives to individuals are consistent with this convergence. Secondly, it can provide technical support which has public good characteristics. This paper focussed on the latter option, particularly on the question of whether there is a case on economic efficiency grounds for government increasing the level of resources allocated to technical support benefiting organic agriculture.

The relatively high degree of reliance of organic agriculture on self-regenerating inputs, the research, development and extension of which has public good characteristics, does not in itself suggest that the current level of allocation of public resources to technical support of organic agriculture is lower than economic efficiency would dictate. This will be the case only to the extent that government has failed to redress this form of market failure. Thus there is no a priori case on first-best economic efficiency grounds for government increasing the level of technical support it provides to organic agriculture. This question can only be answered by determining the extent to which this form of government failure is occurring.

If political or practical considerations are likely to continue to prevent government intervention which aims to reduce external costs associated with agricultural chemical use and underpricing of health services, there may be a second-best economic efficiency argument for increasing the level of public technical support aimed at reducing the external costs of agricultural chemical use. However, the degree to which it follows that those resources should be allocated to organic agriculture rather to reducing external costs of chemical use in other types of agriculture can only be determined empirically.

A number of factors were identified as contributing to increasing incentives and opportunities for farmers to adopt organic farming practices. However, the influence of genetic engineering on the future competitiveness of organic agriculture is unclear at this stage. The direction of influence will to a large extent depend upon the way that government intervenes in the genetic engineering and agricultural chemical industries and upon the way the certification criteria for organic agriculture evolve to accommodate products of genetic engineering. Undertaking analyses which assist prediction of the future pattern of adoption of farming systems is one of the roles agricultural economists can perform to assist government to efficiently allocate resources to technical support for organic and other types of farmers.

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