WORKING PAPER 475

SOIL CONSERVATION AND FUTURE AGRICULTURAL PRODUCTION : THE RELEVANCE OF BIOLOGICAL TECHNIQUES

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INTRODUCTION

This paper is not a review of existing soil conservation techniques but is concerned with soil conservation within the broad framework of environmental and biological conservation. A number of issues relating to modern agriculture and society will be introduced which it is hoped will sooner rather than later help shape a conservation strategy for agriculture as a whole. Various kinds and levels of commitment to a conservation philosophy within agriculture will be identified, the benefits of which could be widely felt, not least in the condition of our soils. The paper is directed at agriculture in the developed West with emphasis on Europe and the U.K. but the ideas themselves are intended to have wider application.

THE CURRENT VIEW OF SOIL CONSERVATION

Soil conservation as currently perceived has different types of emphasis depending on the circumstances of climate, topography and land use but for the majority of us it will mean the prevention of soil erosion or, more precisely, the reduction of accelerated topsoil removal by the agencies of wind and water (Hudson, 1971; Morgan, 1985). It implies, at the very least, the adoption of strategies for inhibiting the movement of soil particles and their unwelcome arrival elsewhere. Some soil conservation measures are thus solely aimed at containment. Falling into this category are the creation of soil surface roughness, contour ploughing, terracing and strip cropping together with use of wind breaks or shelterbelts, for these measures help maximise infiltration and reduce surface wind velocity. Ensuring an adequate crop leaf area can also be an important strategy in areas where the bulk of precipitation occurs within the crop's own growing season (Hudson 1971; Morgan, 1981).

Yet the susceptibility of soil to erosive loss depends largely on the existence and stability of structural aggregates. Over the great majority of soil textures, structural stability is dependent upon humic substances of high molecular weight deriving from the decomposition of organic matter by soil micro-organisms. These I shall return to later; for now we should note that further, well-established soil conservation measures are more obviously agronomic. These include stubble mulching and minimum tillage practices which, while helping to promote higher

equilibrium levels of organic matter, are less than ideal management solutions in other respects. Dare one also say that traditional rotation systems also fulfill this, as well as other aims.

But if we are to consider soil conservation as defined, there are many humid temperate areas where the erosion hazard is low, except on particular soil types such as fine sandy loams and peats, or when aggravated by ploughing steep slopes as with hill pasture improvement or preparations for afforestation. Under relatively risk-free conditions it is clear that even the more ecologically-minded farmers will hesitate to adopt measures which are solely conceived to protect the soil. There is, furthermore, little chance of a soil conservation doctrine being heeded if the economic tide is running too strongly against it, for in commercial agriculture all that happens is that the system will be allowed to run down to a point at which yields or output decline, or farming operations are impeded. In short, an attractive package must be on offer to the farmer or grower if we are to expect any general change in outlook to take place. What is clearly needed is a new and broader view of conservation within agriculture.

PROBLEMS WITH CONTEMPORARY AGRICULTURE

To justify placing soil conservation within a wider perspective it is worth reminding ourselves of concerns which have been voiced about modern agriculture. The longest lamented of these is the banishment of rotations, often regarded as the cause of much soil degradation and erosion (Greenland, 1981). But agricultural developments have also exacted a cruel cost from the countryside in terms of wildlife both by removal of habitats (e.g. drainage and hedgerow removal) and selectively by the use of pesticides (Adams, 1986; Bowers and Cheshire, 1983; NCC 1977, 1984; Shoard, 1980). Large quantities of costly energy are consumed directly for farm machinery and indirectly in the application of synthetic fertilizers. These various agricultural chemicals together with certain farm effluents, as from intensive beef and dairy operations, can also lead to pollution of inland waters. Modern agriculture in the West also contributes virtually nothing to the employment of people. In Europe, while part-time agricultural employment

has increased in recent years, full-time employment is currently falling by over 2% per annum (Span, 29.2.1986, p.41). Meanwhile, agricultural surpluses are now a monument to an industry pampered by support for almost two generations (Bowers and Cheshire, 1983).

It is certainly one of the post-war achievements of agriculture to have so vastly increased production that whole sectors of the market are now self-sufficient, for Britain, and Europe as a whole (British Food, 1986). For example, between 1973 and 1983, European agricultural production increased by about 1.8% per annum. However the EEC has at this time the largest accumulation of dairy surpluses in its history: enough butter to supply all the needs of the 12 member countries for 11 months and enough milk powder for five years - there is even talk of destroying supplies because of storage costs. Grotesque though these excesses are in a world so unequally provided for, the fact of the matter is that the environmental damage of recent decades can be directly attributed to the system of agricultural support which has generated them. A further problem which may be less appreciated is that over the last few years the real value of the net product (which takes into account the current operating costs and replacement of capital, and is adjusted to allow for inflation) has been declining by about 2½% per annum (Span, op.cit.). This question of profitability will be worth returning to later but it implies that many farmers are under pressure to produce more just to remain where they are in terms of cash flow.

Therefore in any discussion of appropriate solutions to our current dilemma, the options should not simply be judged on their ability to address soil conservation, as we often narrowly define it, but by their capacity to meet a range of economic as well as ecological problems. Even certain social issues might also be placed on the agenda.

NEW DEVELOPMENTS

1. Farm support and future conservation strategy

At the present time the European Community (EC) is being pressed to examine the idea of transferring support from its 'price policy' sector to that of 'environmental regulations'. The main aim of this is to

promote better soil structure through minimum tillage and other conservation techniques. This would be de facto an anti-surplus policy for it is reckoned that yields would be depressed by around 10%. The idea is that farmers could be buffered from at least part of the reduced income, as indeed they already are under the provisions of the Wildlife and Countryside Act of 1981, for potential income foregone because of nature conservation restrictions. With the inclusion into the EC of Greece, Spain and Portugal, where soil erosion problems are relatively severe there is perhaps greater prospect of agreement on such policy. A recent estimate puts the area of the EC threatened from soil degradation and erosion at 25 m ha. Worst affected is Greece with about 25% of its area (3.5 m ha) severly eroded and traversed by gullying systems (de Ploey and Van Hecke, 1986).

Accompanying this recent initiative there have been predictions of much land in Britain moving out of agriculture while actual changes in grant aid and quotas have already taken place. The latter has had the aim of reducing the costs of the CAP and concentrating money where it is most needed in the 'less favoured areas'. But each new change in quotas inevitably meets with resistance from particular lobbies, and increasingly from affected groups of angry farmers trapped within a bureaucratic framework. Perhaps the ultimate solution would be to scrap taxpayer support for agriculture altogether as has recently happened in New Zealand.

Recent changes affecting farm profitability have sent a chill wind through farming circles and have, we are told, led to land values falling. Changes which are a matter of degree with some farmers may for others be a matter of changing course or selling up. Environmentalists may initially feel a sense of euphoria about this until it is realised that further farm amalgamation and scale increases may ensue at the intensive margins of production while noises currently emanating from the agriculture minister, Mr. Jopling, seem to signal the expansion of forestry on the extensive margins, in our hills and uplands. The environmental consequences of these particular developments could be most undesirable and it is therefore urgent that the Ministry of Agriculture (MAFF) and Forestry Organizations be charged with new responsibilities for environmental protection. Indeed, the Nature Conservancy Council now

concedes that its policy of protecting increasing numbers of SSSI is ultimately threatened unless land use in the country at large can be brought into line with national conservation objectives(NCC 1977, 1984). Even the National Parks in Britain, while providing a framework of planning controls for landscape conservation, are arguably more cosmetic than involved with the active promotion of conservation (MacEwen and MacEwen, 1982). What is now needed is nothing less than a new charter for the upgrading of the countryside and its resources with as much emphasis placed on healing the scars of agricultural development as in the protection of natural habitats (some of these issues are elegantly drawn out in Bowers and Cheshire, 1983, and Adams, 1986).

2. The demand for health foods

Again, over the last year or so and showing every sign of accelerating is the unprecented increase in demand for health foods. This concern is as much for aspects of food processing such as the consumption of 'whole foods' and the removal of additives as it is for food produced by natural forms of husbandry free from chemical residues. Consequently although major increases in demand have been registered for all health foods, the MAFF national survey for the second quarter of 1986 shows that the sharpest rises have been for wholemeal bread, low fat milk and fruit juices without certain additives. Indeed, in relation to the EC's mountain of unconsumed dairy produce; people are drinking 8% less liquid whole milk than a year ago while butter sales have fallen a further 13% on an already declining trend.

Such a market-led phenomenon is heartening for organic growers whose commercial opportunities have until now been rather restricted. It also points to a measure of current demand for organic produce which is unsatisfied by British agriculture, a situation which farmers already faced with hard decisions would do well to consider. The demand for organic produce in West Germany is expected to increase by about 20% per annum yet it seems mainly the young who are requesting this produce (Werner, 1984). The newly formed Guild of Conservation Food Producers provides a guaranteed market for organically grown crops in the U.K. Already, more than 100 farmers, using

recognized varieties and crop rotations have for example contracted their produce to the millers, W. Jordan Ltd. for a premium rate (Harvey, 1985). Many farmers find it possible to sell from their own farm shops (see e.g. Kiley-Worthington, 1984). In the USA less than 30% of farmers in 1980 marketed their produce as organic, the remainder being sold through conventional channels (USDA, 1980). In Canada, normal commercial outlets appear to predominate (Kramer, 1984) which are disadvantageous to the farmer and require a better general public awareness of the quality that is claimed.

If in future more of the true costs of conventional agriculture were to be borne directly by the producer and consumer it is likely that the economic comparisons would lead many to conclude that organic farming is a serious alternative, a view first put forward by Eugene Schumacher (1974). For this reason various aspects of conservation-orientated farming, or biological agriculture, will now be briefly examined in order to gain some idea of its scope in the future.

BIOLOGICALLY-ORIENTATED FARMING

1. The system, its ideals and status

The USDA defined organic farming as 'a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests' (USDA, 1980 and see also Kiley-Worthington and Rendle, 1984).

Biological husbandry in the majority of cases involves the concept of the mixed farm where animals graze on land rotated through an arable cycle but where there is often some permanent grassland. Such farms are usually among the smaller in size and normally require higher labour inputs than conventional farms not simply to spread muck, as some suppose, but because of the diversity of tasks and the fact that less mechanisation usually accompanies the system. Organic farmers exhibit

much individualism and many will permit limited chemical soil amendment where necessary (e.g. liming). The farm may be operated on organic lines to the minimum extent needed to satisfy the requirements of the Soil Association for marketing purposes but may additionally incorporate a range of practices broadly descibed as holistic, some of which are to be found in indigenous systems in other parts of the world (Smith, 1985, 1987). These include the use of companion herbs and the application of special preparations sometimes in homoeopathic potencies for a variety of plant nutritive and pest control purposes. The most worldwide system in this respect is Bio-Dynamic agriculture (Koepf et al, 1976), while there are a number of societies and institutes devoted to organic husbandry in Britain including the Soil Association, the Henry Doubleday Research Association and the British Organic Farmers and Organic Growers Association.

Organic methods have received full recognition from the USDA for their contribution to agriculture. Indeed other countries appear to be much less prejudiced about organic and non-conventional farming methods, just as they are more ready to accept the contribution of traditional or alternative forms of medicine, as witnessed by the recent attacks of the DHSS on Weleda products and the implications these carry for the public's right of access to alternative medicines. This year, however, after public statements about encouraging organic methods in particular parts of Britain, the alternative agriculture, long promoted by the Soil Association, seems set to enter a new era of detente with MAFF. Such a change of policy probably reflects the new demand for organic produce as much as a new found concern for the environment for it is interesting to compare this slow recognition of organic husbandry with the British government's belated gestures over thermal power station emissions, our continued reluctance to join the 30% club and our attitude over the removal of lead from petrol. There has for a number of years been official state university funding for direct research into organic agriculture in Sweden, the Netherlands, West Germany, Switzerland, Austria and the U.S.A. while it is only very recently, including the last round of NERC funding in the U.K. that a small gesture has been made in this direction (see Woodward, 1984). The latter fits of course into the general picture of underfunding of research in the U.K., though we should bear in mind that this is not purely academic but the

officially, much-vaunted area of applied research. In this respect much of the progress made by the organic movement has been achieved without any state expenditure and those who are all too ready to criticise the amateur standing of organic farming and the modest and often statistically-limited results of its researchers would do well to remember this.

2. Soil fertility and erosion

Soil fertility ultimately encompasses chemical, biological and physical aspects of soil and is the capacity of soil to provide for the growth requirements of crops. In orthodox agriculture the soil is all-too-often treated as a medium for converting fertilizers, sunlight and water into foodstuffs rather than as a living part of the farm. In particular, continuous cropping, in lowering organic matter levels, endangers soil structure and threatens the existence of micro- as well as macro-soil organisms. For this reason alone, rotation systems should be reintroduced irrespective of whether farmers espouse the philosophy of organic husbandry in any wider sense. Certain soil-dwelling basidiomycetes such as Trichoderma viride and Rhizoctania solani, along with groups of bacteria, secrete polysaccharide gums under grassland conditions which confer water stability on soil aggregates. The former do not compete well under cultivation with the result that structure weakens over time (Garrett, 1978).

The studies led by Vogtman (1984) and Pimentel (1983) show that organic farms do, in general, have reduced erosion rates while Jackson (1980) reports that no-tillage corn in Ohio was accompanied by an average soil loss $^{1}/_{100}$th that from conventionally grown corn. Sandy and peat soils together with sloping farmland are clearly the first candidates for a return to rotations.

Soil micro-organisms, besides carrying out vital conversions, produce organic substances which in very low concentrations stimulate plant growth. These include auxins, vitamins, antibiotics and other compounds. Syltie (1985) has shown, for example, that triacontal can be added in as low a concentration as 2×10^{-4} kg/ha and benefit plant growth by improving several indicators of plant performance, including nitrogen uptake and plant resistance to pests. This finding recalls the use

of preparations in Bio-Dynamic agriculture which utilize such varied ingredients as finely ground quartz, dandelion, camomile, valerian, yarrow, stinging nettle and oak bark and show similar effects (at 2-4 ppm concentration) on proteins, vitamins and various enzymes and other fractions in the product (Koepf, 1981). Homoeopathic materials, although much in need of proper scientific testing, do appear to increase plant resistance to disease among other attributes (Scofield, 1984).

Information of this kind would be well to bear in mind when we hear that, under conventional agriculture, new crop varieties begin to fail from disease pathogens, a problem widely encountered and frustrating endeavours in the so-called Green Revolution.

3. Weed and pest problems

Crop rotations have been shown in some instances to reduce weed problems (Elliott 1984, Kiley-Worthington 1984, Vogtman 1984) while in others no advantages are apparent (Pimentel 1983, Kramer 1984). Experience with minimum tillage suggests no advantage with weed problems and indeed it would seem that herbicides are the only solution to weeds which would otherwise have much advantage over the crop. In indigenous systems in the tropics weeds are controlled by ensuring an effective blanket of the leaves of the various crops grown as a mixture. This system also reduces nutrient leaching, protects against erosion and, by re-creating a miniature ecosystem, protects individual crops from pests to an effective extent. There is little doubt from experience with mixed intercropping that this also offers a way forward in ecological pest management (ASA 1976, Speight 1983). Bed layouts in cereal fields with different varieties planted in strips is a modest step in this direction while inter-row systems not only extend the period of soil cover for crops maturing several weeks apart but are able to reduce some pest problems merely by the barrier or fly-paper effect.

Many of these same ecological arguments could also contribute to a reformed forestry policy, for not only do coniferous monocultures

signal a pedological dead end but they can suffer serious depradations from insect pests (e.g. spruce budworm etc.) (see Speight, 1983). Mixed species plantations not only allow for some of the normal silvicultural practices - such as the use of nurse crops but promote a varied ground flora which improves nutrient cycling and soil conditions. Under present practice, soils can experience years of acid degradation follwed by a period of potential instability at and after logging. Mixed plantations are also more desirable for varied wildlife habitat.

Crop rotations not only allow a greater amount of natural recycling but also militate against the build-up of parasites and pathogens in the soil environment (see e.g. Rao et al, 1984). Thus, many of the eeelworm problems of potatoes, peas and other crops, together with further well known pests, are a reflection of the practice of monoculture which itself has been aided and abetted by a large and powerful chemical industry operating under the blessing of governments since the Second World War.

Some fifty years ago when Sir Albert Howard was an agricultural adviser in India he recognized that a main cause of crop failure from pests and disease was inadequate care of the soil. He decided to adopt the indigenous Bengal composting technique and was able to grow crops which yielded well each year without recourse to agricultural chemists, entomologists or pesticides (Yellowlees, 1986). This, as we have said, is precisely the objective of the organic farming movement.

4. Economics

Conventional Western agriculture is fuelled and fertilized by diminishing reserves of fossil energy, the costs of which seem set to increase despite short term reversals. Thoughts of a future energy crisis have therefore seemed to provide the scenario for future adoption of organically sustainable agriculture. But is it necessarily the case that the economics of organic farming have to be seen in this light?

What about yields? In a variety of separate studies, yields of various crops were between 5 and 16% less but sometimes more than those

produced by conventional means (Lockeretz, 1976, 1981; Steinmann, 1983). It would seem that one very important factor in yield comparisons is the variety of the crop under examination (Vogtmann et al. 1984). The argument that organic farming is incapable of providing for a world already short of food is both naive and phoney for it fails to comprehend the nature of agricultural commodity markets. By contrast, lower yields are entirely justified in the face of food surpluses and in the interests of ecological stability.

As far as input costs are concerned they are almost always lower than for conventional systems. Bateman (1984) found that of 35 farms studied in England and Wales, 29 had lower costs and 18 of these were less than half of conventional farms. Koepf (1981) shows that production costs can be a mere 71% those of conventional farming while net income equivalent can be a quarter as much again as that achieved by a similar but conventional farm.

While there has been a remarkable fivefold reduction in energy efficiency for intensive farming over the past 20 years (Wilson 1981), Lockeretz (1981) in studies carried out over five or more years, showed that energy use on organic farms is 40% less per unit value than conventional farming. Conversion even of limited parts of a farm enterprise can produce energy savings. For example, direct drilling needs fewer tractor journeys over the land (therefore less soil damage) and, though requiring herbicide treatment, can save over 11% energy costs (Martin, 1981). One of the more important aspects of the study in the U.S. corn belt by Lockeretz and co-workers is the potential or organic systems to outproduce conventionally run units under poorer environmental conditions. This ought to have considerable relevance to hill farming in Britain and to areas with poorer acid soils.

Again, whereas large size is an important factor in financing specialised and highly mechanised enterprises, smaller size is of advantage in the establishment and operation of organic farms (Schumacher 1974; James 1983). Indeed it has been shown that production per unit area tends to decline with increasing size of

farms (Kiley-Worthington, 1984).

In the Third World it is largely the case that agricultural systems of a non-commercial variety exhibit elements of organic husbandry already because of the costs of equipment, energy and fertilizers, so to say that such methods have application in Developing Countries is merely to encourage the enrichment of systems already being practiced and to discourage any wider use of chemicals (Wilson, 1981; Elliott, 1984). Organic methods are regarded as especially suitable in these situations where there is often a surplus of labour. This prompts a final and not entirely irrelevant speculation that increased farming employment would probably result from any major return to sustainable agriculture in the West.

5. Food quality

It has often been claimed that organically produced foodstuffs have better flavour, appearance and keeping qualities and they will of course be freer of various residues, including pesticides, so far as that is within the control of the farmer (see Vogtman et al, 1984). I want to concentrate here on any evidence for quantitative differences in nutrients or biochemical fractions in the products of organic and conventional agriculture.

Hodges (1981) in a recent review cites six studies showing no differences and ten which show better protein content in the organic produce. Rats fed on organically-grown grain, richer in vitamins, not surprisingly grew better and were more resistant to disease. Seeds in manured soil had a superior germination rate to those given synthetic nutrient. Poultry fed on organically grown grain had better egg production and there was also improved fertility among other farm animals (Hodges, 1981). Lairon (1981) in a study of vegetables found that of 45 separate determinations of nutrient content, 18 showed no significant difference, 2 favoured conventional farming while 25 favoured the organic method. Nutrition alone is however regarded as insufficient evidence for a well founded assessment of the quality of organic produce (Vogtman, 1984).

Indeed if there is some chemical evidence for the benefits of organic produce there remains the more vexed question of the 'vitality' sometimes claimed to be provided by food of this kind. One obvious explanation is that vitality, in so far as it is measurable, is directly related to nutritional composition. However, Rudolf Steiner, who originated Bio-Dynamic agriculture, indicated that synthetically applied elements subsequently taken up by plants had an inherently different quality from identical nutrient elements which had already been biologically cycled (e.g. through cattle) (Steiner, 1924). According to this conception,human food derived from chemical agriculture does not have the same vital forces which human beings require to take over into themselves.

Difficult though such concepts may appear to scientists of conventional outlook it is worth noting that natural medicines and changes of diet towards organic produce have met with success in the recovery of cancer patients (Schmidt, 1986). While this points to the potentially therapeutic value of organic products it also raises cogent questions about at least one of the possible causes of cancer in our modern society.

SUMMARY AND CONCLUSIONS

The preceding discussion, though brief and selective, does I believe show that from many points of view biologically-based farming systems offer not simply the only realistic way forward, but offer flexibility, such that while fully integrated organic farming provides an ideal, individual components of biological husbandry can be introduced according to farm circumstances. In Table 1 I have attempted to summarise some of the points touched on in this paper and to identify what might be described as 'levels of commitment' to conservation-type farming, from zero to four. Clearly such a classification is somewhat arbitrary and farms may exhibit selected elements from 1-4 but the intention is to identify the various components which ultimately comprise a comprehensive conservation package.

Soil conservation is an important topic at this time because of

the widespread separation of the aims of agricultural management from a consideration of soil as a renewable resource. That the soils of many humid temperate areas have sustained the impact of modern agriculture for so long has clearly helped foster this disregard. As I implied earlier, to show concern for the soil is to show concern for the whole related ecosystem so that without changes in the overall structure of agriculture the soil becomes a lost cause.

This paper will I imagine be received by a majority of the converted while a few may with justification feel that here is an academic preaching about matters when his own livelihood is not involved. I may not have added much to a debate which is already more than 20 years old yet these problems are with us in a form which grows more acute and more extensive as time passes. I can only repeat therefore that we have the technological and ecological knowledge to manage agriculture towards a sustainable future and that the time is now overdue for change. This we should allow to take place through a combination of market forces and strong policy restraints.

Just how enlightened an approach to soil and biological conservation is possible in the future will depend on public pressures for environmental conservation, demands for foods produced by organic means - food quality in contrast to over production - and a public policy which steers agriculture along a more sustainable path.

TABLE 1. LEVELS OF COMMITMENT TO CONSERVATION IN AGRICULTURE

Level 0	No measures taken to combat soil degradation - intensive commercial monocultures - measures often environmentally damaging in wider sense
Level 1	Physical measures taken to inhibit soil erosion - terraces, windbreaks, latex films/soil conditioners
Level 2	Macro-agronomic measures to counteract decline in structural stability - minimum tillage techniques, fallowing, rotations
Level 3	Micro-agronomic measures to introduce polyculture and ecological pest management (additional to 1 and 2 above)
Level 4	Sustainable agriculture. Low-energy, mixed farming based on biological principles with or without traditional/holistic practices

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