MODERN AGRICULTURE, SUSTAINABILITY AND BIODYNAMICS

Richard T Smith

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SCHOOL OF GEOGRAPHY • UNIVERSITY OF LEEDS

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ABSTRACT

This paper reviews problems of modern, chemically-based farming, identifies the need for alternative approaches and discusses biodynamics as a way of meeting future needs for a genuinely sustainable agriculture.

CURRENT AGRICULTURAL PROBLEMS

Agriculture has always been a rather risky outdoors experiment so that to have even partially fed a quadrupling world population this century must rate as a great achievement (Keyfitz, 1989). Enormous, however, have been the environmental costs of such an enlarging population and of the agricultural systems which have supported it. Aside from the consumption of non-renewable resources there has been the destruction of forests and loss of productive land due to soil degradation and erosion (Erlich et al, 1977; Allen and Barnes, 1985; UNEP, 1991; W.R.I, 1992/3).

More recently problems have arisen with the use of chemicals as fertilizer or pesticide. Either may be retained by the soil or washed into drainage water causing contamination of irrigation or drinking water. In the tropics, fertilizer efficiency is in question due to a combination of acidity and clay mineralogy which leads to phosphate fixation. In addition, the limited cation exchange of soils due to low alumino-silicate clay and organic matter, provides little protection against leaching while the latter is enhanced under the prevailing high temperatures and periodically intense rainfall (Sanchez, 1976).

The spread of chemical fertilizers has led to profound changes. Monocultures have been encouraged which have increased pest problems both above and below ground. Addition of synthetic chemicals has led to changes in the activity of soil microorganisms (Somerville and Greaves, 1987) such that crops have become dependent upon added chemicals. Allied with continuous cropping, these circumstances lead to a reduction of beneficial soil organisms and loss of soil structure. Again, as crop selection for fertilizer - responsiveness has occurred, older, native varieties suited to local conditions of soil or terrain have been replaced and lost. Current emphasis on certain rice varieties diminishes the overall gene pool; promotion of irrigated and highly productive lowland rice leads to the elimination of upland varieties while in Bali, the shorter-stemmed Java rice is now preferred to the indigenous variety. The large chemical firms also own significant parts of the seed industry which thus increasingly serves their own interests and makes it more and more difficult to obtain or promote seeds suitable for alternative management systems (Mooney, 1983; SCG, 1987).

The chemical fertilizer culture has, therefore, much to answer for despite taking the credit for feeding so many mouths. But additionally, in order to achieve the yields which can be attained by use of chemical fertilizers it has been necessary to deliver increasing quantities of pesticide which can now be measured in all our soils and food products (Fig 1). Although restrictions on the use of many of the most harmful pesticides exist for food crops in many countries, these do not apply in the case of non-food crops such as cotton or flower production so that great contamination of soils and damage to the health of peasants is the result. Unquestionably part of the increased use of pesticides arises from the increasing resistance of pests to existing pesticides but there is also evidence that pesticides can induce pest attack by their effects on plant metabolism (Chaboussou, 1986).

Figure 1. Estimated world-wide sales of pesticides ($USm)

Pesticide:	1980	1985	1990
Herbicides	4,891	6,331	7,183
Insecticides	3,916	4,268	4,815
Fungisides	2,199	2,537	2,947
Other*	559	642	804
Total	11,565	13,778	15,749

* *includes rodenticides, pheromones, plant growth regulators, etc.*

After FAO, 1988

Even if such a technological approach to farming carried no environmental risks, can it really be afforded? In this respect there are parallels between more and less developed countries. In many tropical countries the cost of maintaining the so-called Green Revolution has long proved too great. This is not simply because of the cost of production or import of chemicals but because of poor and fluctuating commodity prices as sugar cane producers as far apart as Fiji and Barbados will testify following the crash of the early 1980s. Without good prices being paid to the producer it is impossible to afford the cost of chemicals or the maintenance of the machinery accessories of modern agriculture. Similarly in Europe and North America poor prices, and more especially reduced price support, has recently led scores of farmers to bankruptcy while many of the remainder are now looking for ways of reducing their input costs.

This is surely a warning to countries in transition and whose Governments are being encouraged to promote chemical farming methods, that the various aspects of an agribusiness approach to farming are unsustainable (MacAndrews and Chia, 1979; World Commission on Environment and Development, 1987; Adams, 1992). While the seductive powers of multinational companies remain undiminished, increasing numbers of responsible commentators are recognizing that Western-style, chemical agriculture is at a crossroads. Its ecological problems have emerged after several decades of reckless commercialism not only in Europe and North America but also in Australia, New Zealand and South Africa where soil and environment are more forgiving. Under harsher tropical conditions of fragile soils and severe pest problems much greater care with the environment needs to be exercised and this care simply is not provided within a wholly industrial ethos.

SUSTAINABLE AGRICULTURE

The foregoing serves to point out that for a combination of ecological and economic reasons conventional chemical agriculture is now under threat. It may be true that larger commercial units will continue to flourish at the expense of the smaller but they will increasingly face environmental constraints. So it is clear that viable alternatives capable of sustaining production by less capital intensive means are needed and these have been developing steadily over the past twenty years (Boeringa, 1980; Edwards et al 1990). Such new approaches to agriculture are generally termed alternative or sustainable (NRC, 1989). But what exactly do we mean by sustainable?

We must first recognize that agriculture is a human activity which takes place within social and economic as well as environmental fields (Conway, 1987). So in order to be sustainable an agricultural system must presumably not only display ecological characteristics which promote fertility and anticipate seasonal climatic variability but be able to respond flexibly to economic and social pressures. Thus, in the broadest interpretation, sustainable agriculture, as with the notion of a sustainable economic system, is more of an ideal than an attainable reality (Barbier 1987; Simon 1989; MacNeill, 1989). In this sense it is a somewhat relative term implying the capacity of a system to achieve stable transitions according to changing circumstances rather than to undergo discontinuous, catastrophic change (Bourriau, 1992). But these are heady matters and most of us who use the adjective sustainable usually have simpler concepts in mind. These restrict the word to the ecological or agronomic framework of agriculture, to the prudent use of the earth's finite resources and to the preservation of a healthy living environment. Such ideas concentrate our attention on a farm's ability to regenerate its own resources (or inputs) rather than to rely on imported materials. It is a transformation from considering farms merely as factories where food and fibre are produced to viewing them as living units of the countryside with their various parts (or functions) contributing to the whole like a living organism (Schumacher, 1974; Kaplinsky, 1990).

There are already various types of farming which achieve or approach such self sufficiency including certain organic and indigenous farming systems and of course permaculture (Bezdicek, 1984; Mollison, 1990). As a design strategy for sustainable rural living the latter incorporates innumerable ideas from many fields and embraces soil, water and energy conservation. It is therefore well placed to provide a practical framework for the introduction of specific agro-ecological methods. But in a world where we require to grow cash crops, often on a large scale, and where land is managed on behalf of major commercial interests rather than those of small scale farmers, there may be no easy or early alternative to the agribusiness approach (Tolba 1987; MacRae et al 1989; Adams, 1992). There are, however, elements of sustainable farming practice which are appropriate for introduction at all scales of enterprise given a genuine desire for reorganisation and for the health of the environment (Richards, 1985; Nanda, 1990; Weerakoon, 1991). While some can only realistically be introduced on a small or garden scale, such practices as agroforestry and various kinds of alley cropping, intercropping, green manuring and use of the biodynamic field sprays, are appropriate on larger scales as well (eg Wilson et al 1986). Furthermore, integrated use of such practices serves the interests of crop nutrition, pest and weed control as well as soil conservation (Papendick, 1976).

BIODYNAMIC AGRICULTURE

Central to biodynamics is the concept of the farm as an organism (Koepf et al 1976; Koepf, 1989; Sattler and Wistinghausen, 1992). Traditionally this is achieved by a mix of arable cropping and animal husbandry with rotation and the use of manures and composts as is established practice in the various branches of organic farming and permaculture (Lampkin, 1990; Mollison, 1990). However, while biodynamics is much concerned with developing and maintaining soil quality it introduces holistic concepts for an understanding of plant growth and life processes generally. Thus the farm depends not alone on the world of material substances but upon influences from the moon, planets and stars. Knowledge of this kind has undoubtedly been lost over the ages for the ancient Greeks saw man within a cosmic rather than simply an earthly setting, as did the ancient Chinese. Vestiges of this former universal knowledge do, however, survive among some tropical indigenous farmers less exposed to Western-type culture who even now organise their agricultural activities in conformity with the lunar calendar.

Biodynamics arose from a series of lectures on agriculture given by Rudolf Steiner in 1924 (Steiner, 1974). Steiner himself was a scientist, philosopher and founder of a modern spiritual science known as Anthroposophy. His indications in the field of agriculture came as much from spiritual perception as from practical everyday knowledge. He was originally approached by a group of farmers about problems surprisingly relevant today, namely the deterioration of soils and the limited period over which new varieties of crop continued to produce viable seed. Steiner saw these as symptoms with a common cause and that we needed to be able to revitalise certain processes in order that agriculture could continue to serve mankind. In particular, the use of synthetic substances for plant nutrient was seen as producing crops deficient in vitality (though perhaps not in size) which in turn reduced their real value in food products. This could be counteracted by the use of organic fertilizers which are produced through the farm organism in which animals, especially the cow, play a vital part.

Soil fertility management and renewal

In addition to this organic approach, as practiced by countless small-scale farmers, Steiner gave outline instructions for the manufacture and use of certain unique substances which have become known as the biodynamic preparations. These represent a major contribution of biodynamics to sustainability for they facilitate the interaction of terrestrial and extra-terrestrial influences in soil and plant matter

(Corrin, 1960). Two of the preparations are field sprays, one for soil and root activity known as preparation 500 and based on cow manure; the other, 501, is based on silica, reinforces the growth of the plant tops and assists the ripening process. While the former may be of particular value in poor soils and dry conditions the latter is of benefit in regions with limited sunshine or damp conditions. A further six preparations, mostly herbally-based, are mainly for compost activation and the regulation of decomposition processes. Through their presence in composted materials they also activate, regulate and generally further the processes of plant growth, but in this respect are in no way comparable to fertilizer.

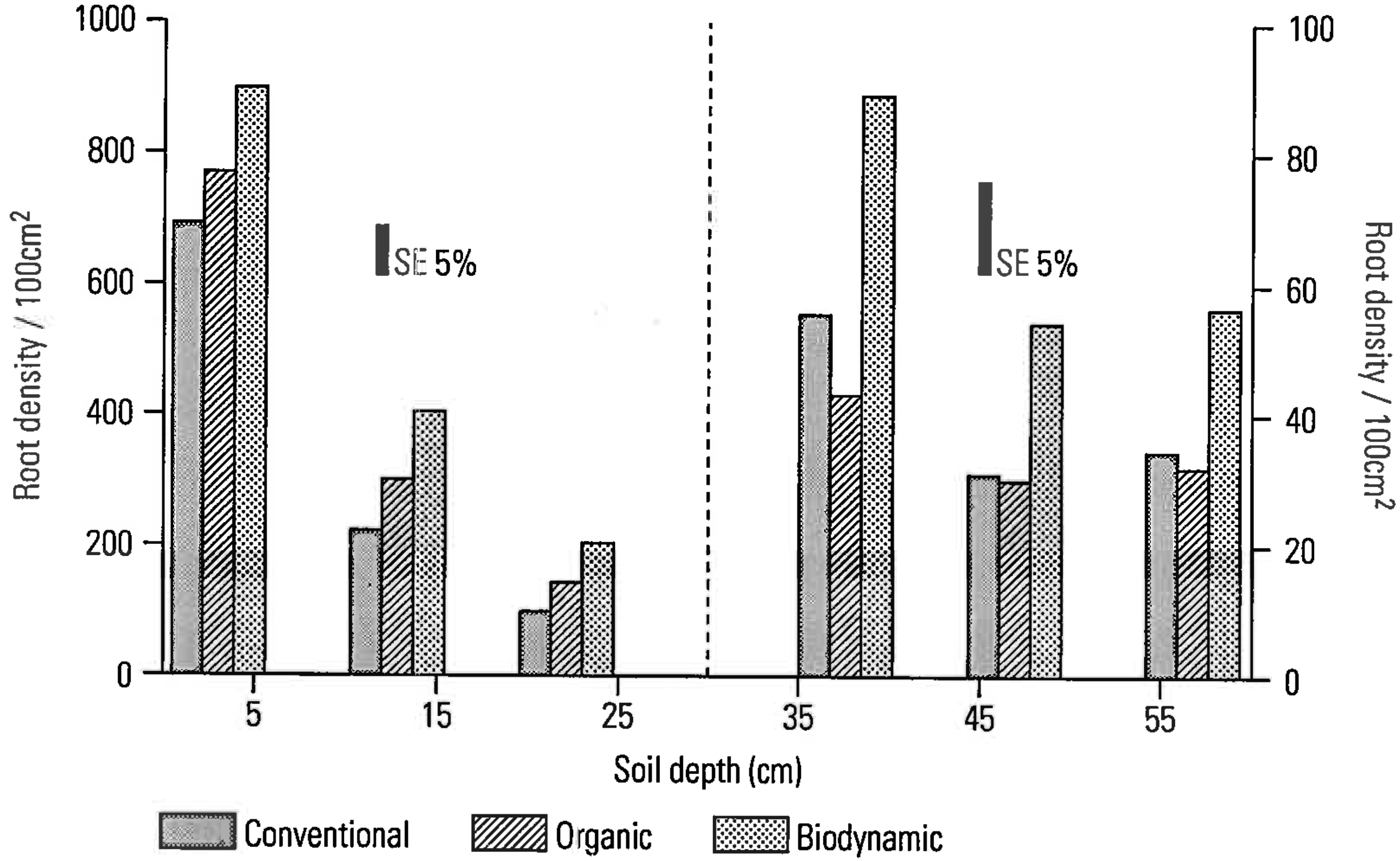
Recent visits to biodynamic farms in Australia and New Zealand have indicated to the writer that the preparation 500 really does achieve remarkable soil regeneration through improved root development. Inhospitable and poorly structured soils have been brought into productive use by using it with or without other cultural methods such as green manuring. This could be of immense value in the improvement of tropical soils exhausted by long years of plantation agriculture. Research at Darmstadt, Germany (Ahrens and Bachinger 1992) shows clearly the effectiveness of such biodynamic management for root development within the soil mass (Fig 2). The biodynamic treatment leads to more effective root distribution throughout the soil while it is interesting to note that there is no significant difference between standard organic and conventional chemical management. Experimental work near Cologne (Reinken, 1986) confirms the picture of effective organic matter penetration with higher humus levels at each depth compared to conventional management (Fig 3). It is clear that deeper and more thorough rooting within soil will give plants grown under biodynamics access to greater reserves of water and nutrient which will be of particular benefit in dry periods. A parallel study also indicates a significantly increased population of worms and greater mycorrhizal activity in biodynamic vegetable plots which corroborates earlier research reported by Pfeiffer (1983). In view of the importance of mycorrhizas in the uptake of soil phosphate it is of interest to note the comments of some farmers that after several years of biodynamics they have no need to apply rock phosphate to their land. The data in Fig 3 show clearly the higher levels of soluble phosphate in the biodynamically-treated soil.

The biodynamic compost preparations also appear to have measurable effects on at least one key soil characteristic, the exchange capacity. Heinze and Breda (1962) in composting experiments at Hohenheim University (Fig 4) showed that in three separate trials, preparations 502-507 increased the exchange capacity of organic matter, indicating an enhanced stabilization of the humus. This greater humus stability was strikingly evident as a darker soil tone in the replicated biodynamic plots at Darmstadt, visited in 1992 by the writer. This would be an especially valuable attribute of biodynamic methods if applied in tropical countries owing to the difficulty of maintaining humus levels under higher soil temperatures.

As with other natural farming methods biodynamics makes use of a range of organic manures, slurries and composts while other materials including lime, rock dusts (eg basalt), calcified seaweed and rock phosphate are used as fertilizers and soil conditioners. Of interest is the fact that using biodynamic preparations over a number of years has allowed some farmers to raise their pH levels without recourse to liming materials. Biodynamic farmers and gardeners also make their own liquid organic fertilizers by fermenting vegetable material (eg nettles) or fish waste - a field in which there is endless scope for innovation. Most will add the compost preparations to these ferments.

Two further biodynamic materials are worthy of mention. The first, barrel compost, consists of cow manure, ground eggshells, basalt dust and preparations 502-507. After twelve weeks or so buried in the earth a small portion is mixed with rain water and applied as droplets (Tompkins and Bird, 1989). This is of particular value in conversion of farms to biodynamic management and has already achieved success in areas of forest decline in central Europe. Barrel compost sprayed on land seems capable

Figure 2. Root density under different management systems



After Ahrens and Bachinger, 1992

Figure 3. Solubility of phosphoric acid and humic acid in vegetable plots

	Biodynamic		Conventional	
	0-30cm	30-60cm	0-30cm	30-60cm
phosphoric acid (mg/100g)				
soluble in acetic acid	17.6	5.1	8.8	3.0
soluble in lactic acid	44.4	12.8	30.5	7.3
soluble in citric acid	86.4	34.9	71.8	27.0
humus (%)	2.6	1.2	2.2	0.9
humic acid (mg/100g)	256.0	62.0	206.0	36.0
humic acid in organic substance (%)	10.0	5.3	9.6	4.0

After Reinken, 1986

Figure 4. Influence of biodynamic preparations on the CEC:C_{total} value of composts

Type of compost		Control	Treatment with preparations 502 - 507
composted manure	top layer	2.78	4.40
	bottom layer	3.03	4.38
concentrated manure		4.33	4.55
concentrated manure with loam and basalt		3.80	4.16

After Heinze and Breda, 1962

of major healing effects following pollution. For example defense against uptake of Sr_{90} may be possible because of the use of egg shells in the formulation which strengthen calcium metabolism in the plant (Tompkins and Bird, 1989; Thun, 1992 personal communication). Biodynamics also appears to be capable of tackling the problem of residual soil DDT. This persistent pesticide diminishes markedly in the soil in the first three years, the most likely reason being enhanced microbial activity (New Zealand Biodynamic Association, personal communication 1993). A further material for use in orchards and forestry is tree paste. This consists of a mixture of clay and fresh cow manure with 1% horsetail (Equisetum) extract and a portion of preparation 500. When mixed to appropriate consistency this is painted onto the trunk, aiding the health of the tree and promoting pest and disease resistance. Dilute versions of this mixture can be sprayed over trees to enhance their general health. The presence of preparation 500 in the mixture stimulates growth and renewal of the cambium just as it does so for roots when applied direct to the soil (Pfeiffer, 1976).

Yields and nutrient balance

It is widely known that organic and biodynamic systems give lower yields than conventional chemical farming, the organic systems frequently yielding 10-20% less. These differences are attributed not simply to the use of chemical fertilizers but to the crop varieties used and to the more rigorous control of pests under conventional management. Fig 5, shows, however, that it is only under optimal weather conditions that conventional farming proves more profitable (Lockeretz et al 1981). In this example from the USA, yields under conventional farming are more critically dependent on rainfall than the organic comparisons which will benefit from better root structure in dry years. Despite reduced yields it is not uncommon for organic and biodynamic produce to command higher prices. Fig 6 (in Sattler and Wistinghausen, 1992) thus shows that biodynamic farms often have an advantage over conventional farms as the majority of overhead costs are lower. Nevertheless, in more developed economies labour costs can still place the organic sector at a financial disadvantage while in low labour cost countries this may be a less important consideration in farm economics. Again, Reinken (1986) reported that although fruit yields were 30% lower under biodynamic production, greengrocers paid 27% more which actually gave higher returns to the farmers than for conventional produce after other costs were taken into account. However, research conducted at Darmstadt, (Abele 1987) reported surprisingly comparable yields between three forms of management (Fig 7). These results are almost certainly due to the use of rather infertile sandy soils which favour organic methods and warn of the reduced efficiency of chemical fertilizers on soils of inherently low fertility.

Many studies have now been conducted on the energy or chemical efficiency of farming systems (eg Pimentel et al, 1983). Compared to conventional farms the results of investigations of biodynamic farms by Wistinghausen (1980) and Kaffka (1984) are remarkable for indicating a positive balance for nitrogen and potassium and even, in one case, for phosphorus (Fig 8). The extraordinary nitrogen figures demonstrate the capacity for nitrogen fixation in healthy soils. It can therefore be appreciated that in the realm of soil and plant nutrition biodynamics is capable of making maximum use of existing resources, of building and restoring soil fertility and is thus by any definition, sustainable. The clear message for tropical conditions from these and the figures of Reinken (1986) and others is that with the effective maintenance of phosphate status under a biodynamic regime, biological nitrogen fixation can be fully exploited. This will eliminate the need for costly and often wasteful use of fertiliser nitrogen whether in dryland or temporarily-flooded conditions.

Figure 5. Economic performance of organic and conventional farms†

Year	Value of production ($/ha)		Operating expenses ($/ha)		Net returns ($/ha)	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
1974*	393	426	69	113	324	134
1975*	417	478	84	133	333	346
1976*	427	482	91	150	336	333
1977#	384	407	95	129	289	278
1978#	440	527	107	143	333	384

† *data averaged over all cropland, including rotation hay and pasture, green manures and crop failures*

* *data from 14 organic and 14 conventional farms*

\# *data from 23 organic farms in 1977 and 19 in 1978; county-average data for conventional farms*

After Lockeretz et al 1981

Figure 6. Differences in gross returns, expenditure and net returns between biodynamic (BD) and conventional (C) farms (DM/ha/yr)

Farm size (ha)	10-20		20-30		30-50	
	BD	C	BD	C	BD	C
Gross returns	6858	6856	7057	5863	3942	4762
Expenditure	3902	5202	3963	4594	2487	3865
Net returns	3016	1639	3181	1247	1502	885

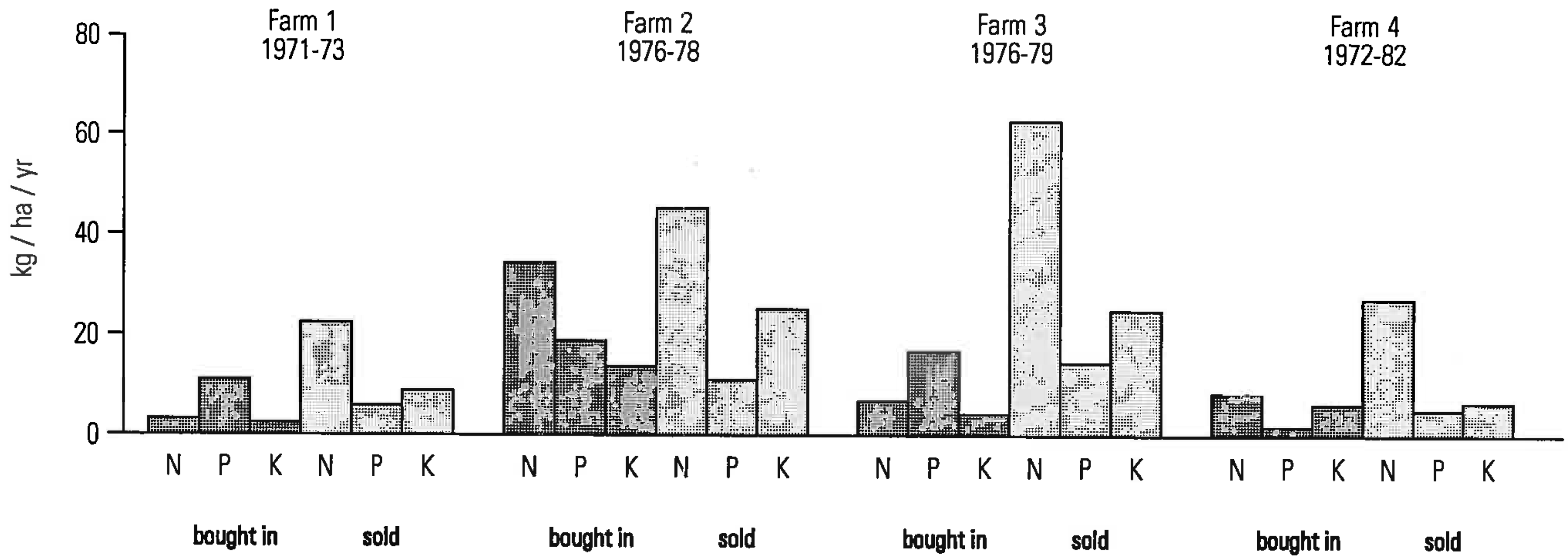
After Ministry of Agriculture, Baden Wurttemburg, in Schlüten, 1985

Figure 7. Crop yields in experimental plots (four year averages in tonnes/ha)

	Conventional	Organic	Biodynamic
Rye	3.73	3.51	3.61
Carrots	66.7	69.7	72.2
Beetroot	63.5	64.2	67.1
Potatoes	25.0	23.9	26.6

After Abele, 1987

Figure 8. Mineral balances of biodynamic farms*



**Farms 1-3 After Wistinghausen, 1980 ; Farm 4 After Kaffka, 1984*

Sowing and planting

While most biodynamic farmers and gardeners make regular use of the various preparations some will also organise their sowing, cultivating and other activities as far as is practicable in conformity with a special calendar. This relates principally to the passage of the moon across the zodiac. Biodynamic calendars are published in several countries, the most widely known being produced in Germany by Maria Thun (Thun 1990, 1993). Thun's own research (at latitude 51°N) has shown that stronger plants are produced if seed is sown or seedlings transplanted when the moon's arc across the sky is descending rather than ascending. These principles can also be followed in tropical areas but as lunar elevation tends to be more constant (zero at the equator) the effect will be lessened.

A similar, better-known cyclical influence is that of the waxing and waning moon. Research by L Kolisko (Kolisko and Kolisko, 1978) has shown that the best yields are achieved by planting about two days before full moon (Fig 9). The reason for this appears to be that the strongest moon influences enliven the seed at the start but do not then force growth too rapidly in the early period of germination. This is analogous to the beneficial effect of the fortnightly descending moon. Planting two days before full moon was formerly widespread among tropical farmers in the Americas (Smith, 1987) and even now it is possible to find localities where agricultural operations are guided by the moon. Brush (1977) investigated farmers in an isolated Andean region. Their customs (Fig 10) indicate that strong plants able to resist disease, and which yield well, are produced only if the influence of moon and soil are not too strong at planting. Furthermore, harvesting ought not to take place during a waxing moon otherwise the produce contains more sap and will deteriorate relatively rapidly. This latter fact is more widely recognized, even by foresters and others who might otherwise not be prepared to accept that the moon has any influence on plant growth.

Further research by Thun and others has shown that crop plants are influenced in their form of growth by the particular constellation which the moon is passing when they are planted. The twelve constellations are divided into four groups of three; each group relating to one of the fundamentals of life, namely earth, light, water and warmth. These are linked respectively to root, flower, leaf and fruit (or seed) and hence to the purposes for which the individual crops are grown. Thus root crops such as potatoes, cassava or taro should be planted on 'root-days' in the calendar and in this way better yields are likely unless other factors intervene unfavourably. Fig 11 thus shows peak yields of potatoes obtained when planting in association with the three earth signs; bull, virgin and goat (Thun, 1983). This having been said, it is essential to bear in mind that such biodynamic practice can never be a substitute for good farming, nor for suitable weather. Moreover, the effects of the constellations are unlikely to be manifested in over-fertilized soils where the influence of the moon alone will predominate (Thun, 1990 and personal communication, 1992).

Control of weeds and pests

For control of weeds and pests biodynamics not only utilizes many well known methods but offers its own distinctive approaches (Thun, 1986; Smith, 1992). In weed control, aside from the advantages of rotation, weeding is done by hand, by mechanical methods and by flaming. On a garden or horticultural scale mixed intercropping of vegetables can reduce weed problems while many biodynamic gardens use raised beds which are planted to a polyculture of crops and herbs so giving weeds little chance to establish.

Thun's experimentation has led her to suggest ploughing (or digging) when the moon is passing the lion constellation as this encourages maximum seed germination, then to prepare the seed bed if possible when the moon is in the region of the goat, when more limited germination takes place (Thun,

Figure 9. Performance of tomatoes planted two days before full moon (I, III, V) and two days before new moon (II, IV)

I	II	III	IV	V
2.9	1.4	2.6	1.2	2.5

Yields as quoted in Kolisko & Kolisko, 1978

Figure 10. Agricultural activities in the Vilcanota valley, Peru according to soil fertility and lunar phase

Soil fertility	Lunar phase	Planting	Weeding	Harvesting
+	+	No	No	No
+	–	Yes	Yes	Yes
–	+	Yes	Yes	No
–	–	No	No	Yes

+ Fertile soil and waxing moon

– Infertile soil and waning moon

(After Brush, 1977)

1986). Again, as for other influences, too rich a soil is likely to negate these fine effects. Reports from biodynamic farms confirm the effectiveness of this technique.

Biodynamics is known also for its use of burned seed preparations and fermented extracts to suppress weed growth in both pastures and arable land. These are potentially very important methods in the search for cheap and ecologically sound weed control. The burning of seed was first suggested by Steiner, for the seed encapsulates the plant's regenerative force and applying the burnt material to the soil as a dry pepper or as a homoeopathic liquid spray, conveys a strongly negative influence on the growth of that particular plant. The idea of fermenting the entire weed plant, including the seeds, was developed from this concept by Thun (1986). For maximum effectiveness of this method it appears that the best time to collect seeds and plant material, is at the full moon providing one can obtain a sufficient quantity at that time. These gentle methods usually require several treatments in successive years before the weed problem is fully overcome (Steiner, 1974; Sattler and Wistinghausen, 1992). In Europe a variety of weeds have been successfully treated, including ragwort, while the author has experimented on bracken (Smith, 1992). On a recent visit to Australia and New Zealand the writer was impressed with the use being made of these methods with particular success recorded against Californian thistles. In New Zealand the diluted weed preparation is sometimes added to preparation 500 before being sprayed by fixed wing aircraft. Weed-counteracting preparations may also be added to other liquids, such as biodynamic fish fertilizer, to reduce the number of separate applications.

For control of pests the principle of rotation and the promotion of ecological diversity including hedges, shelterbelts, woods and ponds will play a major part in checking serious outbreaks. Such considerations are always uppermost in the minds of biodynamic farmers. Diversity of cropping is also an ecological protection against pests as well as an excellent strategy against the risk of failure in any particular crop, thus fulfilling one of the requirements of sustainable farming. On a smaller and garden scale companion planting is commonly practised. This has a variety of advantages, one of which is to counter pests. Herbs may be used which are successful in either attracting pests away from crop plants or of providing a powerfully repelling influence in their presence. In other instances sacrificial planting may be carried out. In biodynamic orchards, pheromones and home-made lures are used to trap insects while the practice of encouraging a diversity of herb cover under the tree rows helps provide a habitat for the predators of the main fruit tree pests. More conventional approaches include the use of natural plant-derivative insecticides such as pyrethrum and derris although it is well to remember that even these short-lasting substances will tend to kill off some beneficial insects. An increasing number of farmers are also now using an emulsion based on neem oil (from the neem tree Azadirachta indica) which is most effective in repelling insects. Use is also made of tree sprays as mentioned earlier.

As with biodynamic weed suppression, animal and insect pests or predators can effectively be controlled by periodic use of peppers or liquid sprays. For mammals, the skin should be burnt when the planet Venus is passing the constellation of the scorpion. For insect pests (eg nematodes) it is advised to burn when the sun is passing through the constellation of the bull (Steiner, 1974; Thun 1990).

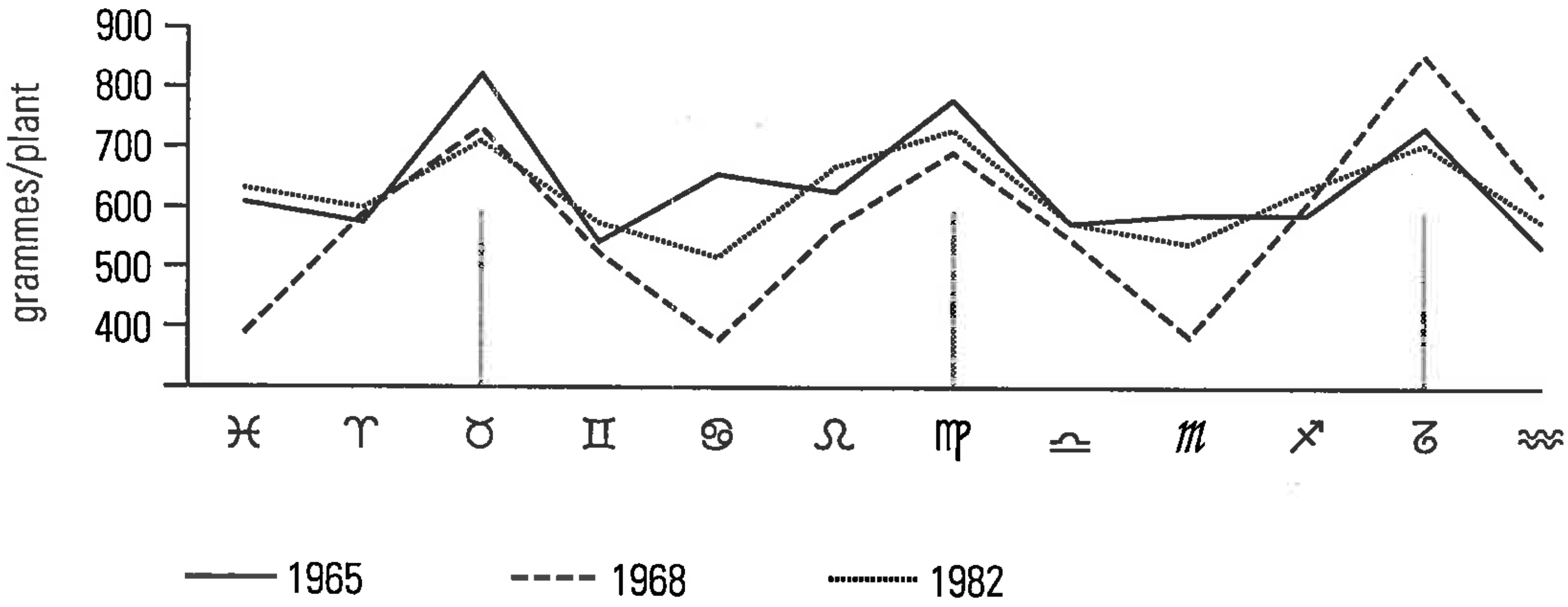
Food quality and health

When visiting biodynamic farms there may be little of difference to strike the eye immediately, for farms of all kinds vary in size, enterprises, farming attitudes and financial circumstances. Farms may thus appear tidy or untidy, somewhat rundown or with new buildings and machinery but after visiting many biodynamic farms the most noticeable feature is the health and appearance of the animals. This would appear to be effective proof of the underlying principles put into practice in this holistic method of farming. Throughout recent travels including substantial parts of Australia and New Zealand it was evident that biodynamic farm animals of all kinds; deer, sheep, goats, cattle and pigs, possessed an excellent condition and in consequence most farmers could count on higher prices for their products. The appearance and quality of the fur was outstanding while farmers reported a very low incidence of bloat, facial eczema, intestinal worms and other disorders and correspondingly minimal veterinarian fees. It is not uncommon for conventional herds to require daily medication against a range of problems while no such antibiotic treatment is given in biodynamics. Any animal disorders are normally countered by naturopathic and homoeopathic remedies which incur little cost, rarely upset the animals and can be made on the farm. Pfeiffer (1983) quotes the results of research on chickens and turkeys fed alternative types of diet with consequences for health and egg production which clearly favour the biodynamic method. Research is currently in progress in Australia comparing biodynamic and conventional dairy farms prompted by a scare over pesticide and antibiotic residues in milk and meat products from conventional farming. Preliminary results are displayed in Fig 12 (Small and McDonald, 1990) where despite much lower inputs, satisfactory levels of production are being achieved with an excellent health record. Readers concerned with dry season performance will also note the lower irrigation needs of the biodynamic pastures. This relates directly to the greater rooting depths, superior soil structure and higher organic matter levels under biodynamic management.

Facts such as these underscore not only the relatively low financial inputs of biodynamics which should be the aim of all truly sustainable husbandry but also the inevitable links between soil, pasture quality, ethical stock treatment and the health and vitality of animals. This having been said, it is for each one of us to consider what benefits might also accrue to human health were we to be generally consuming food produced organically, let alone biodynamically (Schmidt, 1986). At the Bristol cancer clinic in England, some remarkable recoveries have been achieved among patients written off as terminally ill by conventional hospital practice, and among the various therapies employed is a diet based strictly on biologically-produced food. Pfeiffer (1983) quotes physicians' reports on their use of biodynamic products which all seem to indicate that a great improvement in public health would occur if our food was to be produced in this way. There is much current interest in, and generally much ignorance about, the question of diet and health especially in relation to cancer (see Soil and Health, 1993). With the passing of each year new substances are discovered which we should not be consuming so that if we heeded all advice there would be scarcely anything safe to eat. The general public is woefully ill-informed about the positive advantages of biologically-produced food but is increasingly aware of the health risks arising from conventionally produced food (eg residual pesticides) and its subsequent treatment and processing. For example, while much of the original interest in nitrates in vegetables and drinking water (from excess fertiliser nitrogen) centred on cyanosis caused by subsequent reduction to nitrite, the concern now is over the <u>in vivo</u> synthesis of nitrosamines (mainly in the intestine) because of their proven carcinogenicity. It is well known that nitrates can accumulate to luxury levels in growing crops, especially green vegetables. Recent studies indicate however that organic produce has 80% less residual nitrate than conventional and that relatively low risks of accumulation are likely under organic systems (Vogtman <u>et al</u> 1984).

Two other attributes of food, flavour and keeping quality, require brief mention. The flavour of organically-produced food is invariably preferred while studies show that biodynamic vegetables have superior keeping qualities to both ordinary organic and conventional ones (Pfeiffer, 1983; Abele, 1987). This link between food quality and storage potential automatically means that biodynamic produce offers greater flexibility either in terms of more distant marketing or longer shelf life.

Figure 11. Yields of potatoes when planted under successive lunar-zodiacal signs in three separate years



After Thun, 1983

Figure 12. Some differences between biodynamic and conventional farms

	Biodynamic	Conventional
Production		
Cows milked (number)	87	113
Stocking rate (cows/ha)	1.8	1.9
Butterfat (kg/cow)	164	204
Protein (kg/cow)	115	151
Feed inputs		
Grain fed (kg/cow/yr)	60	386
Superphosphate (kg/ha/yr)	0	370
Urea fertiliser (kg/ha/yr)	0	40
Irrigation interval (days)	15	7.5
Disease history		
Milk fever (prevalence %)	5.5	9.2
Acetonaemia (prevalence %)	0.3	4
Calf coccidiosis (prevalence %)	0.05	0.2
Grass tetany (prevalence %)	0	1
Bloat deaths (prevalence %)	0	1
Fertility		
Not in calf cows (%)	4.5	6.6
Mean cow age (yrs)	7.0	5.0
Abortion (%)	0.5	2.1
Phosphorus levels		
Blood (mM/l)	1.4	1.9
Pasture (% of DM)	0.22	0.35
Soil (Olson P μg/g)	11	23

After Small and McDonald, Department of Agriculture, Victoria, Australia, 1990

CONCLUDING DISCUSSION

By what criteria should one judge the success of a farming system? It would be facile to pretend that in conventional agriculture quantity of production was the only yardstick while in sustainable, organic systems qualitative evaluations mattered above all. Both systems strive for adequate output and for quality. But quality itself can be interpreted in many different ways. Every crop has its own list of attributes looked for in marketing and each form of agriculture, pests and weather permitting, aims to achieve certain quality standards, most notably in the appearance of produce. All agriculture is ultimately market-led and while conventional systems aim at a large market where competitive pricing is paramount, biological producers aim for a particular niche provided by people who, by and large, are more concerned with what the food is like to eat, and what it contains (or does not contain), than merely what it looks like. In the latter case we are involved with qualities such as texture, flavour, nutritional value and purity from contamination. While we are in a position to judge some qualities of food, others we take on trust for we can neither see nor taste nutritive quality and purity. Neither can we detect by means other than flavour, texture and keeping quality the intrinsic value of organic and biodynamic produce but information about the health of animals and the apparently curative properties of this food do much to convince us. No one doubts that in global terms the mission of agriculture is to feed the human race and that successful farming usually means making money but there must surely be a deeper moral obligation too. This causes us to redefine successful farming as that which, through its own systemic practices, maintains healthy plants and animals and thereby a healthy human population; and all this while preserving and enhancing the quality of soils and surrounding landscapes. From the evidence to hand it would seem that biodynamics is capable of achieving these ideals which may explain why Podolinsky (1985) has described it as the only truly sustainable agriculture.

Biodynamics can either be understood as part of a modern spiritual science or simply as a collection of farming methods which happen to work. In the author's experience, biodynamic farmers have been drawn to it for either reason but it is a worldwide activity with representation in Europe and North America, Australia, New Zealand and throughout the tropical world, in particular Brazil and the Philippines. In the tropics many low-input sustainable ideas are being introduced through networking NGOs and there is scope for many different sustainable approaches to suit local circumstances and traditions (eg Upawansa, 1987; Thaman, 1988; Ulluwishewa 1991, n.d. and see Chambers et al, 1989). As already suggested, permaculture provides a viable framework for many rural communities and biodynamic methods can easily be introduced as part of an overall package for sustainable agriculture. Biodynamics as a form of sustainable agriculture has potentially enormous benefits to offer the tropical farmer in contrast to the essentially short-term exploitation which accompanies the arrival of chemicals. This benefit is felt nowhere more than in the building of soil fertility, various aspects of which have been discussed. Moreover, as a holistic method biodynamics is also in tune with many indigenous systems as well as blending harmoniously with Eastern religious traditions. And if we recall the broad definition of sustainable agriculture developed earlier, there are grounds for believing that holistic, ecologically-based agriculture, incorporating diverse crops and activities, should be more economically as well as ecologically stable in the long run and thereby contribute towards social stability.

According to Steiner it is the unseen, non-material energy forces in our food which we require in order to sustain and renew our physical condition. These we take in along with the substances in our diet. If through poor farming methods or excessive food processing (eg irradiation) those forces are significantly weakened or eliminated, our health is likely to be affected. An increasing number of people in more affluent countries are now aware of the importance of diet and in particular our intake of fresh fruit and vegetables. It is, of course, in fresh food of any sort that the most lively forces are still present but the further question which this paper has addressed concerns the farming system under which that food is produced. Education of our populations in this matter will be a major factor in shifting the current world emphasis away from the chemical approach and towards biologically sustainable methods of farming.

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