SCIENCE, RESEARCH AND ORGANIC FARMING

Paper by Lawrence Woodward, Director Elm Farm Research Centre, extracts of which were delivered to the Soil Association Annual Conference at Harrogate. January 2002 and at the British Association for the Advancement of Science in Glasgow. September 2001

Organic farming has been dismissed as unscientific. This perception is often based on a lack of understanding of underlying concepts. Researchers in this field accept the scientific discipline whilst seeking new methodologies to explore the holistic character of these concepts. Of central importance is the concept that health, food quality and the nature of the agricultural system are inextricably linked. The paper will review the key theoretical bases of the organic approach in scientific terms and discuss the various methodologies used in this area. It will argue that a holistic approach to scientific investigation is valid even if at present it is more of an aspiration than a reality

In 1943, Lady Eve Balfour, one of the leading protagonists of the ideas that led to the creation of organic agriculture, wrote in the introduction to her book “The Living Soil” "My subject is food, which concerns everyone; it is health, which concerns everyone: it is the soil, which concerns everyone - even if they do not realise it - and it is the history of certain recent scientific research linking these three vital subjects."

Throughout her life, Eve Balfour was bursting to tell all those who would listen, and those who wouldn't, what she and others had realised - "that health, whether of soil, plant, animal or man, is one and indivisible." (3)

Eve Balfour did not have a scientific background but many of her colleagues, supporters and fellow protagonists had formal training and careers in such areas as medicine, nutrition, chemistry, biology, soil science and agriculture. What is notable is their insistence that their ideas be developed through research as well as practice and that the scientific method be adhered to.

That is not to say that they did not feel that new methodologies would need to be developed but the examination and testing of concepts through the application of science was second nature to most of these people. Just as resting on faith was an anathema.

This scientific and research tradition has been a critical part of the organic movement ever since its beginning and remains so today. It is therefore a cause of much frustration to researchers working in this field, that statements are made about how unscientific organic agriculture is. Especially as they tend to be made by people who have themselves behaved unscientifically by not doing thorough enough research before drawing their conclusions.

It is a matter of fact that ever since the 1920s, private and publicly funded research into organic food and farming has been carried out in some way in many countries. The vast majority of this work has been undertaken using mainstream, reductionist methods and most of it by researchers with mainstream qualifications from mainstream universities and institutions (9,10).

There is now a large body of literature reporting on this work in the form of peer-reviewed papers, government reports, conference proceedings, as well as a vast amount of so-called “grey” literature, which has proved to be one of the best routes for technology transfer (11).

But it is also a matter of fact that those researchers investigating the underlying conceptual framework as opposed to the techniques of organic agriculture have often been frustrated by the limitations of the reductionist methodology and statistical analysis when applied to whole biological and ecological systems. Especially when the concepts concerned are based on the theory of whole organisms or "living entities" which are not "entirely resolvable into parts" (1).

Much has been made of the need for an holistic methodology to enable these investigations to proceed successfully. Unfortunately, this approach is rather like the first cuckoo in spring – much talked about but rarely seen. That this is the case is to a large extent due to the scientific rigour of those sometimes-maligned "organic" researchers insisting that such methods pass muster with respect to attributes such as reproducibility, transparency and appropriate statistical treatments.

Yet the charge that organic agriculture is "unscientific" still finds credence in some quarters. Why this is so needs to be addressed. Setting aside those highly influential factors; vested interest, blind prejudice and malevolence, and simple stupidity, we are still left with three that are worthy of comment. One is that it is a philosophical or political movement and cannot therefore be scientific. The second is that it is diverse and lacks coherence except as a marketing exercise. Whilst the third is that it is inherently unscientific because it is based on concepts that are not explicable in rational, scientific terms.

I*t is a philosophical or political movement and cannot therefore be scientific*

The last two points will be dealt with in a little detail later. But the first one should be covered now. Yes, the organic movement is in part a philosophical movement and in part, in a broad sense, a political movement. The extent to which it is those things varies from time to time and from place to place. But yes it is based upon a "world-view" that is relatively distinct, if not always coherent. However, this perspective arises from concepts, observations, research, anecdotal and circumstantial evidence that can be and is tested by the scientific method.

Not all the researchers working in this field share that "world-view". Some do but that does not mean they are not able to employ the scientific method in an objective and truthful way. Indeed, I believe that if you show me a scientist who claims not to have a "world-view", I can show you a fool, a fraud or someone who does not deserve citizenship in a democratic community.

From the 1980s onwards, organic farming took on a new lease of life throughout the world. The dramatic growth in sales of organic food, the increase in the numbers of farmers converting to organic production and the column inches devoted to the subject has been seen by some as phenomenal. To others, these are the results of decades of hard work, both physically and intellectually.

Whether organic food and farming proves to be merely a turn of the century phenomena or a pivotal part of a fundamental change in our approach to the health of Man, animals, crops, ecosystems and our planet remains to be seen.

In order to achieve the latter there needs to be a greater and more widespread clarity and understanding about what it is and how it came about. The organic movement's scientific tradition needs to assert itself more against the tendency to cliché, superficiality and hype that has poured from supporters and opponents alike in recent years.

Far too often organic agriculture is defined or described by what it is not. The most common example is the notion that "organic farming is farming without chemicals". Whilst this description has the advantage of being concise and clear, it is unfortunately untrue and misses out on several characteristics which are of fundamental importance. However, organic farming is a system that seeks to avoid the direct and/or routine use of readily soluble chemicals and all biocides, including those that are naturally occurring or nature identical. Where it is necessary to use such materials or substances, then the least disruptive at both micro and macro levels – that is to say from soil bacteria through plants and animals to man's wider environment – are used.

Another common misconception is that organic farming merely involves using so-called "organic" inputs instead of "agro-chemical " ones. A straight substitution of mineral fertiliser by manure is likely to have the same – probably adverse – effect on plant quality, disease susceptibility and environmental pollution. This neo-conventional approach is not organic farming. The misuse of organic materials, either by excess, inappropriate timing, or both, will effectively short circuit or curtail the development and working of the biological cycles that the organic system seeks to build on.

Also mistaken is the notion that organic agriculture is a return to farming as it was sometime in the past. It is true that some traditional farming characteristics remain features of the organic system – e.g. rotations, mixed farms, mechanical methods of weed control. However, organic farming seeks to build upon the increased understanding of such things as mycorrhizal associations, the rhizosphere, the turnover of organic matter and other areas of soil life, crop and animal husbandry that have come from modern science. Although the organic movement might reject some technologies such as aspects of genetic engineering it does seek to use scientific knowledge and information – for example from genomics - because the appropriate application of science is essential for its further development.

It lacks coherence except as a marketing exercise

In the last two decades there have been many documents published which set out the details of organic standards and regulations. However, they all have much that is shared. Arguably still the most accessible definition of organic agriculture is the one framed by The United States Department of Agriculture (USDA) in 1981. It provides a handy description of the key practices as they are found on-farm.

"Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilisers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

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The concept of the soil as a living system….that develops…..the activities of beneficial organisms… is central to this definition" (5)

Here we can see what organic farmers do not do, what positive things they do instead and the context in which they work; i.e. the living soil.

This idea of the soil as a living system is part of a concept that will be returned to. But on-farm, in a practical context it points to the key management driver for the organic farmer. That is that everything affects everything else. On an organic farm there is not one method of weed control or of supplying nitrogen. The ley, green manures and appropriate cultivations do both those things, as well as their more obvious other functions.

Here is the key to understanding what organic farm management looks like – or should like look – wherever it is. It concentrates primarily on adjustments within the farm and farming system, in particular rotations and appropriate manure management and cultivations, to achieve an acceptable level of output. External inputs are generally adjuncts or supplements to this management of internal features. (4) This is the common basis of organic agriculture where ever it is found in the world – practical, clear and coherent enough for all but the dullest or most obstructive.

This is not to say that organic farms are carbon copies of each other. Far from it, as the USDA recognised "…..Many organic farmers have developed unique and productive systems of farming ….. it is also likely that these systems are highly complex and involve unknown or poorly understood chemical and microbiological interactions."

The USDA therefore concluded that a new research approach is necessary. "A holistic research approach, which may involve the development of new methodologies, is needed to thoroughly investigate these interactions."

What this actually means, whether it is valid and, if it is, how to do it are questions that some researchers in organic agriculture constantly grapple with (12). A number of guidelines have been established by researchers experienced in this field (13,14,15):

1) Research should be conducted within a viable farming system

2) Research methods such as pot trials should only be a subsidiary component of any organic research programme and not be the sole method of investigation

3) All researchers involved should have a thorough grounding in and understanding of organic agriculture

4) Researchers should work closely with and be prepared to learn from established organic farmers.

The sting in the tail is that, having accepted all that, researchers often encounter severe difficulties when undertaking their work. As the work is being conducted within an established organic system with prohibition on the use of agro-chemicals, it can be extremely difficult to achieve controls over extraneous factors.

For example, a trial assessing clover varieties for their potential for undersowing in cereals can easily be frustrated by inconsistent levels of weeds across a site or by the encroachment of different varieties across the plots. These sorts of problems – where field conditions or some other agronomic factor can mask the relatively small differences the trial was set up to investigate – regularly have to be faced by researchers working within organic systems.

Following these guidelines has proved to be extremely difficult. Despite the increase of interest in organic research and the number of projects, we have barely progressed our understanding neither of how an organic system works nor of the validity of its underlying concepts. (Although reasonable progress has been made on specific technical or organisational applications.)

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The fact is that in real life – with resource constraints compounding methodological differences – the development of "a new research approach" by and large remains more of an aspiration than a reality. William Lockeretz, for more than 10 years editor of the American Journal of Alternative Agriculture, summarises the situation as follows;

"Organic research is hardly different from conventional research. Few papers in the field can honestly be called holistic or system-oriented. And very few are even slightly multidisciplinary. The main difference compared with conventional research is what gets studied - some aspects of organic farming - not in how one studies it……..Neither in the kinds of questions posed nor in the ways they are answered do I find any clear, systematic distinction between research on organic and on conventional systems." (10)

Lockeretz does acknowledge that there are some exceptions and particularly mentions work in the area of food quality assessments. This is notable because the essential concept of the organic movement is that health, food quality and the nature of the agricultural system are inextricably linked. It is on this that organic agriculture was originally built and still shapes its development today.

There are many names world-wide for what we in the UK call organic agriculture and there is some variation between them. Although government backed regulations in many countries including the European Union now exist to provide a legal framework and floor which affords reasonable equivalence for the purposes of consumer protection.

It is inherently unscientific because it is based on concepts that are not explicable in rational, scientific terms.

In conceptual terms however, the genesis of organic agriculture is arguably found in three schools of thought, which originated in the first three decades of the twentieth century.

The Biodynamic or anthroposophical school of Steiner, the Organic-Biolgical school of Muller and Rusch and the Organic school of Howard and Balfour.

Also important is the work of Schuphan and Voisin who promulgated the idea of the "biological value" of soil, plant and food in the early 1960s. (3,6,7)

There are some highly significant differences between them. For example the anthroposophical perception of "ethereal and astral forces" is unique to the biodynamic school (7). But there is an essential core of agreement which (although battered and shabby in parts) remains at the heart of the organic movement. This has four aspects;

1) The concept of the farm as a living organism, tending towards a closed system in respect to nutrient flows but responsive and adapted to its own environment.

2) The concept of soil fertility through a "living soil" which has the capacity to influence and transmit health through the food chain to plants, animals and Man.

3) The notion that these linkages constitute a whole system within which there is a dynamic yet to be understood.

4) The belief in science and an insistence that whilst these ideas might be challenging orthodox scientific thinking, they could be explored, developed and eventually explained through appropriate scientific analysis.

These pioneers sought to examine, test and develop their ideas scientifically. However, from a modern perspective a good deal of their research seems inadequate. Some experiments are poorly reported, some are badly designed and some suffer from the limitations of the equipment and methodology of the time (6).

Yet there are also examples of remarkable prescience. Ideas held by the Muller-Rusch school regarding the transfer of genetic information that not so long ago were regarded as implausible have now been vindicated.

It is not surprising that the science of these pioneers is found wanting. To truly examine these concepts requires not only large sums of money but also a large intellectual leap, possibly into a black hole but also, many have argued, into holism.

As mentioned earlier that word or variations of it is commonly found in the literature of alternative agriculture to this day. However to understand how it relates to the genesis of organic agricultural theory it needs to be read and used in the way it was in the 1920s and 1930s. Perhaps the most cogent exposition of holism at this time was written by Smuts in 1929.

"Holism is the theory which makes the existence of "wholes" a fundamental feature of the world. It regards natural objects, both animate and inanimate, as wholes and not merely as assemblages of elements or parts. It looks upon nature as consisting of discrete, concrete bodies and things and not as a diffusive homogeneous continuum. And these bodies or things are not entirely resolvable into parts; in one degree or another they are wholes which are more than the sum of their parts, and the mechanical putting together of their parts will not produce them or account for their characters and behaviour. The so-called parts are in fact not real but largely abstract analytical distinctions, and do not properly or adequately express what has gone to the making the thing as a whole." (1)

“Organisms or biological wholes are not isolated units …….and they do not exist apart from their surroundings (which are themselves complexes of wholes) but on the contrary are in close contact with them, and evolve and vary partly in response to the stimulus which comes from them.

The evolving wholes are in close and responsive relation to their environment, the influence of which on them is in part temporary, and confined to the individual duration of each whole, and in part…. perpetuated through generations of wholes” (1)

The degree to which this theory has survived as part of the concept of organic agriculture to the present day can be seen in the emerging discipline of organic plant breeding. According to the seminal report on the subject “The most important conviction that unites the ….organic production chain is that products, production methods and processing methods should respect the wholeness of the living entity as much as possible, to ensure that living entities – the farm organism, the plant organism and the human organism – retain their self-regulating ability.

That is why……organic breeders should only work at the level of the crop and plant. DNA techniques, and to a large extent cell techniques too, occur outside the context of the whole plant in its relation to its environment. These techniques manipulate bits of plants in sealed, artificial laboratory conditions. In view of the goal of organic plant breeding, they are an ecological detour.”

A key point here is “the concept of “plant x environment interaction” , the environment (available nutrients, soil structure, moisture content, air temperature, etc) and changes in the environment during the plant’s growth have just as much influence on a plant’s appearance (phenotype) as its genes. In other words, a plant (genotype) is continuously interacting with its environment.” (2)

(Of course conventional plant breeders recognise this last point to some extent but they do not give it anything like the same importance nor do they acknowledge the same intellectual antecedents).

But are those antecedents worth anything? What is the evidence, the research, the observations and considerations that support these concepts? Well there is very little but there is more than none. There is not enough to satisfy a critical scientific mind but there is something to arouse interest.

In respect of the idea of the farm “a living entity” operating self-regulating cycles within a relatively closed system. The early work of the Haughley Experiment (16) and that reported by Koepf (17) showing that such systems can maintain productivity and fertility over time with few if any outside inputs has been added to. Anecdotal evidence from farmers, long-term research trials in Europe and the US, case studies and numerous single factor studies have supported it. (11,18)

That is not to say that this body of work is either definitive or conclusive. It is not and much remains to be done. But it can be said that well-functioning organic systems operate in a different, at times surprising way, to conventional farms. Those differences seem to be due to the inter-action of multiple factors that are generally not seen in conventional systems.

There is a growing body of work regarding the production system, the idea of biological food quality and the link to the health of animals and Man. This includes the observations and experiments of Sir Robert McCarrison as reported by Balfour (3).

McCarrison, having systematically observed many peoples and many diets, realised that there was a quality in the diets of the healthiest peoples which was absent from the least healthy; "that the food in all these diets is , for the most part, fresh from its source, little altered by preparation, and complete; and that, in the case of foods based on agriculture, the natural cycle is complete. Animal and vegetable waste - soil - plant - food - animal - man; no chemical or substitution stage intervenes."

It also includes the Haughley Experiment, where over 11 years a completely closed organic system was compared with rotational conventional system and a non-rotational, conventional stockless system. Even over this short period of time differences were noted in food quality, and the productivity, longevity and general health of livestock in favour of the closed system. Unfortunately, the collection of data, statistical treatments and the reporting of results are not robust enough for modern science (16).

Later work does not however suffer from this drawback. A relatively large amount of research has been completed on the quality of both crops and livestock. There is a clear trend that in appropriate crops organic produce contains more desirable components (vitamins, dry matter, protein) and less undesirable substances (pesticide residues, nitrates, sodium) than conventional produce. In livestock trials, animals fed on organically grown feed generally show greater fertility and longevity than those feed on conventionally produced feed (19,20,21).

Most of this work has been carried out using mainstream methods and statistical analysis however some so-called “novel methods” of analysis have been used in some of the trials. Picture-Developing Methods, Copper Chloride Crystallisation. Measurement of Low-level luminescence and Forced-Storage-Tests have been used to measure factors that are not revealed by chemical analysis.

These factors have been called vitality and structural energy. Clear differences have been identified between food grown in different agricultural systems and it is postulated these differences might be important for health. (19).

As the science of ecology has developed in recent decades it may now be that the concept of the farm as a living organism might not sound as preposterous to conventional scientists as perhaps it once did. But the idea that the way food is produced is important to the health of those who consume it and that food may contain qualities that are not accessible to conventional analysis flies in the face of orthodox science.

The conventional view of nutrition is that it is enough to ensure that a diet contains adequate proteins, carbohydrates, fats, vitamins, mineral salts, trace elements etc. That how they got there is of no relevance and the presence of pesticide residues per se is of no consequence to the health of the consumer. Hence statements from the Food Standards Agency and others that there is no meaningful difference between organic and conventional food.

But the world moves on and the FSA has a bit of catching up to do. A recent medical conference looking at the health implications for research and food policy of the mapping of the human genome considered that: “ The discovery of only 35,000 genes instead of the

expected 150,000 means that the nutritional environment played a pivotal role in human evolution……..we now know that the key to evolution and the behaviour of human disease is in the environment interacting with the gene and not the other way round."

One paper by the Director of the Medical Research Council's Haemostasis Research Group at the Hammersmith Hospital was entitled "Genome evolution, blood and soil – a message from deep time"(23). The abstract stated; "Blood here stands for coagulation and thrombosis, soil for the environment, deep time for the fact that the clotting system hasn't changed in 450 million years but our food has – drastically in the last 150 years. ….We now know that the way a puffer fish clots its blood in response to injury is exactly the same as the way every vertebrate "upwards" to man clots its blood and has done so for all those ages. Yet in the past 150 years a great epidemic of blood vessel disease and thrombosis – often fatal – has swept through economically advanced human populations. What has changed? Obviously not the blood clotting system. Clearly some environmental change (soil or food production/consumption) has impacted our ancient genomic heritage in unexpected and deadly ways."

Here is organic agriculture's underpinning concept – scientific or philosophical – that the health of soil, plant, animal and man is one and indivisible brought right up to date by the most modern science.

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