Pseudo-science: a threat to agriculture?

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'On what principle is it that when we see nothing but improvement behind us, we are to expect nothing but deterioration before us.'
Thomas Macaulay 1830

Abstract: *The case for agricultural science is asserted, but in the context that science is under threat in contemporary society because of the adoption of post-modern philosophies which give credibility to pseudo-science and give rise to what is now being described as Post-Normal Science. The author examines the question – Is there a legitimate argument to take to science managers, scientists, politicians and society to say pseudo-science is dangerous and should not be tolerated? It is concluded that science must be asserted and it must regain its proper moral high ground in society. To achieve this there must be changes to science policy and to how science is managed. Science, at least government (publicly) funded science, must be returned to its normative function.*

Key words: pseudo-science, publicly funded science, organic farming, scientific evidence

Introduction

In 2010, the United Nations estimated that by 2050 the world population will be about 9 billion. The world will therefore need to produce more food by increasing the area of land under cultivation and/or by increasing yields per unit area. The case has been well made elsewhere (Edmeades[1] *et al.* 2010) that to achieve this 'requires a sharp boost in research investment in plant agriculture from public and private sources, accompanied by facilitating policies'. It is this last point that I wish to expand.

In this paper, the case for agricultural science will be asserted again, but in the context that science is under threat in contemporary society because of the adoption of post-modern philosophies which give credibility to pseudo-science and give rise to what is now being described as Post-Normal Science.

The importance of agricultural science

The real value of science is best observed by looking backwards (Edmeades 2009). For example, despite major arguments at the time, we all now accept the evidence that the earth is not flat, that the sun is at the centre of our solar system and that solid matter is made up of particles. The same perspective makes a strong case for agricultural research.

We are on average better fed, healthier and wealthier than ever before (Figure 1). According to Havlin *et al.* (1999), this is a consequence of discovering and harnessing new sources of energy and, especially since the 1950s, the application of science (Figure 2). The same conclusion emerges from the longest running experiment in soil science (Figure 3). As a consequence of improved plant genetics, coupled with the use of insecticides and pesticides, the yield of wheat, as measured in this experiment,

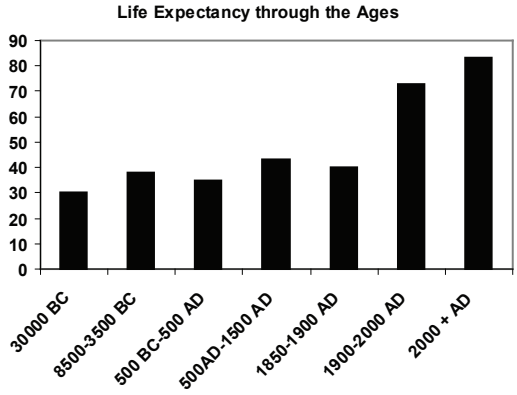

Figure 1. Life expectancy through the ages. (http://filipspagnoli.wordpress.com/2009/09/29/human-rights-facts-148-life-expectancy-throughout-history/)

[1] Not to be confused with the author.

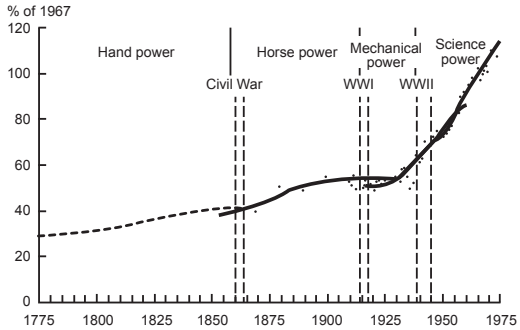

Figure 2. US agricultural productivity growth over the past 200 years. (from Havlin et al. 1999).

has increased ten-fold from about 1 tonne/ha/yr to 10 tonnes/ha over a period of 150 years. The so-called Green Revolution which began in the 1960s, and without which many people would have starved, is a more contemporary example of the success of science and technology.

Of course the incremental increases in productivity due to science may become harder and harder to achieve (Edmeades *et al.* 2010) but, as they noted, there are still significant differences between actual farm production and that possible under controlled research

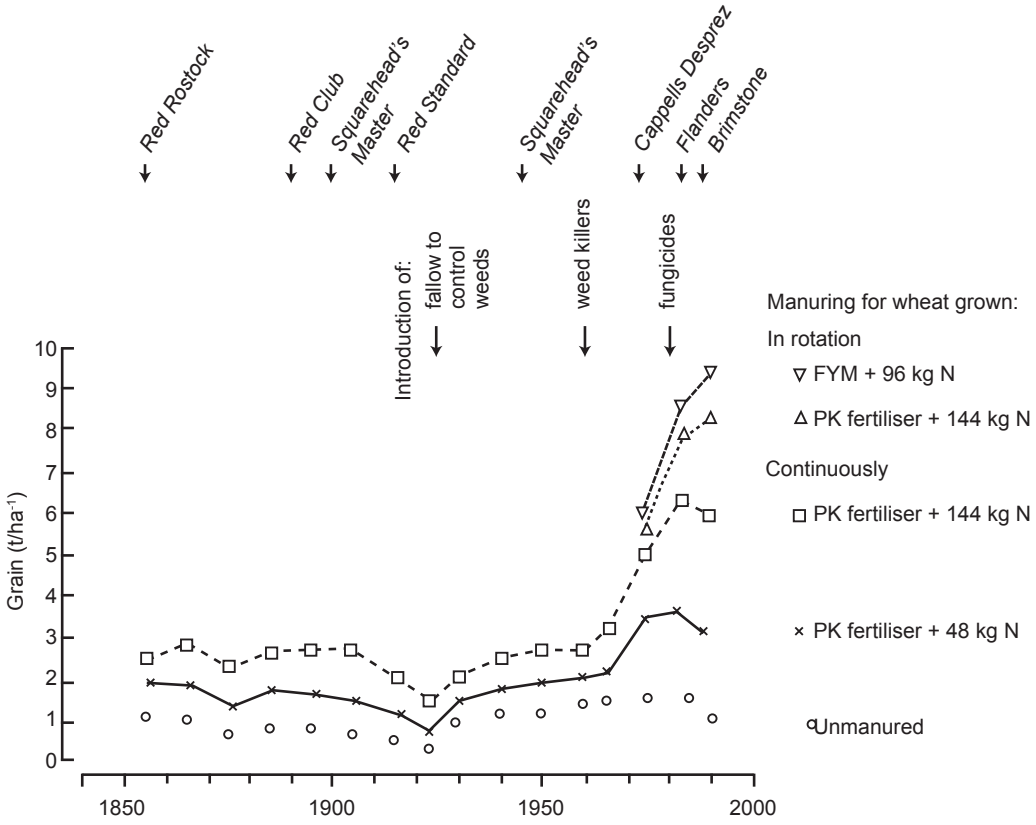

Figure 3. Wheat yield over time from Broadbalk, Rothamsted (Refer Edmeades 2003).

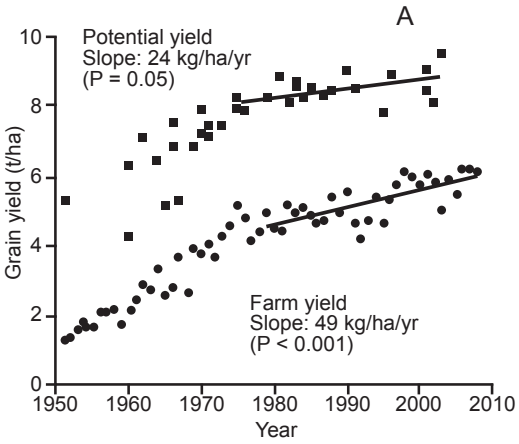

Figure 4. Changes in farm yield and potential yield over time for wheat in Mexico (from Edmeades et al. 2010).

conditions (e.g. Figure 4). Thus, there are two pathways to increase food production – through more science and improved technology transfer. There are, however, clouds of doubt which threaten these opportunities.

Post-modern philosophy

Respect for science is being eroded and to understand why, we need to understand the philosophical settings of modern society. Simplistically[2], in the Dark Ages the Church was the authority because only the priests could, *via* prayer, find the truth as revealed by God. If failures occurred they were a consequence of disobedience to Gods laws (Table 1). The Age of Reason emerged out of this gloom with the development of what we now call the scientific method – truth was that revealed by the application of logic and reason to the empirical evidence. Science became the authority. The industrial revolution was a consequence, and as indicated above, the progress made by society, at least western society, was astounding.

But confidence in science and its products – technology – began to be questioned after two world wars and the development of the atomic bomb. Science, while not the cause, was seen as part of 'the problem' – there must be, some argued, a better way forward for society. This led to the philosophical movement called post-modernism which sets aside evidence as the authority and asserts that the 'truth' is what you believe – if you believe it, then it is your 'truth' – the age of individualism had arrived. Importantly, in this setting, all opinions are to be given equal authority; irrespective of where the evidence lay.

The political expression of post-modernism is found in what is called *laizie faire* politics – less government is good government! Accordingly, it was argued that it is not the government's role to

Table 1 Authority and belief through time (modified from Roche and Edmeades 2005).

Period	Truth	Authority	Attitude	Example
Dark Ages	Revealed by God though prayer.	Church	Thou shalt obey the laws of God.	Pray for a good harvest. Your animals died because you sinned.
Age of Reason	Revealed by reason based on the evidence	Science	What is the evidence and what can logically be deduced from the evidence.	Liquid fertiliser are ineffective. Albrecht's ratio theory is flawed.
Post-modernism	If you believe it is true	Individual	Science is the reason for all our problems. A new way must be found.	Homeopathy works because I believe it. Organic farming is better for the environment.

[2] To avoid being accused of pseudo-science myself (see discussion later) I must declare that I have no training in philosophy and do not keep up to date with the relevant literature. What I have recorded here is my personal understanding based on limited reading. If there are errors of fact, logic or interpretation I would be most grateful to have them corrected.

set or impose standards – that was now to be left to society and its representatives, the professional and industrial bodies – self-regulation became the mantra. A relevant agricultural example in New Zealand is the Fertiliser Act 1960 which was repealed in 1997 as part of a package of reforms. It was replaced by the Federated Farmers 'FertMark Scheme'. This is a voluntary scheme and deals only with 'truth of labelling'. As a matter of policy the agronomic efficacy of products is not considered. Needless to say it is completely ineffective at protecting its farmer members from products marketed on the basis of pseudo-science. Presently in New Zealand, it is quite legal to sell almost anything and call it a fertiliser as shown by one of the examples discussed later.

Post-modernism has progressed to what is now being called 'Post-Normal Science'. This holds that science is subservient to the story that must be told. The role of science is no longer about discovering new 'truth', but supporting the 'story' which is perceived to be the truth. This gives rise to the notion of 'noble-cause science', which allows scientists to ignore contrary evidence, or worse, manipulate the evidence, if the cause is noble. There is evidence of this in the current climate change debate as will also be discussed later.

It is in this manner that post-modernism has provided a philosophical framework that legitimises pseudo-science. This applies especially to one of its 'success' stories – environmentalism. Indeed, Geering (2002) a well respected New Zealand theologian, has suggested that environmentalism is logically the new 'God'. We have gone, it appears, full circle from the Gods of the Dark Ages to the Gods of environmentalism[3].

[3] A clear distinction is required. We must find ways of using our resources – soil, water, air, energy carefully and efficiently and I have no doubt we can and will. After all, the hallmark of modern man is success (refer to Figures. 1–4). But this will only be achieved by the application of the science method based on evidence. This approach is to be contrasted with 'environmentalism' based on a blind faith that we are ruining the planet and we must repent and serve the new God of 'environmentalism'.

Psuedo-science

Post-modern philosophy not only provides a fertile breeding ground for pseudo- (false, fake) science, but it also undermines the importance of science. How else do we explain, for example, at a time in human history which owes so much to science, that alternative 'medicines', for which no proof of efficacy is required, sit on the same shelves as real medicines, which must meet strict evidentiary requirements? How is it that a recent business award in New Zealand went to a person whose company offers farmers homeopathic remedies for their animals? And how is it that a leading New Zealand farming magazine can run this 'success story' with not a comment to warn farmers that homeopathy is pseudo-science? All of these questions are, in themselves, evidence of how invasive pseudo-science has become in modern society. With the help of Coker (2001) it is instructive to look at some examples of pseudo-science to explore how it operates.

Psuedo-science is anti-science

At its heart pseudo-science is anti-science because it can only prevail if science is undermined and belittled. Here are some examples related to agricultural science:

> 'Our chemical experiment (i.e. the past 80 years of farming) using high leaching fertilisers has effectively stripped the majority of the minerals from the soil …… these serious deficiencies are arguably the most urgent problem we need to address in the coming century ' Nutritech Solutions Pty Ltd

> 'Past agricultural practices have resulted in the demineralisation of our farming soils and the chemical sterilisation of the soil biology that would normally deliver these minerals to the plants'. Abron Living Soil Solutions Ltd

Given the empirical evidence in Figures 1 to 4 these generalised statements are false. They also demonstrate some of the other characteristics of pseudo-science – science words, or words that sound scientific, are used, even though at the same time they condemn agricultural science as the problem! And this is another reason why pseudo-science is so pernicious. A competent scientist aware of the evidence would not be duped, but what about the layman, or indeed

the technically illiterate journalist looking for an alarmist story that will sell?

Psuedo-science uses fear-mongering

Pseudo-science plays on people's emotions by implying that doomsday is imminent. Here are two examples related to agriculture:

> 'We now have the lowest nutrient density in our food than we have ever had in out history and we can relate that to what is happening health-wise' Dr Christine Jones
>
> 'Millions of acres of soil that sustained the worlds feed supply are under assault. For decades farmers have learned to use large quantities of fossil fuels to produce crops. But these synthetic additives have pushed our soils, our environment and our health to the limit.' Dr Arden Anderson

Once again the evidence about human longevity and soil productivity, discussed earlier are alone enough to negate these comments and we are entitled to ask Macaulay's question posed at the beginning of this paper: 'On what principle is it that when we see nothing but improvement behind us, we are to expect nothing but deterioration before us?'

Psuedo-science uses conspiracy theories

> '…..why does conventional agriculture… sanction and perpetuate the obscuring and demoting of William Albrecht's landmark work in soil science, as well as his forced early retirement, in order to secure substantial grants from major chemical companies…' Dr Arden Anderson

Psuedo-science claims wisdom from the past now overlooked

> 'Biological agriculture is a new paradigm, a rekindling and modernization of ancient wisdom'. Dr Arden Anderson

Psuedo-science is too good to be true

> 'Most of the diseases are nutritionally related so that things like cancer, cardiovascular disease, diabetes – all these things are related to the fact that we do not have the trace elements in our bodies'. Dr Christine Jones

Many claims made by those who practice pseudo-science are simple nonsense. Consider for a moment that cancer, cardiovascular disease and diabetes could be cured by the administration of a cocktail of trace elements! As my colleague Dr Roche would say, 'If it sounds too good to be true it probably is!'

Psuedo-science calls for a new way of thinking!

> 'We need a fundamental redesign of agriculture and the whole approach to food and food production' Dr Christine Jones
>
> 'Science needs the freedom to think outside the square by incorporating intuition with intellect to create new opportunities and new business' Mr J K Morris, Agrissentials Ltd

Why, given the evidence showing the success of science and technology is it necessary for a 'fundamental' change? I agree that agricultural science faces a large challenge as it attempts to feed a world of 9 billion people and at the same time reduce our environmental footprint, but this does not imply that agricultural science is flawed in some fundamental way. And the meaning behind Mr Morris's statement above becomes clearer when it is realised that his New Zealand company, Agrissentials Ltd, sells ground basalt rock and claims it is a 'fertiliser' – the old science says it is ineffective, but the new intuitive – if you believe it 'science' – will claim its positive merits!

In effect, these people want to change the rules of science so that their 'new science' will endorse or embrace their opinions or products.

'Scientists' practice pseudo-science

The boundary between real science and fake science becomes even more blurred because some people who can legitimately claim to have a science degree, practice pseudo-science. Some of the examples above have been deliberately chosen to demonstrate this point. This is not only very confusing for laypeople, including the press, but it is distressing for scientists who sense that their profession is being compromised.

While it is perhaps understandable that pedlars of snake-oils overstate the claims they make for their products, how is it that people with science backgrounds can indulge in pseudo-science? Coker (2001) suggests that this arises when scientists plunge into disciplines outside their area of competence, and noted that, science is

not a badge (a noun), but an activity (a verb). A scientist can be described as a person who has learned to understand and apply the scientific method – what logical conclusions can be made after considering all the evidence. In this sense, science is a tool, and what differentiates a scientist from a non-scientist is whether the tool of science is being applied in a particular case? Thus, the test that distinguishes a scientist from a pseudo-scientist is not the qualification held by the person, but whether the statements, claims and conclusions made by that person are based on an objective and logical analysis of all the available evidence. The statements recorded above by Drs Anderson and Jones fail this test, despite their qualifications.

Modern science policies

The case for science has been eroded further by modern science policies and management – science world-wide has been politicised and commercialised. As explained elsewhere (Edmeades 2004, 2009, 2011) these changes shift the focus and purpose of science and technology transfer from its normative[3] role to one of finding research dollars and/or serving a political agenda. There is evidence of this in New Zealand as agricultural science 'cuddles up' to the 'organic dollar' and in the process imbues pseudo-science with a credibility it does not deserve. Some scientists secure and confident in their funding, or because of their professional integrity, resist this urge, but others cannot as two recent examples demonstrate.

The National Institute of Water and Atmosphere (NIWA) is a government owned research organisation. Its website records the average New Zealand temperature for the past one hundred years as shown in Figure 5. This suggests that the average New Zealand temperature has increased since about 1900. The New Zealand Climate Science Coalition has quite legitimately obtained the raw data (Figure 6). It shows no warming.

These data are derived from seven long-term climate stations and there are legitimate reasons for making adjustments to the record to accommodate changes around, or shifts in, their location. However, after exhaustive enquiries through layers of political obfuscation from the Government and NIWA, Brill (2010*a*) found that the evidential basis for these changes does not exist. In response to this challenge and to support the earlier Seven Station Series, NIWA published a further graph this time based on an Eleven Station Series. Brill (2010*b*) exposed this also as a contrivance, achieved by the selection of particular weather records.

Importantly, the issue here is not climate change. It is about the conduct of science. The checks and balances which are essential for the science process to operate, require that science, and in particular publicly funded science, must be open to scrutiny. While it is essential that science is used to inform Government policies, the process of science must never be captured by politics. Is this a local example of sloppy science or is it, what was alluded to earlier – Post-Normal Science – science in the service of a good story? I note that this is a world-wide problem (D'Aleo and Watts 2010).

Universities, once regarded as the bastions of independent free-thought and debate in society, have also been engulfed by the clouds of commercialisation and politicisation as the following example demonstrates.

Ravensdown Fertiliser Cooperative Ltd is marketing a product – a denitrification inhibitor – called EcoN. Based on research from Lincoln University (the patent is owned jointly by the two parties) it is claimed that it can increase pasture production by up to 20% (Cameron *et al.* 2009). This is an important feature of the marketing message to farmers. I reviewed all the available field trial results in New Zealand (n = 28 trial years) and concluded (Edmeades 2008) that the average pasture response was 2% ± 1%, exactly as predicted based on its nitrogen (N) content (DCD is an N compound).

The problem in this case was not the quality of the research, but the extrapolation of the Lincoln results to the 'on-farm' situation. All the research conducted at Lincoln University measured the effects of EcoN in the presence of

[3] Normative = pertaining to a norm, establishing a standard.

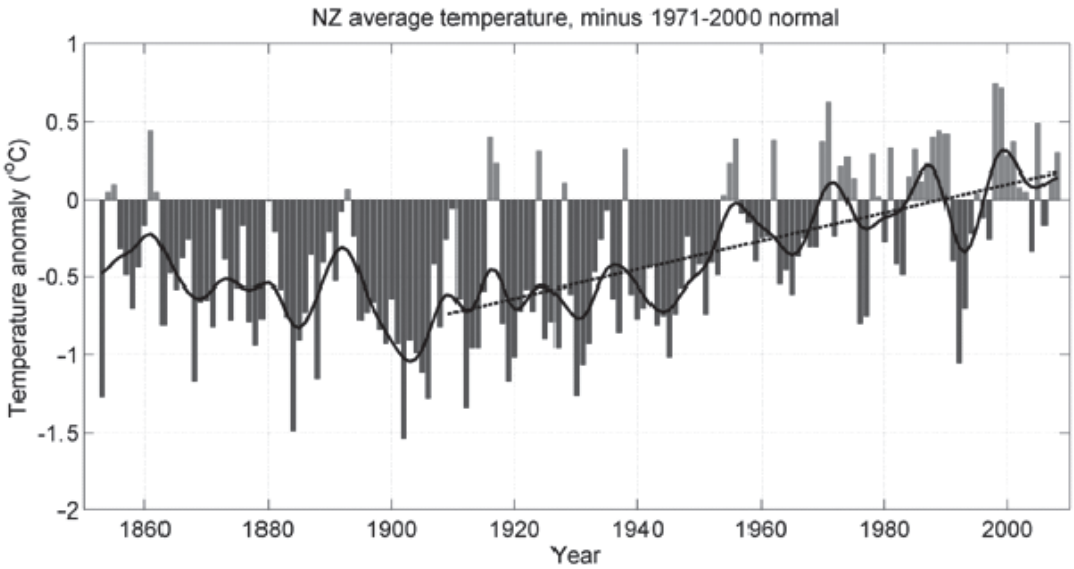

Figure 5. Adjusted average NZ temperatures from 1860 to 2000 as reported by NIWA. (http:/www.niwa.co.nz/our-science/climate/news/all/nz-temp-record)

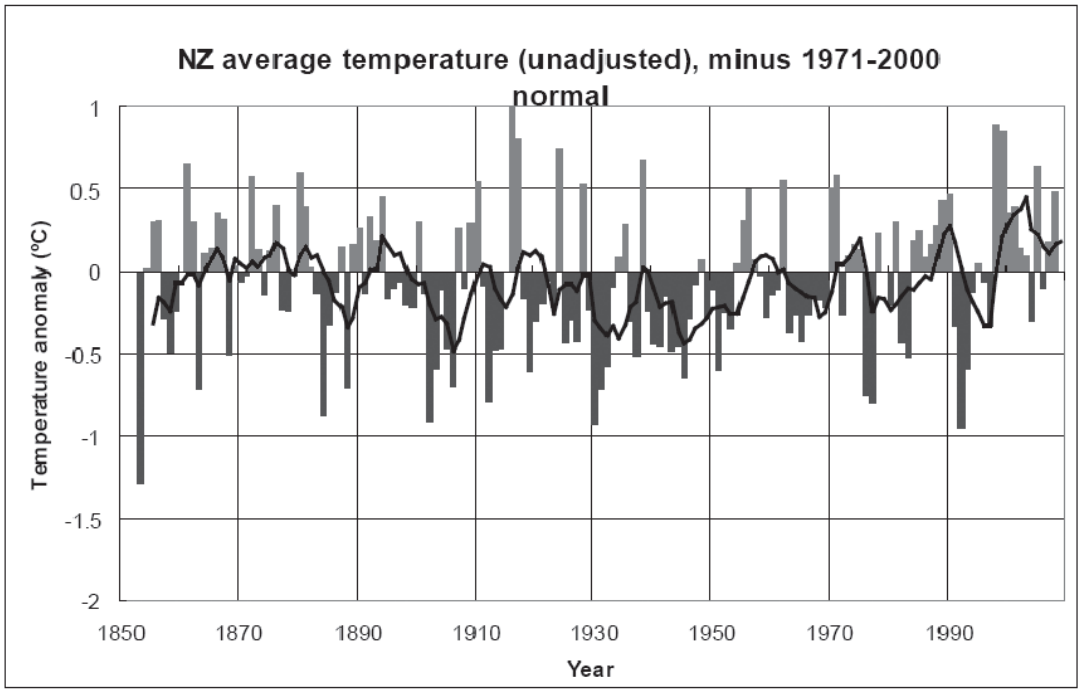

Figure 6. Actual average NZ temperatures from 1860 to 2000 from NIWA data. (http://www.climateconversation.wordshine.co.nz/docs/awfw/are-we-feeling-warmer-yet.htm

large N inputs (200 kg urea N/ha and 1000 kg urine N/ha), which of course do not occur in the farm situation. As the researchers themselves say they have been investigating the 'worst case scenario'. It was in my view, inappropriate to use the Lincoln University results to promote the product to farmers. Is this a case where the commercial imperative distorting the science message?

If the commercialisation of science is here to stay what should be done in such cases to protect the public interest? I think the only solution is that scientists, when writing and commenting about products and services, are made to declare all their private interests, so that the public can make its own assessment as to what weight, if any, should be placed in any opinion and conclusions which are offered.

The organic movement is psuedo-science

Green politics is now a given world-wide. In New Zealand, we have a Green Party whose goal is to make New Zealand organic by 2020. Organic farming is becoming legitimate and is attracting research dollars. But the whole organic farming movement is pseudo-science, as I will now discuss.

Prior to the mid 1800s people wondered what the 'life force[4]' was in soils that made plants grow. It was, at that time, reasonable to infer that it may have something to do with the organic matter, because it was known by experience that the application of organic manures and composts did improve plant growth on some soils. The German scientist von Liebig was the first to begin to unravel this mystical knot. He showed that the 'active ingredients' (leaving aside water, atmosphere and sunlight for the moment) in soils were nutrients. Limited by the knowledge and technology at the time, he identified just three; nitrogen, phosphorus and potassium. We now know that 16 nutrients are essential for healthy plant growth. Furthermore, we know conclusively that organic matter *per se* is not required – this fact is readily demonstrated by growing plant in hydroponics. Thus, the supposed mystical power of organic has evaporated in the light of the evidence.

Despite this evidence the myth of organic matter not only remains, but has become more strident in this post-modern – if I believe it then it is true – era. Indeed, some argue that the only path forward for the world is to adopt 'organic' farming practices, which they claim would result in healthier soils, animals and people plus less environmental damage. These claims are false. Goulding *et al.* (2009) provide evidence from many trials showing that the yields achievable from organic farming are on average about 68% of those that can be achieved by conventional practices. Additionally, there is no evidence that organic foods offer nutritional advantages, relative to conventional food (Woese *et al.* 1997; Bourn and Prescott 2002; Dangour *et al.* 2009; Goulding *et al.* 2009), or that organic fertilisers are better than chemical fertiliser (Edmeades 2003). To complete the picture, Kirkman (2005) has summarised the evidence showing that organic practices do not confer advantages in terms of environmental outcome.

The fact that the organic farming movement is apparently thriving today is itself a measure of the dangerous leniency offered by post-modern thinking. Those people who espouse its cause demonstrate Post-Normal Science in operation – evidence be damned, we must save the planet!

Does it matter?

The question arises: does it matter? Is there a legitimate argument to take to science managers, scientists, politicians and society to say pseudo-science is dangerous and should not be tolerated? I think there is.

Liquid fertilisers derived from natural products have been and are marketed to farmers world-wide. Many claims are made for these products based on pseudo-science. I recently reviewed (Edmeades 2002) all the international literature and reported 810 trial-years of data on 28 such products across a wide range of crops. The only possible conclusion was that these products are

[4] Soil organic matter of course has many beneficial effects on soil properties including the storage of water and nutrients and the enhancement of soil structure, but it is not essential for plant growth.

ineffective when used as recommended – in fact they were no better or worse than water! Most of this research was conducted by publicly funded government agencies – was it good use of the taxpayers money?

Assuming that field research costs about $NZ 20,000 per trial-year, this represents about $16m in research time and effort. To this must be added the costs incurred by unsuspecting farmers who purchased these products, plus the loss in crop production resulting from their use. If it could be calculated it would represent many millions of dollars. And it was all wasted because it was, and is, entirely predictable based on known science that these products could not work based on the concentrations of what they contained (nutrients, organic matter and plant growth stimulants), and the recommended rates of application. All of this wasted effort and lost production because science was not asserted and pseudo-science prevailed!

Iowa State University maintains a 'Compendium of research reports on the use of non-traditional materials for crop production' (Iowa State University 2011). It lists the results for many trials and products. Many of these products are dubious and are marketed on the basis of pseudo-science. Once again the cost in terms of wasted science resources and loss in agricultural productivity must be enormous.

A more local example was reported by Virgona and Daniel (2011). Despite that fact that there is abundant evidence showing that increasing soil P levels in pastoral agriculture can increase productivity and profitability, this technology is not being applied by farmers. While there are likely to be a number of reasons, is it possible that these farmers have not taken up this technology because they have heard the pseudo-science – chemical fertilisers are dangerous, we are ruining our soils? Even if they did not necessarily agree, what effect does such pseudo-science have on their confidence?

Similarly, farmers on both sides of the Tasman are being told by pseudo-scientists that the 'old' method of soil testing and fertiliser advice, which is based on scientific evidence, is out-of-date and that a theory, suppressed for years by the establishment, has been rediscovered – Professor Albrecht's Base Cation Ratio Theory is now in vogue. Once again this is pseudo-science in action for it is known that the Ratio Theory is, not only technically flawed, but results in grossly incorrect fertiliser advice (Kopittke and Menzies 2007; Fertiliser Review 2011) and hence inefficient agricultural production.

Consider further, if the pseudo-science of 'organic farming' was accepted by the majority then it is predictable based on current evidence that the world food production would decline to about 68% of current levels. The options then become stark. Either 32% of the world's current population would have to starve or the area under cultivation would need to increase substantially, with its concomitant effects on soil erosion from the most vulnerable soils and loss in biodiversity.

The ongoing application of pseudo-science in agriculture is very dangerous – it is wasteful of science resources, results in misleading advice to farmers, undermines farmer's confidence and cost millions of dollars in lost productivity. If agricultural science is going to meet the challenge of feeding 9 billion people by 2050 and at the same time ensure clean water, clean air and healthy soils and food then the only path forward is for evidence-based progress.

Solutions?

Carl Sagan, one of the great astronomers and thinkers of the twentieth century, summed it up succinctly, with what I hope will be immortal words:

> 'The only antidote to pseudo science is science itself.' Carl Sagan

To give effect to Sagan's imperative, science must be asserted and it must regain its proper moral high ground in society. This is not arrogance for it is not claiming too much. To achieve this there must be changes to science policy and to how science is managed. Science, at least government (publicly) funded science, must be returned to its normative function. Science works best for society if scientists are free to speak openly on matters of public importance, without the fear of either losing their jobs or their funding or

both – the principle of academic freedom must prevail. For it is only when these changes are made that scientists and their managers will once again have the courage and the confidence to speak for science.

> 'Those who are fortunate enough to have chosen science as a career have an obligation to inform the public about voodoo science'. Robert Park

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