THE FUTURE OF FARMING: WHAT NEEDS TO CHANGE?

A Personal View

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My concern

We are gathered here this evening to honour the life and work of Professor Hugh Bunting whose spirit demanded that difficult issues and concerns be addressed with honesty and forthrightness. In the spirit of Professor Bunting, and as his student, I too have a concern to address this evening and I will endeavor to elucidate my concern with honesty and forthrightness.

My concern is about the quality and direction of the agricultural production systems in the UK and mainland Europe, and therefore of the agriculture sector in general, which in my opinion have moved dangerously off course onto a path of declining productivity and increasing negative externalities, a path that is considered to be unsustainable ecologically as well as economically and socially. Indeed, my concern is that I consider the agriculture production paradigm as is predominantly conceived and practised – the intensive tillage-based interventionist farming with its high and addictive dependence on agrochemical inputs and heavy machinery -- is no longer fit to meet the agricultural and rural resource management needs and demands of the 21st century.

The future, as I see it, requires farming to be multi-functional and at the same time ecologically sustainable so that it can deliver ecosystem goods and services as well as livelihoods to producers and society. Farming needs to effectively address local, national and international challenges. These challenges include: food, water and energy insecurity, climate change, pervasive rural poverty, and degradation of natural resources.

What has ignited and fueled my concern?

My concern reached a 'tipping-point' this year with a dust storm in northern Germany. This dust storm caused an 81 car pile-up killing 7 people; the dust storm was caused by intensive tillage that leaves the top soil pulverised and exposed to wind and rain. My 40-odd years of work in agricultural research and development internationally made me aware of other recent events which brought me to this point of needing to outline the changes I deem essential to put agriculture onto a more sustainable path and improve our planet. To name a few: (1) some 3 million tones of soil took off in a giant plume from Ukraine, dumping thousands of tones of it in Kent; (2) in Europe, the number of agricultural birds has been reported to have dropped by some 50%; (3) in the UK, detectable amounts of pesticides in food are being reported; (4) in the European Commission, UK was amongst the five governments that blocked the deliberations on

the soil directive framework; (5) donor agencies including DFID continue to fund international agricultural research in the name of poverty alleviation that does not produce sustainable pro-poor production system solutions for strengthening household food security and rural livelihoods; 6) DEFRA's solution to 'safeguarding our soils' is the mouldboard plough as seen in its document "Soil Strategy for England"; 7) LEAF's document "Simply Sustainable Soil Solution" for improving land sustainability displays on the cover page a photo of a field in a dissected terrain being ploughed; and, 8) many agricultural students from European universities - including the UK - graduate with poor knowledge of sustainable production intensification and of systems such as Conservation Agriculture (CA) or System of Rice Intensification (SRI) that are more productive and ecologically sustainable;.

My concern has grown stronger by the consequences of unquestioned faith and reliance on the 'industrialised agriculture' mentality of technological interventions of genetics and agrochemicals in tillage-based agriculture. Now known as the 'old paradigm', this way of farming since WWII was seen as the best option for production intensification and agricultural development to keep hunger and famine at bay after WWII. Subsequently, this paradigm was thought to be a partial solution also for poverty alleviation in the developing countries.

The consequences of this unquestioned belief in industrialised agriculture produced: (1) the now disputed notion that traditional varieties were lacking in absolute potential and could not respond, as modern varieties do, to inputs of mineral fertilizer. Modern varieties combined with intensive tillage and agrochemicals were considered essential to boost yields and required output and at the same time maintain enhanced 'soil fertility' level. The consequence has been a large scale *in situ* loss of traditional germplasm resources globally; (2) declining yields and factor productivities since the eighties in the heartland of the 'Green Revolution' in the Indo-Gangetic Plains of South Asia; and (3) the CGIAR abandoning its research on production systems development to unfunded National Agricultural Research Systems (NARS) by claiming that production systems were location specific while CGIAR was in the business of generating international public goods of wide applicability. The consequence is that strategic research on sustainable production systems has all but disappeared from international research agenda. By dismantling production systems research, a further consequence was the decimation of staff with expertise in agronomy, crop physiology, soil microbiology, agro-ecology and farming systems.

The destruction of soil and agro-ecosystems by tillage-based production systems

Taking enforced time off from my profession in 2004 allowed me to catch up on professional reading and to reflect on my experiences and observations during my career. It gave me an opportunity to inform myself of the conclusions other concerned experts in the field and institutional leaders internationally were reaching. Reading and researching my colleagues'

work, their questions and conclusions served as a filter through which I could interpret and make sense of things that I had observed and questioned over the past five decades.

My personal view and conclusion is: *the root cause of our agricultural land degradation and deceasing productivity – as seen in terms of loss of soil health -- is our low soil-carbon farming paradigm of intensive tillage which disrupts and debilitates many important soil-mediated ecosystem functions. For the most part our soils are becoming de-structured, our landscape is exposed and unprotected, and soil life is starved of organic matter. This loss of soil biodiversity, destruction of soil structure and its recuperating capacity, increased soil compaction, runoff and erosion, and infestation by pests, pathogens and weeds indicates the current poor state of the health of many of our soils,*

Further, I concluded that the condition of our soils was being exacerbated by: (a) applying excessive mineral fertilisers on to farm land that has been losing its ability to respond to inputs due to degradation in soil health, and (b) reducing or doing away with crop diversity and rotations (which were largely in place around the time of WWII) due to agrochemical inputs and commodity-based market forces.

Furthermore, I and others determined that the situation is leading to further problems of increased threats from insect pests, diseases and weeds against which farmers are forced to apply ever more pesticides and herbicides, and which further damage biodiversity and pollute the environment.

It seems to us who deal with agricultural production systems that with intensive tillage as a basis of the current agriculture production and intensification paradigm we have now arrived at a 'dangerous' point in agro-ecosystem degradation globally, including in the industrialised North. However, we also know that the solution for sustainable farming has been known for a long time, at least since the mid-thirties when the mid-west of USA suffered massive dust storms and soil degradation due to intensive ploughing of the prairies.

For instance, in 1943, Edward Faulkner wrote a book '*The Ploughman's Folly*' in which he stated that there is no scientific evidence for the need to plough. More recently, David Montgomery in his well-research book '*Dirt: The Erosion of Civilizations*' shows that generally with any form of tillage including non-inversion tillage the rate of soil degradation (loss of soil health) and soil erosion is greater than the rate of soil formation. According to Montgomery's research, tillage has caused the destruction of agricultural resource base and of its productive capacity nearly everywhere, and continues to do so.

For these natural science writers as far back as 1943, tillage is not compatible with sustainable agriculture. We only have to look at the various international assessments of the large-scale degradation of our land resource base and the loss of productivity globally to reach a consensus as to whether or not the further promotion of any form of tillage-based agriculture is a wise

development strategy. I contend that to continue with intensive tillage agriculture now verges on irresponsibility towards society and nature. Thus I maintain that with tillage-based agriculture in all agro-ecologies, no matter how different and unsuitable they may seem for no-till farming, crop productivity (efficiency) and output *cannot be optimized* to the full potential. Further, agricultural land under tillage is not fully able to deliver the needed range and quality of environmental services that are mediated by ecosystem functions in the soil system. Obviously, something must change.

Two farming paradigms

Essentially, we have two farming paradigms operating, and both aspire to sustainability. (1) The tillage-based farming systems, including intensive tillage with inversion ploughing during the last century, aims at modifying soil structure to create a clean seed bed for planting seeds and to bury weeds or incorporate residues. This is the *interventionist paradigm* in which most aspects of crop production are controlled by technological interventions such as soil tilling, modern varieties, protective or curative pest, pathogen and weed control with agrochemicals, and the application of mineral fertilizers for plant nutrition. (2) The no-tillage farming systems, since the forties or so, take a predominantly ecosystem approach, and are productive and ecologically sustainable. This is the *agro-ecological paradigm* characterised by minimal disturbance of the soil and the natural environment, the use of traditional or modern adapted varieties, plant nutrition from organic and non-organic sources including biological nitrogen fixation, and the use of both natural and managed biodiversity to produce food, raw materials and other ecosystem services. Crop production based on an ecosystem or agro-ecological approach can sustain the health of farmland already in use, and can regenerate land left in poor condition by past misuse.

The post-WWII agricultural policy

The post-WWII agricultural policy placed increasing reliance upon ‘new’ high yielding seeds, more intensive tillage of various types and heavy and more powerful machines, combined with even more chemical fertilizers, pesticides and herbicides, and mono-cropping. According to my reading, factories producing nitrates for manufacturing explosives needed for WWII quickly had to find an alternate market once the war ended. The crop production sector was a sitting target for the explosives salesmen who went around convincing farmers that high yields and more profit could be obtained with mineral nitrogen and that there was presumably no real need for crop diversification and rotations with legumes or for adding organic sources of plant nutrients or animal manure. This technological interventionist approach became the accepted paradigm for production intensification, and was promoted globally -- referred to as the Green Revolution paradigm of the 50’s and 60’s -- and resulted in the following:

- loss of SOM, porosity, aeration, biota (=decline in soil health) -> collapse of soil structure -> surface sealing, often accompanied by mechanical compaction, -> decrease in infiltration -> waterlogging -> flooding) (Figure 1);

- loss of water as runoff and of soil as sediment;
- loss of time, seeds, fertilizer, pesticide (erosion, leaching);
- less capacity to capture and slowly release water and nutrients;
- less efficiency of mineral fertilizer: "*The crops have become 'addicted' to fertilizers"*;
- loss of biodiversity in the ecosystem, below & above soil surface;
- more pest problems (breakdown of food-webs for micro-organisms and natural pest control);
- falling input efficiency & factor productivities, declining yields;
- reduced resilience, reduced sustainability;
- poor adaptability to climate-change and its mitigation;
- *higher production costs, lower farm productivity and profit, degraded ecosystem services.*

Figure 1: Consequence of intensive-tillage paradigm. Notice that due to soil compaction and loss in water infiltration ability caused by regular soil tillage leads to impeded drainage and flooding after a thunder storm in the ploughed field (right) and no flooding in the no-till field (left) (Credit: Wolfgang Sturny).

Warning bells have been sounding almost continuously since the 1940's including:

- *Ploughman's Folly*, by Edward Faulkner, 1943
- *Living Soil*, by Eva Balfour, 1943
- *One Straw Revolution*, by Masanobu Fukuoka, 1947
- *Silent Spring*, by Rachel Carson, 1962
- *Dirt: the erosion of civilizations*, by David Montgomery, 2007
- Spread of no-till farming in the Americas, particularly since the 1930's in North America and since the 1970's in South America
- The UN conference on Environment, Stockholm 1979
- The UN conference on Environment and Development, Rio 2002
- Conservation Agriculture World Congress process since 2000
- Millennium Ecosystem Assessments 2005
- IAASTD Report 2007
- UK Foresight Report 2011.

A solution: Conservation Agriculture (CA), a no-till agro-ecological system

Conservation Agriculture (CA), also known as a 'no-till' farming system, is an effective solution to stopping agricultural land degradation and for rehabilitation, and for sustainable crop production intensification. CA has gained momentum in North and South America, in Australia and New Zealand, in Asia in Kazakhstan and China, and in the southern Africa region. CA has the following three core inter-linked principles:

- **Minimizing mechanical soil disturbance** and seeding or planting directly into untilled soil, in order to maintain or improve soil organic matter content, soil structure and overall soil health.

- **Enhancing and maintaining Carbon-rich organic matter cover on the soil surface**, using crops, cover crops or crop residues. This protects the soil surface, conserves water and nutrients, promotes soil biological activity and contributes to integrated weed and pest management.

- **Diversification of species** – both annuals and perennials - in associations, sequences and rotations that can include trees, shrubs, pastures and crops, all contributing to enhanced crop and livestock nutrition and improved system resilience.

These principles and key practices appear to offer an entirely appropriate solution, with the potential capacity to slow and reverse productivity losses and environmental damages. In conjunction with other complementary good crop management practices for integrated crop nutrition, pest and water management, and good quality adapted seeds, the implementation of the CA principles provide a solid foundation for sustainable production intensification. These principles can be integrated into most rainfed and irrigated production systems to strengthen their

ecological sustainability, including horticulture, agro-forestry, organic farming, SRI, 'slash and burn' rotational farming, and integrated crop-livestock systems,

CA is a lead example of the agro-ecological paradigm for sustainable production intensification now adopted by FAO as seen in its recent publication '*Save and Grow*'.

Currently, there is some 117 million ha under CA (some 8% of global cropland) of which South America has the largest area with 55.6 m ha (47.6% of global total) followed by North America with 40.0 m ha (34.4%). Australia and New Zealand have 17.2 m ha (14.7% of global total). Asia has 2.6 m ha (2.2%). Europe has 1.2 m ha (1.0% of global total). Africa has 0.3 m ha (0.3% of global total). Overall, some 50% of the global area under CA is located in developing countries and 50% in industrialised countries.

In the adoption of or transformation to CA, there are constraints and opportunities that must be addressed in different ways in different places depending on their nature. These include:

- Weeds that can be controlled using integrated management practices involving a combination of surface mulch, cover crops, rotations and herbicides.
- Labour requirement which by and large is reduced with increase in labour productivity (in terms of output per unit input) in all CA systems whether with manual, animal or mechanised farm power.
- Larger farmers are not the only beneficiaries of CA. Small farmers with any farm power source can practice CA and harness a range of benefits. Similarly, field-based horticulture production can also benefit from CA, whether small or large scale.
- Livestock can create a competition for residues but over time CA generates more biomass which can permit effective management of functional biomass and the so called competition for residue with livestock. A combination of on-farm livestock management and area integration of crop-livestock with community participation provides a basis for overcoming this constraint.
- Temperate areas of Europe are claimed to be different from other areas where CA has been widely adopted. This appears to be a myth, as seen from the viewpoint of almost a 'wholesale' transformation to CA in some states in Canada and in Western Australia and parts of USA, and more recently the introduction of CA in Finland, Switzerland, France, Germany and Denmark.

Constraints to CA adoption appear to be surmountable for up-scaling when:

- Farmers are working together in testing and sharing experience and generating new knowledge.
- Appropriate and affordable no-till equipment and machinery is available.

- There is relevant knowledge generation and technical capacity in the research and extension system to offer advice to farmers, industry and policy makers.
- Any risk involved in transforming to no-till systems is buffered through appropriate insurances and/or incentives.
- There is effective policy and institutional support for adoption and widespread uptake.

CA - an opportunity to save and make money and to improve the planet

Against the background of rising input, food and energy costs, CA can decrease fertilizer needs by 30-50%, water needs by 20-30%, fuel consumption by 50-70%, pesticide and herbicide use by 20%. Reduced cost of production with CA is a key to better profitability and competitiveness, as well as keeping food affordable. For example, using CA on Tony Reynolds' farm at Thurlby, Lincolnshire (UK), crop establishment cost comparisons show that costs are £245 and £36 for traditional method and for no-till seeding respectively. Similarly, his fuel use dropped from 96 litres/ha under the traditional tillage method for land preparation and crop establishment to 42 litres/ha under the no-till method.

Reynolds' experience of switching to CA confirms that the known advantages of CA include higher soil carbon levels and microorganism and meso fauna activity over time, minimisation or avoidance of soil erosion, the reversal of soil degradation, improved aquifer recharge due to greater density of soil biopores due to more earthworms and more extensive and deeper rooting. CA advantages also include adaptation to climate change due to increased infiltration and soil moisture storage and increased availability of soil moisture to crops, reduced runoff and flooding, and improved drought and heat tolerance by crops, and climate change mitigation through reduced emissions due to 50-70% lower fuel use, 20-50% lower fertilizer/pesticides, 50% reduction in machinery and use of smaller machines, C-sequestration of 0.05-0.2 $t \cdot ha^{-1} \cdot y^{-1}$ depending on the ecology and residue management, and no excess CO_2 release as a result of no burning of residues.

Advantages offered by CA to small or large farmers include better livelihood and income. For the small farmer under a manual system, CA offers ultimately 50% labour saving, less drudgery, stable yields, and improved food security. To the mechanised farmers CA offers lower fuel use and less machinery and maintenance costs.

To the community and society, CA offers public goods that include: less pollution, lower cost for water treatment, more-stable river flows with reduced flooding and maintenance, and cleaner air. At the landscape level, CA offers the advantages of better ecosystem services including: provision of food and clean water, regulation of climate and pests/diseases, supporting nutrient cycles, pollination, cultural recreation, conserving biodiversity, and erosion control. At the global level, the public goods are: improvements in groundwater resources, soil resources, biodiversity and climate change.

Our immediate challenge

In light of the above discussion, the question that must be addressed is: "What needs to change to enable farming, research systems and agriculture education in the UK and mainland Europe to heed the warning bells of the negative agro-ecosystem consequences generated by tillage and the overuse of agrochemicals?"

CA is being practiced and found to be effective and efficient in Europe by some farmers including in the UK (e.g. on Tony Reynolds' farm in Lincolnshire, Figure 2), in Finland, France, Germany, Switzerland, Spain, and Italy. However, the total area in Europe is some 0.4 % of the arable cropland. In the UK area under CA is believed to be around 24,000 ha.

So, what needs to change in order for more farmers (and stakeholders) to follow Tony Reynolds' example?

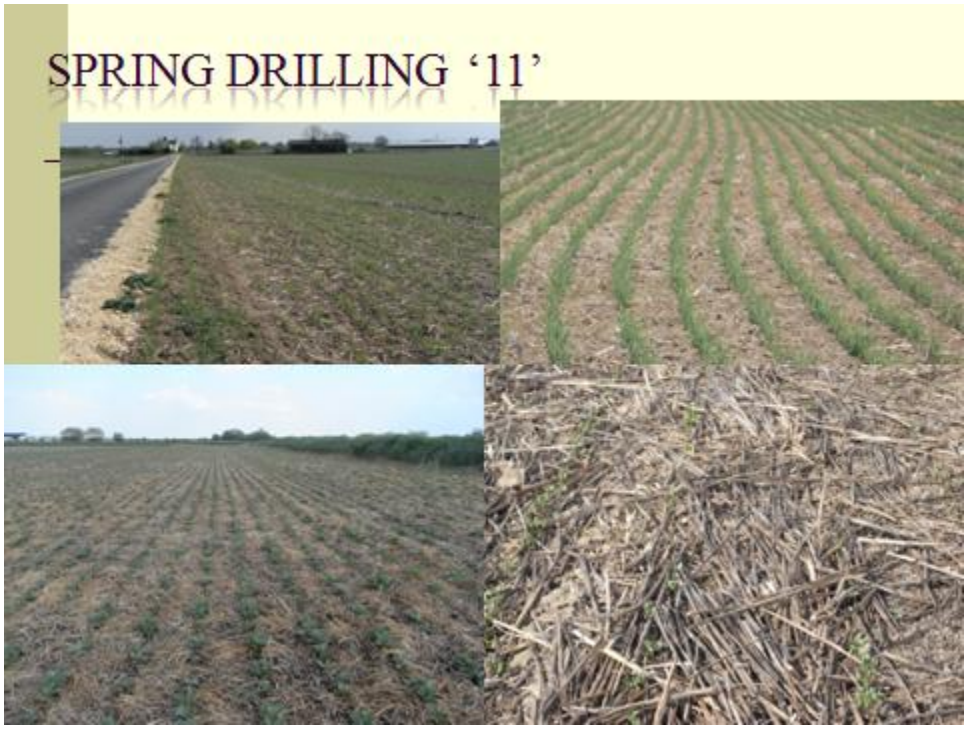

Figure 2: The no-disturbance principle in action on Tony Reynolds' farm with direct no-till drilling in spring 2011. In all photos the soil is covered by crop residues and direct drilled crop is coming though the mulch layer (Credit: Tony Reynolds).

Progress so far – There is 'good news' from the rest of the world outside of UK and Europe.

- A quiet no-till revolution led by farmers, particularly since 1971/72 in Brazil, has been spreading in all continents (but very slowly in UK and Europe) and CA now occupies over 117 million ha globally.

- Principles of *sustainable intensification and ecosystem services* are better understood than ever before, and are being implemented by some farmers in those countries where there is appropriate government support and guidance.
- Although agro-business money has captured government policy through controlling research and therefore our universities in the UK and mainland Europe, this can be turned into a win-win collaboration as has occurred in countries such as Brazil, Paraguay, Argentina, Canada, Australia/NZ and now happening in Kazakhstan, China and parts of Africa.

Changes I would make to UK and European farming if I had Merlin's magic wand

- All stakeholders – farmers, supply and value chain service providers, academics, researchers, extension agents, policy makers, civil servants, consumers – become engaged in understanding and harnessing the full power of the no-till agro-ecological paradigm.
- More self-empowered associations of no-till farmers establish themselves to become a force for change and serve as disseminators and leaders for change, capacity development and up-scaling of CA across UK and Europe.
- Funding becomes available for research on the new paradigm, whose benefits are becoming better known.
- Scientists/researchers from public and private sectors ask the questions that would resolve the constraints to adoption and spread of CA systems. Farmers are able to improve their practices of the new paradigm to deliver enhanced productivity and outputs as well as environmental services.
- Scientists/researchers on no-till farming and agri-businesses inform European government policy and enable governments to integrate the three basic CA components into the next CAP.
- Universities exist whose strategy of agricultural education lines up behind the principles of sustainable production intensification as is now known and spreading. Graduates will be able to work with agro-ecological systems such as CA, SRI, CA-SRI, CA-horticulture, CA-agro-forestry, CA-organic farming etc.
- DEFRA, DFID, and all European donor and development agencies adopt the principles of the new agro-ecological paradigm in their strategies and employ staff who knows how to facilitate the mainstreaming of the new paradigm.
- The next generation of farmers, researchers, policy makers, development experts, private sector providers are educated and fortified with the knowledge of the principles and practices of the new no-till (agro-ecological) paradigm for sustainable agriculture intensification and environmental services because of a re-examined strategy behind academic agricultural curriculum.

- Everyone uses the powerful tool of Internet to establish communities of practices to promote the new paradigm so we can together accelerate the agricultural transformation in the UK, mainland Europe and internationally.

In concluding this lecture of my reflections on lessons I have learned, I acknowledge that I have been rather outspoken about the changes I think need to happen in the farming sector. However, even though I accept sole responsibility for my wish list of changes above that I deem necessary for farming in the UK and Europe, I cannot take full credit for these ideas as they come from many colleagues and institutions from around the world. I specially would like to thank the University of Reading for giving me the platform of post-graduate teaching each year to try out new concepts about rethinking agriculture development. I appreciate the work TAA continues to do in promoting sustainable agriculture development based on the many decades of experience of their members in agriculture. And, I am fortunate to continue consulting for FAO which allows me to see first-hand the progress being made by all types of farmers in diverse ecologies around the world in changing the paradigm of agriculture towards more environmentally friendly and sustainable production practices based on Conservation Agriculture. It has been my great pleasure to get to know Tony Reynolds and to witness his delight in sharing with others the experience and benefits of transforming his farming practices in the UK to Conservation Agriculture (Figure 3). I hope that my lecture this evening has been in keeping with the spirit and legacy of Professor Bunting. Thank you everyone for your time.

Figure 3: 'Dad's Army': Tony Reynolds showing 'Dad's Army' the large size of his earthworms (his most important farm workers -- a centimetre in diameter) in an oil seed rape field on his farm on 4 June 2011 (Credit: Kieth Virgo).

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