Delivering increased food production from sustainable agriculture – drivers and challenges

Views of: Professor John Pickett, CBE, FRS, NAS (Foreign Associate), Cardiff University, School of Chemistry.

I'm not on-farm frequently and then mostly in sub-Saharan Africa, trying radically to improve yields sustainably from smallholder farming. Nonetheless, whatever we achieve in this quest, the world will continue to rely on industrialised farming, and yet this is not, even taking on board the most advanced farming as we have in the UK, going to deliver the rapidly growing global food needs, and certainly not sustainably. To make matters worse, specifically in the UK, we are inexorably creeping towards a very likely Brexit disaster including in terms of UK food production, as evidenced by Stephen Howe's recent blog "BREXIT: Farmers' biggest challenge since the Repeal of the Corn Laws." At the same time, we have to contend with, in terms of industrialised agriculture, un-evidenced criticisms, from some policy makers, elements of the public media and even scientists who should undoubtedly know better, of extant farming practices essential for food production at the current level.

Of course, being insects, there is a risk to honeybees and other pollinators from the neonicotinoid insecticides. However, the registration of such agents embodies treatment regimes minimising the risks to an acceptable, i.e. minimal, level of non-target impact. These aspects of registration have now been made available for public scrutiny, but critics of neonicotinoid use, including some scientists, choose, apparently for their own convenience, not to take these risk-limiting actions, which are legally binding, into account. Why is this? Well mainly, it's a quick fix and bypasses the much more demanding and expensive process of finding out exactly how the many constraints on healthy pollinator populations act and, more particularly, how to intervene against these constraints constructively. The paranoia surrounding this group of insecticides is symptomatic of many of the disruptive views of current agricultural practice, which is possibly directed most unreasonably against the herbicide glyphosate. Indeed, we all, at least those of us in the know, have amusing anecdotes relating to how benign legal glyphosate use is to us, the environment and the rest of the non-target organisms. These anecdotes make such a sad backdrop to the ill-informed attacks on this particular chemical, even by policy makers let alone some of the media and lobbyist groups. The UK has a very robust history of not being fooled by such nonsense and, in this process, we thank those distinguished scientists such as Professor Sir John Beddington referred to previously by Stephen and particularly those like John who have advised policy as Government Chief Scientists. The negative fall-out from ill-informed criticism of current agricultural practice remains though and, even under the most optimistic Brexit scenario, we will likely suffer loss of new agrochemical development for our region as the industry concentrates on more lucrative and particularly reliable markets elsewhere. Indeed, I have said to European policy makers still persevering with a view that GM should not be developed in Europe, that we could become as disadvantaged as southern Europe was in the 1600s when the Inquisition acted against emerging scientific principles thereby, for example, forcing the work of Galileo to be published in the

enlightened north of Europe. Although this event related so clearly to the industrialisation of the north at the expense of the superstitious southern states of Europe, at the recent meeting to which I referred, the corporate response was to dismiss such a notion. However, many individuals from the meeting offered agreement privately. While the direct correlation with the development of science in the north and the role in underpinning the industrialisation of this region compared with that in the south is well evidenced, the lessons are still slow to be learnt.

As an agricultural scientist, I, like any other scientist, test hypotheses. Although after having to overcome firstly some media and public opposition, my colleagues and I were able successfully to test a hypothesis relating to novel pest control in the field. This hypothesis tested false. We had great support in funding from the BBRSC, from the UK GM environmental release agency and from those agencies seeking to ensure that legally sanctioned research, even in the field, can proceed unmolested. The science itself was successful and we produced a GM wheat based on an elite variety, Cadenza, that produced the aphid alarm pheromone which allowed to be tested the hypothesis, which was that wheat producing this aphid repellent, an extremely benign chemical, would be less attacked by cereal aphids and at the same time would cause increased foraging by insect enemies of the aphids. For two spring and one autumn sowings of Cadenza compared with GM Cadenza wheats releasing the pheromone at two levels, we saw no pest control or increase in beneficial insect foraging. We now need to test newly conceived hypotheses relating to releasing more accurately the pheromone in imitation of the burst of pheromone produced when aphids are attacked naturally.

The main lesson from this unsuccessful attempt at a novel pest management strategy is that the need to test hypotheses is part of the scientific development process and not a setback to the science itself. Thereby, science moves forward to create new successes of potential value and yet, without realising the nature of this process, scientists can give the impression of continually arguing with each other and, more damagingly, that either “side” of the argument could be correct. If an understanding of this process and the associated issue of risk analysis, rather than merely following a correlative, and not causal, association, could be more widely appreciated, we could move forward faster and more effectively. Indeed, correlative only associations are at the heart of many un-evidenced criticisms of agriculture, with land-owing farmers and rich multinational agrochemical companies, whilst doing their best to promote efficient agriculture, being regarded suspiciously from un-evidenced and distorted social considerations. This diverts from real problems and iniquities, and yet we all have the means critically to assess the claims made against current agricultural practices and technologies. Insecticide deployment is much more rational than ever, and the introduction of newer more selective insecticide classes only by chance correlates with reductions in wildlife populations, including pollinators. The apparent correlation is not causal and where cause is found, then this is a contrivance from the legal use of such compounds in agriculture. After all, no-one would ever consider other obvious non-causal correlations, for example that the increase in obesity in the developing world and the increase in athletic achievements could possibly represent a causal association, and yet to those of us close to subject, the ill-informed attacks on glyphosate are just as ridiculous.

Whether agricultural scientists or not, all scientists need to be optimistic and positive – the hypothesis should not be seen as a proposal, but only as an idea to be tested. Any threat to the objectivity of hypothesis testing will weaken the scientific process and, where hypotheses test false, we must move systematically to a new hypothesis. Some funding agencies would like to obviate this process, but the UKRI Research Councils, in their peer-review of funding new research projects, require a clearly defined hypothesis. So, I believe that we can develop new science that can facilitate increased food production and that this can be done more sustainably. Those fleeing from the demands of this new objective, sadly including funders and scientists, try to attack the very word "sustainability" – what does it mean? For agricultural sustainability, the meaning is simple, but represents an immense challenge that shows no overall solution presently. The challenge being that all seasonally applied inputs of seed, land preparation, fertilisers, irrigation and crop protection must be targeted for reduction and eventual elimination. Annual cropping has achieved tremendous levels of production in not much more than 10,000 years of development. However, a pillar of sustainability, even though apparently distant, is the perennialisation of arable agriculture. Thus, nitrogen fixation all the way to crop protection, must be delivered by the crops or the cropping system. New advantages will certainly accrue, but many new problems will need solutions. Farmers who, contemplate this, will rightly shrink from the prospects of such changes, but nonetheless represent an extremely progressive industrial sector in terms of embracing new technologies. However, we need, as agricultural scientists, to demonstrate to the farming community that, as well as promoting science towards the overall goal of sustainable intensification of agriculture, we look with total commitment to solving the inevitable problems that will emerge. Thus, while root systems will show more value in perennial cropping, new pests attacking the roots must be managed sustainably.

The rapidly and continually developing new tools of GM must be incorporated, at all levels, in the quest for the sustainable intensification of global agriculture. At the same time and wherever possible, we must invent alternatives to current and ever growing increased high carbon footprint contributing technologies. We need to forget robotics until we capture hydrogen fusion energy. The future crop plants will need to look after themselves while, with or without robotic vehicles, we enter the crop to harvest our food, but probably not energy unless from waste which we should assiduously continue to obviate.

So, do we have a plan? We do and probably the most detailed is the report of the Royal Society arising from a working party chaired by David Baulcombe published in 2009 "Science and the Sustainable Intensification of Global Agriculture". Sadly, little has been achieved in pursuing the recommended priorities of this report, partly because of the situation as described in relation to Brexit by Stephen. Many of us have followed with reviews, ever more provocative, offering new ways forward where science can contribute to increased production sustainably. The final drivers in this process will be rapidly rising food prices, the impact on society impoverished by placing continually increasing resources in relatively non-essential areas and, finally, food availability or more emphatically the lack thereof. It is also of relatively little societal value to develop novel electronic gadgets and new medical procedures for populations not having access to sufficient or suitable food. As these hard realities impact, changes to the business of agricultural food production will

need to emerge. The redirection of the balance specifically within the food related industries will involve, by requiring a real move towards sustainability, placing prestige and financial credit at the food production end of the operation i.e. agriculture. The food retail industry must adapt to pay a real price for produce at the farm gate and not continue to force down prices against sustainability and animal welfare. The food retail industry cannot pretend that simply adding sugar, salt and even water is really adding value and in any way justifies the returns that this industry currently captures. Food shortages on the scale to which I refer may seem to be a long way off but the agricultural industry and the science that serves its future must be ready to deliver and the public and its servants to receive the products of these endeavours.