Figure 1 Advising farmers means getting up close and personal with crops and making sense of their growth and productivity

Technology in the field – literally!

Rory Galloway describes how everyday technology is used in his role as an agronomist (or crop doctor!)

I was working with a group of trainee teachers recently at BASF's biodiversity site in East Yorkshire (Figure 2). They were there to learn about human impact on the environment and how farmers manage their land; it was about developing their biology subject knowledge in a real-life context. Their experience was enhanced by the farmer joining us for the majority of the day and what they soon realised is that, although he would shun the title, he was a scientist as much as a farmer.

Their tutor discussed with them the notion of building science capital and how broadening children's horizons in terms of 'what a scientist is' is key. Many of those trainee teachers left that day seeing farmland through a completely different lens and there was much discussion around the benefits of this to learners in schools.

This article outlines my role as an agronomist – a little known job! – and also how using what is now an everyday piece of technology has changed how and what I can do. The drone, now readily available in the high street, has added a new dimension to my work. I hope, by sharing it here, it enables you as teachers to offer another perspective to your classes and perhaps engage more children in thinking about what constitutes science.

What is a crop doctor?

That source of all reliable information(!), *Wikipedia*, defines agronomy as '*the science and technology of producing and using plants for food, fuel, fibre, and land restoration*'. As an agronomist, it is my job to advise farmers on how to grow crops sustainably to the best of their ability, maximising farm productivity, efficiency and profitability (Figure 1). This advice can cover many aspects of crop production, such as crop rotation, crop varieties, plant physiology, fertiliser and crop protection.

I do not come from a farming background and I am the first person in my family to work in agriculture, as far as we know. I fell into this industry after I blindly bought an old Land Rover from eBay, which unsurprisingly was made of rust, and I needed some money to repair it. This led me to my very first job, age 14, helping a local farmer with lambing, which then turned into a weekend and school holiday job.

When I left school, I decided to pursue a career that I really enjoyed and went onto study at Harper

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Figure 2 The trainee teachers visiting the biodiversity site at Top House Farm, Goole Goole

Adams University in Shropshire, a university specialising in education for the agricultural and rural sector. Before I started at Harper Adams, I got a summer job with the agricultural research company, Bayer CropScience, working on crop trials, where I spent the summer driving a tiny plot combine and learning about agrochemical trials. In my third year at Harper Adams, I had a placement year with KWS UK, a plant breeder in Cambridgeshire, learning how to cross wheat plants and all that's involved in the lengthy process of producing new varieties for the UK market.

After graduating with a BSc(Hons) in Agriculture and Crop Management, I started work with an agronomy company called Hutchinsons as a trainee agronomist, where I gained the legal qualifications required to advise farmers on crop production and crop protection.

I now work for BASF and, because I am not confined to an office, I love it. I spend a lot of time out on farms with farmers and not one week or day is the same. Therefore, it is very difficult to describe a 'typical' day and, being such a seasonal industry, my day-to-day life changes with the seasons. Activities range from providing technical presentations to farmers, meeting farmers on farm to provide advice, hosting demonstration trials for farmers to visit and professional development, plus a lot more in-between.

I know I am making a difference in my role when I can see advice I have given has been put into place on a working farm and has made a positive difference, improving farm sustainability, performance and profitability. Farming can also be quite a lonely profession, so developing relationships and working together is a key part of my role. Acting as an ambassador for the agricultural industry is also very important, as farming is often the target for negative press; education and promotion of the great work farmers do is imperative.

The technological revolution

Technology in farming has advanced a great deal, but still has a long way to go. At the beginning of 2019, the then Environment Secretary, Michael Gove, stated that we are on the verge of a fourth agricultural revolution. This fourth revolution is being called the technological revolution, with developments involving artificial intelligence, big data analysis, drones, machine learning and robotics.

We are using and developing technology to not just improve farm productivity, but to improve farm efficiency and, therefore, sustainability. Targeted and tailored crop inputs are a major part of this, increasing inputs to areas of crop that require it, and reducing inputs where they are not required. It sounds quite simple, but is much more complicated than would first appear.

The drone I demonstrated to the

Figure 3 Demonstrating use of the drone for crop assessment and management

Figure 4 (above and below). A drone's-eye view of the biodiversity site and wheat plots

trainee teachers is a *DJI Phantom 4 Pro*, which is at the mid to lower end of the drone market (Figure 3). It can be bought off the shelf, but costing over £2000 is not something you go out and buy in a hurry! I have a licence from the Civil Aviation Authority that allows me to operate the drone commercially and, most importantly, safely.

Other than a toy, which takes nice pictures and video, the drone is a great tool for crop assessment and management. You can see so much more from the sky than you can from the ground: you notice things you wouldn't notice if you were standing right next to them, such as variations in crop growth or soil type and drainage (Figure 4). You can also cover much more ground: where walking fields takes a lot of time and is relatively inefficient, a drone can effortlessly cover acres at a time. Drones can also be mounted with various multi-spectrum and ultra-high definition cameras, which can allow the identification of weeds and diseases.

A tool commonly used in agriculture is NDVI (normalised difference vegetation index), which can be measured using both drones and satellites. NDVI is a spectral-reflectance index, which shows a combination of crop canopy size and greenness. The main drawback of satellites is that they can only take pictures when there is no cloud cover and pictures are of a lower resolution. However, compared to drones they are more cost effective and can cover a much larger area in a similar time frame.

BASF's digital farming platform is called Xarvio, which is a cloud-based tool that allows farmers to predict crop growth, disease pressure and pest pressure. This enables them to identify crops that may require their attention, without stepping a foot outside! Although this technology will never replace a farmer, it can become a very useful management tool that improves farm efficiency. The second part to Xarvio, currently in development, allows farmers to variably apply crop protection products depending on crop biomass maps, created from satellite images. Again, targeting inputs where they are required, improving sustainability.

Digital farming will play a huge part in my future role in the agricultural industry. There is still so much we don't understand and the technology is quickly developing, which is what makes it exciting!

Wider roles of scientists

At BASF, the breadth and depth of scientific roles amaze me. Just within the Agricultural Solutions part of the business there is an array of roles, starting from the scientists who discover the molecules we use in plant protection products, to those who trial and test the products within the field. A good proportion of our 'scientists' are not lab based: they are out in the field in wellies!

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