ON FARM EXPERIMENTATION: SOME HISTORICAL HARBINGERS

Changing perspectives

Oliver (2013) reviewed some definitions of precision agriculture (PA), or precision agronomy, and Tremblay (2021) pointed out the interest of the On Farm Experiment Community (OFE-C) of the International Society of Precision Agriculture (ISPA) in changing the perspectives of the analysis of experiments, including the potential for revisiting Bayesian statistics as described by Matthews (1998).

Cook *et al*. (2013) suggested an operational research approach to on farm experimentation based on the observation and analysis of farm operations.

Historical background

Franzen and Mulla (2016) reviewed the history of PA and of the development of the facilitating technologies such as global positioning satellites (GPS) receiving devices.

But what harbingers went before? There is a distinguished historical precedent for an on farm experiment (OFE) approach to investigation and development. The 18th-century livestock breeder Robert Bakewell (1725–1795) had a technique called ram letting. Rams he had identified as promising were let out to sheep farmers all over England, particularly breeders like Collins of Darlington (Stanley, 1995). Bakewell's work was even quoted by Darwin (1859) in his *Origin of species*, arguably one of the most influential publications in the history of the biological sciences.

While Bakewell's work may be a well-known example of an early OFE it is not the only one. Thomas Coke of Holkham Hall, Norfolk (1754–1842) held what became known as the Holkham Sheep Shearings (Spencer, 1842), at which he exchanged information with his tenants as they explored and experimented with the new crop rotations which had been evolving since the work of Townshend (1674–1738) (Wade Martins, 1990).

There is a historical precedent for the aim of PA to address spatial differences within fields. There was an early recognition of the existence of spatial differences, even if not down to the level of sub-meter accuracy now available to PA. In 1937 Scott Watson and Hobbs wrote that "It was one of the earliest discoveries in farming that one piece of land would grow better crops than another." That recognition had been effectively invoked when in the 6th century A.D. Pope Gregory and Archbishop Augustine organised England on a system of parishes. Within these parishes there were usually three large communal fields divided into strips (Charles, 2002). Village families held randomised replicated strips in the three fields with the intention of giving them all fair shares of good and bad land: an early attempt at achieving some of the aims of PA, and of the randomisation and replication formalised centuries later by Fisher (1925).

Atkins *et al*. (1999) pointed out that the strips were not of standard size, but roughly based on the ploughing of a *furlong, about 220 yards long (about 200 m), though shorter on heavy land. These small strips of about 0.1 to 0.2 ha would have made site-specific management possible, but at the time the strip holders would have generally lacked both the resources and the knowledge to fully exploit that advantage.

The small strips became impractical as technology improved. Systematic animal breeding was impossible in three large open fields as the unfenced animals roamed about at will and mated at will. Often one field in three was fallowed each year to regain fertility but this practice was unsupportable once the growing towns had to be fed during the Industrial Revolution. So eventually in the 18th and 19th centuries parish fields were enclosed by planting hedges to make compact farm holdings.

The three-field system is preserved at Laxton, Nottinghamshire, where 711 ha in the parish were purchased in 1951 by the Ministry of Agriculture to preserve the heritage for the nation (Rundle, 1955). Maps of the fields in 1635 and in 1908 (after some limited enclosure) survive, and were reprinted by Charles (2002) with the permission of the Bodleian Library, University of Oxford, and the Trustees of the Laxton Visitor Centre.

In some English fields, the ridge and furrow of the strips can still be seen, particularly in dry summers. Presumably, the sensors used in PA (e.g., Carter and Young, 2013; Viscarra Rossel and Adamchuk, 2013; Stone and Raun, 2016; Sun and Li, 2016; Zhang, 2016) would detect them objectively even when not visible.

A traditional field analysis technique which attempted to address spatial variation within fields was random quadrat sampling (Pound and Clements, 1898). I still possess a 0.5 m quadrat, as used in agricultural botany classes during the 1959/60 university year.

Some points on the way forward?

PA is now in commercial use, so that research techniques and analysis need to be designed accordingly. As recorded by Charles (2020) the landmark statistical methods developed by Fisher (1925) and Fisher and Yates (1938) served generations of agricultural scientists and students very well for decades, and there are still applications for them, though Matthews (1998) described the Fisher approach as " … flawed attempts of Fisher *et al*. to create an objective theory of statistical inference…". But the advent of precision agriculture has raised questions about both experimentation and field practice, so that statistical analysis may have to adapt accordingly, for the reasons noted by Oliver (2013) and Tremblay (2021). Bayesian approaches may be part of the change. Perhaps one of the challenges will be to adopt a new methodology without losing any relevant virtues of the old.

The so-called Bayesian inference was proposed by Thomas Bayes, an 18th century English clergyman (1702–1761), whose theorem was described by Matthews (1998), claiming that " … the axioms of probability reveal subjectivity to be a mathematically ineluctable feature of

the quest for knowledge … requiring that their inherent plausibility be taken explicitly into account". Farmers will often have their own ideas about plausibility, and a Bayesian approach would acknowledge their experience.

Some risks

In 2017 the Centre for the Study of Existential Risk, founded in 2012 by Tallin *et al*., studied factors which could lead to a collapse of civilisation and to global disorder. Food shortage was classified as a high-risk factor, so research and production methodology are important.

Some snippets of ancient history

In a review of the history of hazards to the sustainability of soil and of food supply Charles (2019) quoted Montgomery (2017), who speculated that one of the factors contributing to the decline of the Roman empire may have been the neglect of its soils. Yet earlier Roman authors showed respect for the soil and knowledge of it. Virgil (70-19 BC), quoted by Baxter (1846), wrote "… what each region bears, and what denies," suggesting that he knew that not all soil was the same. Columella (4–70 AD) wrote 13 books on agriculture, including reference to soils (Charles, 2002).

Footnotes

1. *A furlong was 10 chains long. The 22-yard chain survives internationally to this day as the distance between the two wickets on a cricket pitch.
2. The three-field system with furlong strips was not the only system of land tenure in pre-18th century England. The monasteries had land farmed by monks in fields without strips, and in many villages the church held fields called glebe.
   After the Norman Conquest of 1066, there were also large estates with tenant farmers. The estates of Thomas Coke (1754–1842) and of Charles Townshend (1674–1738), quoted above, were examples, and both estates are still in commercial operation. Townshend is known to history as Turnip Townshend for his work on crop rotations, even though his day job was Foreign Secretary.

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