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Editorial

Precision agriculture and information technology

As everyone knows, *knowledge* (along with its less-sophisticated sibling, *information)* is power. For a long time, detailed knowledge (in agriculture) has been generally inaccessible or was prohibitively expensive to acquire. Advances in electronics, communications, and software over the past several decades have removed those earlier impediments. Inexpensive sensors and microprocessors — coupled with integrating software, mobile power sources, and satellite communications — now enable farmers and natural resource managers to collect vast amounts of geo-referenced data (Auernhammer, 1994; Jahns, 2000). Further downstream processing of that data produces meaningful information and ultimately, knowledge (Udink ten Cate and Dijkhuizen, 1999). A number of this special issue's papers deal with technologies for information gathering and application, which often appear under the terminology 'precision agriculture' and 'information technologies'.

Natural, inherent variability between and within fields means that mechanized farming could traditionally only apply crop treatments for 'average' soil, nutrient, moisture, weed, and growth conditions. Necessarily, this has led to over- and under-applications of herbicides, pesticides, irrigation, and fertilizers — except on rare, average sites. Precision agriculture technologies are being developed that can sense micro-site specific conditions in real time and can automatically adjust treatments to meet each site's unique needs. Richard Plant, in his paper, attempts to distinguish between *site-specific crop management* and *precision agriculture*, wherein the former refers to cropping and the latter is more inclusive of all, information-centric agricultural activities. Hermann Auernhammer's paper tries to make a similar distinction. Dr. Plant also notes that, in intent, precision agriculture is more akin to traditional agricultural practices, wherein small-scale, non-mechanized farming permitted spatially variable treatments. Mao-hua Wang's paper states that China's 'precision cultivation' approach to farming has been practicing these ideas for many years through the small, rural farmer's intimate knowledge of each small corner of each field.

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Furthermore, geo-referenced data collection and analysis can lead to mapping of crop yields (Stafford, 1996) and animal tracking/monitoring (Rossing, 1999). In fact, Richard Plant's paper argues that variability in all other field conditions, e.g. soil characteristics, moisture, nutrients, etc., are ultimately realized in crop yields, which then implies that yield mapping should assume the central role. While most efforts have focussed on grain-crop yield mapping, the same can be done for non-grain crops (Godwin, 1999). Despite significant research and development successes for precision agriculture, adoption of these technologies has lagged.

Eventual implementation of precision agriculture technologies will be largely economic. Because information has both a benefit and a cost, the former must outweigh the latter. However, Hermann Auernhammer's paper suggests that increased environmental benefits are a significant factor, also. At least, precision agriculture technology will allow farmers to collect and document environmental variables, which can then be used for 'greener' management activities and to promote their environmental soundness to customers. Currently, large-scale agribusiness enterprises profit primarily through economies of scale, which offset suboptimal, broadcast treatments. Spatially variable cropping will enable these businesses to increase profit margins substantially. Even so, smaller operations, which currently lack economies of scale, should also benefit from precision agriculture improvements — if the technology can be made affordable to small landowners. Both Plant and Auernhammer suggest that landowner cooperatives (or management zones or virtual land consolidation) can enable groups of small operators to obtain sophisticated technology that might otherwise be financially prohibitive individually.

While countries with well-developed, large-scale agriculture can rely on economic and environmental incentives to promote precision agriculture, these approaches may not work well in less developed countries. There, financial and technological infrastructures are lacking, so governments must step in to help encourage new ideas and to foster innovation. Dr. Wang provides some insights into China's approaches, including technology farms, research centers, industrial parks, and region-specific development. Despite any number of incentive approaches, however; it still remains for the farmer/landowner to adopt and effectively apply new technology.

Two papers by Jos Verstegen and Ruud Huirne and by Friedrich Kuhlmann and C. Brodersen examine some of the issues related to information technology (IT) adoption. Furthermore, IT adoption has been addressed by numerous journal articles recently (e.g. Lewis, 1998; Ascough et al., 1999; Kagan, 2000; Tomaszewski et al., 2000). In their paper, Verstegen and Huirne found that IT usage by hog farmers was related to farm size and the extent of management that the farmers employed. That is, larger hog operations require greater management effort, which requires more sophisticated methods, i.e. IT. Kuhlmann and Brodersen offer 'transaction costs' and 'principal agents' as two explanatory theories for current the adoption trends. They also examine control systems and planning systems as two very different ITs that farmers view very differently. Finance and risk management assistance appear to be two areas where farmers see immediate benefit. Many factors affect farmer IT adoption, just as with any other business purchase. However, the final paper in this section by Alan Thomson and Daniel Schmoldt examines ethical issues of software design and suggests that adoption may also be related to ethical choices software developers make in creating IT. Buyer preference and post-purchase satisfaction are often tied to nontechnical aspects of IT, i.e. not just what task it helps the user accomplish, but also how it addresses privacy, accuracy, property, accessibility, and quality of life. Human preferences involve complex feelings of 'good' and 'bad', rather than solely intellective choices. As advanced technologies, such as precision agriculture and other information systems, become commonplace in the next century, human-centric IT will command market dominance over technically aware IT.

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