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"Challenges to Organic Farming and Sustainable Land Use in the Tropics and Subtropics"

Precision Agriculture, Modelling and Land Use Planning

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Abstract

Precision agriculture (PA) is a holistic management approach that originated in the early 1990s with the goal of optimising profitability and productivity while minimising the adverse environmental impacts in each spatial unit of the field. It is centred on sound use of agronomic principles, and involves variable application of external inputs and other cultural practices to match varying soil and crop conditions. Practical implementation of PA, however, is dependent on technological developments to collect, manage, analyse and utilise vast amounts of site-specific data. Rapid advances in both hardware (positioning and sensor technologies, yield monitors, variable rate applicators, etc.) and software (data collection, geographic information systems [GIS]) coupled with the availability of low-cost powerful computers has made PA a reality today. However, PA must not be viewed in terms of technology use alone, as its principles are applicable in a wide range of situations. Although PA is intuitively considered more efficient in input use than traditional agriculture, documentation of its economic and environmental benefits remains incomplete. Perhaps that is why only a small minority of farmers incorporated PA technology into crop management in 2002 even in developed countries. Adoption in the developing countries is very low so far, although concerted efforts are being made to promote it at various levels. In the keynote presentation, a brief introduction to the principles and component technologies of PA is given, with emphasis on driving forces for its adoption in the developing countries. A simple methodology for precision management of cropping systems is outlined and the conditions in which PA offers the greatest economic and environmental benefits are highlighted. The prospects and progress for PA adoption in selected cropping systems are also presented.

Precise management of water in agriculture has become crucial nowadays due to increasing demands from the industry and urban areas. As we learn from the work of Al-Karadsheh et al., the next generation in irrigation scheduling is not just when and how much, but when, where and how much to irrigate. A cost-effective precision irrigation system must be capable of applying not only water but also various agro-chemicals. The development of new algorithms is vital, however, to successfully utilise and/or adapt the machinery for PA. The paper by Sutiarso et al. is interesting in this context, for it describes the development of an algorithm called "parallel parking theory" as part of the efforts to develop a trajectory path controlling method for autonomous farm tractors. Using this algorithm, the authors report significant improvements in the accuracy of the detection of target objects.

Application of PA concepts requires significant modelling efforts. For instance, determining the relationships between crop yield and various controllable (e.g., agro-chemicals) and uncontrollable (weather, topography, etc.) factors in cropping systems remains a challenging task. Environmental Policy Integrated Climate (EPIC) model, which can simulate both

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crop rotations and movement of agricultural chemicals, is useful in predicting crop yields and soil erosion.In this subsession, Gaiser et al. report the applicability of a modified version of EPIC called EPICSEAR to simulate soil water balance and biomass production in maize-cowpea intercropping system in Brazil. It is worth noting, however, that different models yield different outputs, and that simulated results often differ widely from the actual conditions. Lange et al. report such differences based on their studies on seepage in sandy loam soils of Brazil. Siebert and Döll analyse uncertainty and sensitivity of the Global Water Model WaterGAP, and Döll et al. examine the applicability of Global Water ModelGAP to estimate the impact of global change on water scarcity. Feldkamp et al. address the issue of developing a new concept-oriented forage model, wherein the usefulness of a model is expressed by the probability that it drives the decision maker to an optimal decision.

Prior to introducing PA concepts, it is essential to assess the potential of agro-ecosystems on a regional basis, and identify the limiting factors for successful crop production. Inadequate land use planning and insufficient characterisations of local conditions remain major barriers for successful utilisation of arable lands. Many presentations address such issues relevant to the developing countries. Based on an agricultural zoning analysis, Karimuna and Denich identify the principal limiting factors for agricultural land use in Sulawesi (Indonesia), while Sultmann demonstrates the usefulness of remote sensing and GIS in land use classification in the Tai region of Cote d'Ivoire. Mulindabigwi and Janssens examine the influence of land use systems on organic matter dynamics and water use efficiency in Benin, and Sereke et al. describe a land evaluation study for achieving sustainable highland agriculture in Northwest Thailand. Osman and Sauerborn examined long-term rainfall varibility in Ethiopia based on an ongoing collaborative project between German and Ethiopian organisations. Ibisch identifies the need for integrating various objective methods for evaluation of the conservation status using socio-economic proxy indicators in conjunction with integrated land use planning in Bolivia. Two presentations look at the environmental quality aspects. Mitra et al. report the issue of methane production and emission in rice fields of the Philippines, and Rogge describes the results of a survey on agrochemical use in Cote d'Ivoire. In most countries, the available information on agriculture is widely scattered but the Internet now offers new opportunities. Boje et al. approach this issue on a national basis by introducing the new German information system for agricultural and environmental research.

All in all, the papers and posters presented in this sub-session offer a comprehensive approach to achieving sustainable agriculture through analysing opportunities and obstacles for PA, crop modelling and land use planning.