Precision Farming Japan Model*

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Abstract

A new concept of community-based precision farming is accompanied by well-organized wisdom farmers and a technology platform. The wisdom farmers groups improve upon the conventional farming system through the management of hierarchical variability: variability among farmers in terms of motivations and cropping types as well as within-field and between-field variability. Which variability should be managed for increased total economic returns with reduced environmental impact must be considered. The technology platform organized by innovative companies develops and provides three key technologies: mapping techniques, variable-rate techniques and decision support systems which take into account rural constraints. The best linkage of the wisdom farmers and the technology platform would produce information-oriented fields and information-added products that encourage multi-functions of agriculture creating new value-chains in the agro-production-consumption system.

Keywords

precision farming, information technology, innovation, knowledge management

Introduction

A change from "seeds-oriented development" to "needs-oriented development" is one of the paradigm shifts nowadays not only in industry but also in agriculture. Needs to be considered come from administration, markets or consumer, producer or grower, and transport. For example, a BSE crisis has impacted on systems from administration to the transport, and has led to a new keyword: traceability in/through the agriculture and food supply system. In general, this kind of issues accelerates the development of new management approach to distinctive information, technology and crop production. One approach to meeting such a need is research into creating information-oriented fields and information-added products.

Precision farming provides a forthcoming solution incorporated with systems approach for current

agricultural issues, such as environment vs. productivity. It is based on advanced information technology including describing and modeling soil and plant variability, integrating controlled works to meet the site specific requirements, aiming at increased economic returns as well as to reduce energy input and environmental impacts (NRC 1997, SKY-farm 1999, Vanacht 2001).

People tend to consider that precision farming approaches are only available for big scale farms because of its intensive technologies with high investment, and to often estimate that the scale merits can appear on the farms of hundreds to thousands of hectares. In Japan, the average farm scale is 1.5 ha and most of the farmers are working as a second job, moreover their ages are over 65 years old on the average. We still have a small amount of expert farmers with sophisticated skills and wisdom, producing high quality agro-products and consequently

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getting income of tens million yen per year. Big concerns for farmers have been how to increase consumer confidence in food supply as well as to increase efficiency of production and to get/train their successors. Japanese farmers are combating such complex and trade-off problems, which leads them to look at the potential application of precision farming to small scale farms (Shibusawa 1999, 2000, 2001).

The objective of this work is to extract the fundamental concept of precision farming and to apply it to small scale farms as a community-based precision farming Japan model.

Fundamental Concept of Precision Farming

Information-oriented Work Cycle of Precision Farming

The term "Precision Farming" or "Precision Agriculture" is capturing the imagination of many concerned with the production of food, feed, and fiber. For example, it offers the promise of increasing productivity while decreasing production costs and minimizing environmental impacts (NRC 1997), or it is the management of arable variation to improve economic returns and to reduce environmental impact (Sky-Farm 1999). High-tech images are also engaging, which leads us to use information technologies into agricultural practice with helps of a systems approach

to look at the whole system.

There are three fundamental technologies, as shown in Fig. 1, and the farm works are circularly linked to each other in a cycle which results in the accumulation of the best knowledge and skills (Shibusawa 2000, 2001). Describing the variability is the key task, in particular to describe within-field variability. The variability should be understood in at least three aspects: spatial variability, temporal variability and predictive variability. Based on understanding of the variability, the decision support system provides some feasible solutions for farming practice with respect to trade-off problems such as productivity and environment. The decision support system involves data, information and knowledge about crop growth models and market needs. One option is to use variable-rate technology (VRT) for adjusting the agricultural inputs to site-specific requirements at each location in the field. Consequently the cycle works to enrich the database of farmers in terms of field management, marketing, and cost/risk management. This spiral-developing farm work system is the fundamental feature of precision farming.

A key task is information management in precision farming practice. The quality of information will be improved through four phases: data,

Figure 1. A developmental cycle of precision farming works.

information, knowledge and wisdom, as shown in Fig. 2 (Shibusawa 1999, 2000).

"Data-phase" refers to a lump of signals and numerical values, which are not practically usable in decision making. "Information-phase" provides some meanings from a set of data, such as excessive-appropriate-lack of fertilizer using thresholds or any evaluation index. "Knowledge-phase" implies individualization of information in some logical ways, which can help one to make a decision, such as application guidelines. "Wisdom-phase" refers to an

individual person creating an original solution like professional farmers' approaches. Information technology and artificial intelligence tend to be powerful in levels up to knowledge-phase, but the wisdom-phase requires intellectual and creative activities of farmers and professionals to make a breakthrough over the conventional approaches. Precision farming practice requires good management of all phases in the information, that is, the best assistance of information technology to the wisdom of farmers.

Figure 2. Level of information.

Changes of Total Farming System

In general, a farming system consists of five factors (Shibusawa 1999, 2000): plant variety, field feature, technology, regional infrastructure, and motivation/intention of farmer. Better integration of the five factors can create a competitive farming system fitted to domestic conditions/constraints.

Precision farming offers variable management utilizing field maps, variable-rate technologies and decision support systems. As shown in Fig. 3, generating the field maps makes plant and field factors

information-oriented. Variable-rate technology not only increases the efficiency by re-organizing the three factors; technology, plants and fields, but also creates a solution that better fits the regional infrastructure and/or constraints, such as environmental regulations. The decision support system provides system optimization techniques, which have wide-ranging impacts on farmers' motivation as well as all factors to be re-organized. That is, precision farming brings about an innovation in the whole system of agriculture as it is.

Figure 3. Precision farming technologies make innovation in the whole system of agriculture.

Community-Based Precision Farming

Adoption of precision farming in US follows company-based and cost-driven schemes that requires big-farm management with reduced costs. It is economically viable on farms of more than 500 ha in size (Vanacht 2001). In the case of Japan, community-based and value-oriented schemes will be the motivation of farmers with small farms. European countries might stand between the US and Japanese types in their adoption of precision farming.

The feasibility of precision farming for small scale farming is an attractive topic for agricultural scientists as well as agricultural politicians in Japan. Note that precision farming is specialized by variable management, and that the variability requires precision farming approaches. Understanding in-situ variability is a key point in promoting precision farming.

Two types of variability, that is, within-field variability and between-field or regional variability, are introduced here. Within-field variability is embedded in a single field with a single plant variety in general. Between-field variability implies the variability among the fields in which different crops and farm works tend to be managed. When it comes to describe the between-field variability, each field can be treated as a mapping unit. Which variability should be managed for increased economic returns with reduced environmental concerns needs to be

considered.

In a single small farm, the farmer can better understand what is going on in each field, which enables variable-rate application for site-specific requirements with farmers' knowledge and skills. When it comes to covering an area of a few tens of hectares including lots of small fields, for example a farm work contractor or a farm company, have to manage the regional variability due to cropping diversity. They also have to coordinate the farmers with different motivations due to different cropping styles, as shown in Fig. 4. Regional precision farming requires management of the hierarchical variability: within-field, between-field and between-farms variability. High-tech approaches like a yield meter with GPS can be available for such a scale of regional precision farming, and moreover measures for environmental concerns should be undertaken in a similar scale of the area.

Managing the hierarchical variability requires two organizations: wisdom farmers and technology platform, as shown in Fig. 5. The society of wisdom farmers spur top management of innovation in regional farming systems, such as the re-arrangement of five factors of farming system and development of scenarios for introducing precision farming approaches. The technology platform develops and provides technologies available to meet rural constraints as well as encouraging marketing channels for high-quality/

Figure 4. Types of precision farming corresponding to farm scale.

traceable agro-products. A community of the wisdom farmers and the technology platform will produce information-oriented fields and information-added products, which can respond to consumer concerns as well as motivate farmers through increases in productivity/profitability, reduction of environmental concerns, improvements in traceability, and so on. Fig. 5 sketches a Japanese community-based precision farming model.

Rural development by introducing precision farming is an attractive topic in Japan. As shown in

Fig. 6, precision farming practices produce information-oriented fields, which can provide good information for plans for managing environmental conservation or designing landscape amenity in a rural area. When the multi-functions of agriculture are re-evaluated using information-oriented fields, such value-added space can be used for creating a new business incorporated with other local industries. A local network of industries will produce many kinds of value-added products including such as new bio-materials, education spaces, and green tourism space.

Figure 5. Community-based precision farming Japan model.

Figure 6. Aspects of rural development by introducing precision farming.

Trials for Community-Based Precision Farming

Community-based precision farming is being conducted in several areas in Japan. Details are not described here but two trials are illustrated in Figs. 7 and 8. One was founded at Toyohashi city area in May of 2001, and has a technology platform named Toyohashi PF-net Society and a society of wisdom farmers named Atsumi Farmers Association. Toyohashi PF-net Society has conducted seminars on precision farming every two months, extension of information

technology to farmers, and provided consultation to collaborating companies and farmers. Atsumi Farmers Association has undertaken field experiments using soil sensors and held meetings to develop the concept of a Japanese model of precision farming. Local governments are also encouraging these grass-roots movements.

The other trial is in the Honjo city area with help from Waseda University and Tokyo University of Agriculture and Technology. The city's Honjo Society for Foods, Agriculture and Environment aims at increasing consumer confidence in food supply,

Figure 7. A trial of community-based precision farming at Toyohashi city in Japan.

Figure 8. A trial of community-based precision farming at Honjo city in Japan.

introducing the Japanese model of precision farming, and creating a zero-emission system in the city area. The city hall gained ISO 140001 certification in March 2002. Leaders of the farmers founded a learning/practice group called the Honjo Precision Farming Society in April 2002.

Both agricultural areas are famous for their activity in horticulture producing high quality products in Japan and the farmers are very interested in the marketing of their products. They focus on how to produce and manage "information-added products".

The first step in both trials was to have intensive workshops on the concept of precision farming, technologies available, market needs, and so on. They invited professionals in many disciplines and fields, such as agricultural scientists and engineers, retailers, IT engineers, and agricultural politicians. This led them to have community-based strategies on how to produce information-oriented fields and information-added products. The second step was technology demonstrations such as a real-time soil sensor to describe the variability of the field. The third was a social experiment involving sales of information-added products in collaboration with local retailers. They have determined some needs of consumers and retailers. These trials showed that complexity in food markets as well as in field management should be described more clearly, and that the development of database spanning from fields to market is an important issue for introducing precision farming.

Conclusion

In a case of small scale farms, precision farming can be extended as a management strategy for hierarchical variability: variability in farming style as well as within- and between-field variability. Such complex variability should be managed in community-based approaches, which led us to have a Japanese model of precision farming composed of a wisdom farmers' society and a technology platform; this organization is called by a precision farming community (PF-community). The PF community has responsible for producing information-oriented fields and

information-added products to make innovation in an agro-production-consumption system. A few trials of this community-based precision farming are ongoing in Japan.

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要旨

コミュニティベース精密農法は知的営農集団と技術プラットフォームにより展開される。知的営農集団の役割は、階層的ばらつき、すなわちほ場内のばらつき、ほ場間のばらつき、そして農家集団における動機や作型などのばらつきの管理を通じて、従来型農法の革新を行うことにある。重要なことは、どのばらつきが全体として環境負荷軽減と収益性向上に効果があるかを判断することである。技術プラットフォームの役割は、各種制約条件の下に、精密農法の3要素技術であるほ場マッピング技術と可変作業技術及び意志決定支援システムを提供することにある。知的営農集団と技術プラットフォームの適切な協力共同は、「情報付きほ場」と「情報付き農産物」の生産を可能にし、生産・消費システムにおける新たな付加価値連鎖の創造による農業の多面的機能を強化することに貢献できる。

キーワード

精密農法, 情報技術, 革新, 知識管理