FOOD PRODUCTION STRATEGY IN EAST ASIA

- Engineering perspective in the third millennium-

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Abstract: Zoning of agricultural production is possible since it is based on the country union such as EU. This zoning is much more efficient for increasing agricultural production since it is much dependent on climate. Precision agriculture is one of the promising techniques for increasing production with environmental sustainability. Closed artificial environment systems such as greenhouses are promising for agricultural production in the severe environmental conditions we will face in the future Manure and odor treatment in livestock production systems are still large issues to be solved from the viewpoint of both environment pollution and renewable energy.

Introduction

"Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will show the immensity of the first power in comparison of the second. By that law of our nature which makes food necessary to the life of man, the effects of these two unequal powers must be kept equal." These are well-known statements by Thomas R. Malthus, an English economist who forewarned of the present global situation about 200 years ago. In 1972, the Roman Club indicated overall problems of population increase, food shortage and depletion of limited natural resources. This was reported in the popular book "The Limits to Growth."

Again, "Tough Choices: Facing the Challenge of Food Scarcity" by Lester Brown, Director of World Watch Institute, gave us a shock. The world population is increasing exponentially and the rate of increase has been large after the 1960s. In

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1999, the world population exceeded six billion, and it is estimated that in 2050 the population will be over ten billion if the rate of increase does not change. On the other hand, with food shortage (the condition that nutrient deficiency occurs under light physical work) the population was predicted to be over 800 million in 1990. Every year, the area of desertification is running over 5 million ha, of which 1 to 1.3 million ha is in irrigated and 3.5 to 4 million ha is in non-irrigated lands. At the same time, many grassland areas are also undergoing desertification. Under these conditions, food production must increase rapidly in order to supply food to the increasing population. Essentially more energy input will be required, leading to environmental disorder as a total structure. Therefore, it is essential to discuss energy and environmental problems along with increasing food production. The large population increase in China, GNP increases and the delay of environmental conservation measures in East Asia are good examples of factors that need to be considered in discussing those problems now.

The scenario of food production increase is that first cultivation land should be fully reclaimed. Then, new varieties tolerant to diseases and unfavorable environmental conditions need to be innovated by so-called biotechnology techniques, and their cultivation should be managed well. In recent years, development of biotechnology has been apparent, but for example, considering concepts such as adding C4 plant functions to C3 plants, more time and work are needed to develop technology to meet the food shortage. On the other hand, other factors such as global warming also impact food production and should be taken into account. In this sense, greenhouse production is essential to keep crops in optimal conditions even as new varieties are innovated for most crops. Even in open field cultivation, some energy inputs are required, and the energy problem is linked with food production in general.

Science and Technology Background

Along with the industrial revolution, mostly in industrialized countries, food production was increased by land reclamation together with the innovation of agricultural machinery such as tractors. In recent years, biotechnology, materials technology, and information technology including electronics have played important roles toward another revolution in the world. Now the world is getting closer mostly through IT such as the Internet, and the distance in various aspects between developed countries and developing countries is getting shorter. Environmental issues have been hot topics in recent years in not only developed countries but also developing countries. The largest trade-off is between development and sustainability. Science and technology must contribute in both aspects.

Political Background

Environmental issues are good examples of how politics are involved. It is not easy for most countries to give the highest priority to environmental protection or conservation. Economic development as a driving force is an essential factor for most countries, and it is more the case in developing countries. In East Asia, the situation is similar.

A large difference between Europe and Asia is the distance; not physical distance, but political and economic distance among countries is larger in Asia. The EU is an ideal union of neighboring countries for facing the complicated situations in the 21st century. Zoning of agricultural production is possible since it is based on this kind of union. This zoning is much more efficient for increasing agricultural production since it is much dependent on climate.

Present and Future in Agricultural Engineering

Agricultural engineering was originally technology for agricultural production and now also serves the same purpose but with sustainability and environmental protection. It is well-linked with other technologies such as biotechnology, materials technology, and IT, and Agricultural Engineering should play the major role for agricultural production (Fig. 1).

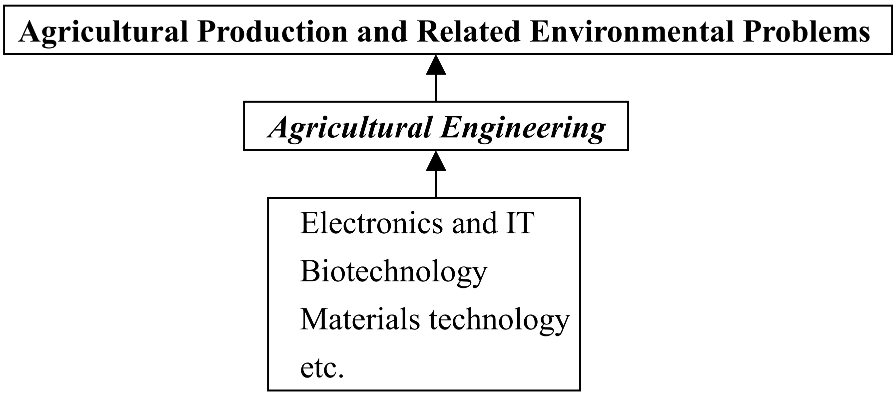

Fig. 1. Contribution of agricultural engineering in the future.

Strategies in Open Field Production

Precision agriculture is one of the promising techniques for increasing production with environmental sustainability. In East Asia, the average farm size is not large and cost efficiency is the major problem. Precision agriculture itself is not only for open field agriculture. The application of precision agriculture started in the 1970s with cow identification. Each cow had a transponder and all data on each cow was accumulated on a computer for careful management. Now this system is being applied to field crops and can be applied to closed artificial environment systems. All techniques such as GPS positioning systems, sensor and vision techniques, data handling and decision-making strategy software are components that need to be developed for field crops and integrated into new agricultural machinery systems. In a closed system, positioning is accomplished through a moving camera from a close distance enabling the acquisition of precise plant data.

Application of fertilizer and agricultural chemicals can be minimized and optimized by precision agriculture, but excess fertilizer that is not absorbed comes out from the system and is a cause of environmental pollution around the system. Zero emission from any agricultural system is an ideal concept although it is rather difficult to accomplish in an open field operation. Environmental disorders related to global warming and climate change, such as soil erosion and desertification of not only cultivated lands but also grasslands, are other problems that need to be solved.

For overall crop management, gantry systems and vehicles with automatic navigation systems have been investigated for years. Various sensors, specific actuators, and end-effectors have to be developed. Agricultural robotics need similar components to handle biological objects with a certain speed and accuracy, and this is more difficult to accomplish than in general hardware industries such as the auto industry. It is still true to say that training of monkeys to harvest fruits is a much more efficient and realistic way than to construct a robot for the same purpose.

Strategies in Closed Artificial Environment Systems

Table 1 shows recent developments in the greenhouse industry. It is apparent that the greenhouse area in each country is increasing with very rapid growth in China. The three countries listed in Asia are all in East Asia.

Closed artificial environment systems such as greenhouses are promising for agricultural production in the severe environmental conditions we will face in the future. However, since they are energy consuming systems in general, energy savings with zero emission is a major issue for these systems.

Not only energy savings but also progressive development to use natural energy such as solar and wind power, and renewable energy such as biomass should be accelerated. Innovations in new energy sources could solve the situation.

For plant production, most parts will be automated along with the expansion of cultivation area, which is essential in East Asia. Internal systems such as transportation systems for plant production, robotic systems for potting plants and transplanting, and closed hydroponic systems are already very common in European countries and in operation to some extent in East Asia too. The most sophisticated type of closed system plant production is the so-called plant factory, and some are in operation in Japan and Taiwan. Since the whole system is enclosed, the accomplishment of closed or zero-emission systems can be realized if the energy problem is solved. However, one component that presents difficulties is accumulation of undesirable salts in hydroponic systems. In most cases, this problem is overlooked, but it is impossible to supply chemical nutrients to exactly meet the plants’ needs. Dumping of the entire hydroponic solution is sometimes necessary; otherwise, the salt concentration would increase in the solution and the pH level would go out of control in a closed system. A closed hydroponic system needs an accurate and stable sterilization component, of course.

Covering materials are of great concern for the future since they are the basic components in protected cultivation. Not only the optical and thermal properties but also other properties such as vapor permeability, biodegradability and ability to protect against insects are of interest. The rooting media is another important material for hydroponic systems. Natural and natural by-product media available in the region of the cultivation sites has to be developed instead of relying on artificial media such as rockwool.

Strategies in Livestock Production

Environmental pollution is very serious around pig production houses, which in Japan, are very simple, small-scale structures located close to villages. Poultry production is on a large scale and well-mechanized, which sets the local product prices at the world prices. Complete closed systems can be applied to these two systems in the future.

There is a wide range of dairy cow production systems operating in Japan, from small-scale to large-scale. On large farms, monitoring systems for individual cows and automatic milking systems will be a normal feature in the future.

Manure and odor treatment in livestock production systems are still large issues to be solved from the viewpoint of both environment pollution and renewable energy.

Conclusion

Agricultural engineering is a multidisciplinary field of science and will play a crucial role in solving agricultural production and related environmental problems. Agricultural engineering from now on will work with close and strong ties to other new technologies such as IT and biotechnology to meet agricultural production demands under severe environmental conditions.

Table 1. The area of plastic greenhouses in the main horticultural countries (Takakura and Fang, 2002).

	1991	*1999*
World		682,050 (ha)
Africa and Middle East		55,000
Turkey		14,000
Morocco		10,000
Israel	1,500	5,200
Algeria	4,802	5,005
Rep. Of South Africa		2,500
Syria		2,000
America		22,350
U.S.A.	2,850	9,250
Colombia		4,500
Ecuador		2,700
Asia		450,000
China	200,000	380,000
Japan	45,033	51,042
Korea		2,200
Europe		180,000
Italy	65,000	61,900
Spain	35,000	51,000
France	9,000	9,200
Hungary	4,000	6,500
Serbia		5,040
Czech and Slovak Rep.		4,300
Russia	4,850	3,250
Greece		3,000
Portugal		2,700
United Kingdom	1,000	2,500

Poland	2,000

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