PRECISION FARMING AND ITS POTENTIALITY
- INNOVATIVE FRONTIER TECHNOLOGY FOR AGRICULTURE -

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ABSTRACT

The characteristic features of Japanese agriculture are rice production and its highly mechanized small scale farming system due to the limited land space. Agricultural production system in mechanization has been currently changed from mass production system to flexible manufacturing system, which became already much popular in industrial production one. This can be explained that the target crop for mechanization has been shifted from majority crop (rice) to minority crop such as vegetable and fruit because of the overproduction problem of rice and its production control policy, successful completion of rice mechanization, and the rapid development and distribution of computer technology. Agricultural robots and precision farming have a great potentiality not only to change the agriculture, but also to solve many problems even for global issues. Precision farming should be normally applied to huge scale farming from the viewpoint of its efficiency. It looks almost impossible to apply both precision farming and agricultural robot technologies to Japanese condition due to the typical reasons characterized by small scale farming and low efficiency caused from the scale demerit in application, because it is generally said that at least more than fifty hectares area of farm land is needed for the efficient and effective application of precision farming.

In this paper some of the examples of agricultural robot application and its possibility are introduced, then the idea how the precision farming combined with agricultural robots can be applied under Japanese condition is introduced, and proposed for the potential collaboration project among Inter - partner University.

1. INTRODUCTION

Mechanization in Japan has been developed based on a small-scale farming in rice cultivation because of the limited size of paddy field in addition to the social needs and importance of increasing the production as the staple food after the end of World War II. For recent half century, agricultural machine has been drastically changed from man-powered, animal-powered, and mechanically powered. Type of agricultural machinery has been also changed from walking type to riding type. Mechanization brought the increase of yield per unit area. Japan is now facing to the overproduction problem of rice. For

almost thirty years, the production control policy has been continued for rice. The shift from rice to the other crops has been recommended such as wheat and soybean. They are however no so attractive than rice because the rice price has been fully kept stable by the central government from the viewpoint of supporting the rice farmers financially. This kind of backup accelerated the promotion of rice mechanization. However mechanization is now expanding from rice to the minority crops such as fruits and vegetables, with the rapid progress of computer technology. Currently some of the driver-less fully automated machines is technologically developed even though they are not commercialized yet due to the problems to overcome, such as safety and product liability, which the manufacturer must be responsible for the accident caused by the poor design. Research topics closed up and promoted now in Japan are agricultural robot and precision farming, which should be applied to the huge scale farming, otherwise the merit in application can not be found. In this paper the method of applying those two high technologies to the Japanese condition is proposed

2. PRECISION FARMING

In designing agricultural machinery, the following three were the factors to be considered in the past two decades since 1970: 1) safety, 2) automation and 3) energy saving. However the attention to environmental issues was not seriously paid. By the warning of global warming due to the big amount of carbon dioxide production, we became to be aware of importance of global environment preservation. The terminology “Sustainable Development” and its meaning are seriously discussed and emphasized recently. The meaning of sustainable development is to promote the economic activity without jeopardizing environment. Precision farming satisfies this condition as follows.

Fig. 1: GPS controlled Rice Transplanter under operation

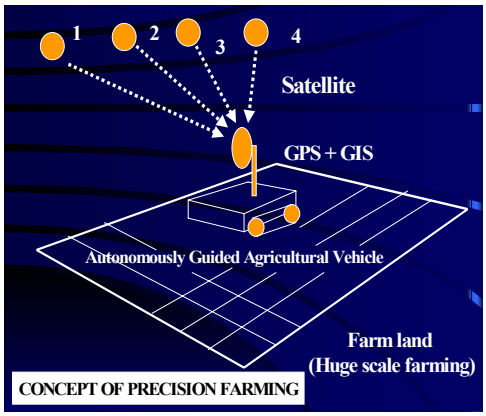

Fig. 2: Concept of Precision Farming

It can cover a huge scale of farm land by the support of using satellite. Farm field considered is divided into many small meshes and the various data for each mesh such as soil fertility, moisture content, yield, and etc. are measured, collected and installed as the

database in geographical information system (GIS). Global positioning system (GPS) is also used to identify the exact location of both machines and farm field for giving the suitable treatment and operation to meet the condition obtained as the database in geographical information system (GIS). As the various kinds of operation can be given based on the data obtained from the measurement, more precise control and necessary treatments such as fertilizer, herbicide and pesticide applications, are applied timely to a each area of mesh accurately with suitable amount. This farming method leads not only to the saving of material resources and energy in operation, but also to the control to jeopardize the environment.

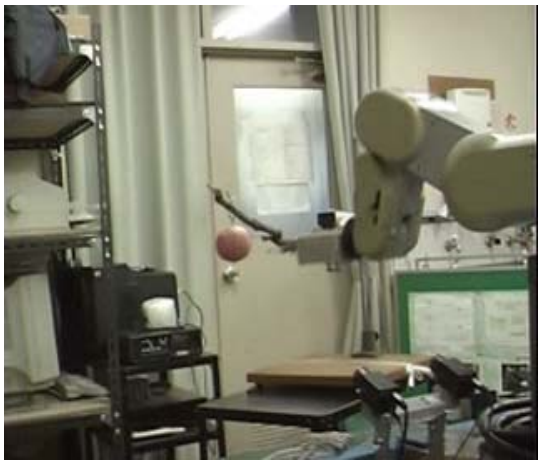

Fig. 3: Fruit harvesting robot under operation

Technologies involved in promoting precision farming are shown below.

1) Tele-communication based on Information technology (IT)
2) Mobile robot control technology
3) Computer technology
4) Mechatronics technology
5) Machine vision
6) Pattern recognition
7) Material handling
8) Image processing technology
9) Sensor fusion
10) Instrumental measurement and analysis
11) Data processing
12) Ethanol production technology
13) Bio-technology and genetic ngineering application for developing higher yield rice variety for ethanol production.

The development of these integrated technologies mentioned here can be drastically accelerated and promoted by the introduction of precision farming. The original and unique high technological device and equipment can be developed, and those are easily applicable not only to the small scale farming, but also to the huge scale farming even in

Europe and USA, which are very much competitive in the world market. Therefore the trial of introducing the precision farming may push up the level of various technologies mentioned above, especially computer and telecommunication ones.

3. RECOMMENDABLE CROP AS KEY RESOURCE

It should be notified from the viewpoint of considering the global issues that the useful key resource should be proposed to overcome a tetralemma consisting of the following four issues such as population, food, energy and environment. The author would like to recommend rice as one of the hopeful key resources, which can contribute a lot as the resources of food, energy and environment. Rice is a main staple food resource in Asia being produced over 450 million tons per year, whereas the total production in the world is 500 million tons per year. Japanese has been totally relied on the rice production up to now. Thailand is one of the most famous rice producing and exporting country in Asia. Ethanol can be produced from rice, of which the production efficiency is 430 liter per ton of rice. This figure is the biggest one among the agricultural crops including sugarcane, maize and cassava. Rice can absorb a big amount of carbon dioxide, almost 17 to 19 tons per hectare while growing in the paddy field. On the other hand, the carbon dioxide production in rice mechanization is almost 820 kg/ha. Therefore it can be found from this figure that rice can absorb carbon dioxide roughly 16 to 18 tons/ ha. This figure looks bigger than the tree of the forest as shown in Table 1. According to table 1, it can be seen that some of the trees absorb almost the same amount of carbon dioxide as rice, but most of them are less than that. It can be concluded from this data that growing rice can solve or relax three global problems of food, energy and environment.

Table 1: CO2 absorption by various trees expressed by carbon based

Place	CO2 absorption(ton/ha)
Brazil	1.0
	4.5
USA Tennessee	5.3
Oakridge city	4.4
Massachusetts	3.7
Central Italy	4.7
Japan Takayama	1.17
	0.67
	1.36
Canada	1.3
Saskatchewan	0.56

As already introduced, Japan has been facing the overproduction problem of rice. This problem has been accessed by the production control for recent thirty years, however no

solution has been found from this policy. The other policy of making rice competitive in the world market based on the technologies of low cost production and value added ones, focusing on the increase of consumption and demand. For this purpose, the various type of high technology should be tried to apply associated with the collaboration of university, government and industry. Research proposal can be easily materialized since both Thailand and Japan are well known as rice producing countries. For the promotion of managing the stable and healthy national economy, the possibility of finding a new type of farming system should be looked for. One of the most important requirements as the key resource is that the bio-resource nominated for key resource must solve all problems of food, energy and environment simultaneously. Rice can be recommended as one of the most hopeful key resources from this point of view.

4. RESEARCH PROPOSAL

Not only in Japan, but also in Thailand it looks not so difficult for the government to prepare the experimental paddy field, of which the area should be at least more than 500 to 1000 hectare. In Japan totally five thousands hectare of newly reclaimed land for the purpose of promoting the agriculture, however due to the following two reasons, they are not completed yet and it is agreed for some of the lands between the people living in local area and central government that they should not be developed any more. Based on this social background, one of them was already purchased by the local government under the agreement that the land should not be used for the purpose of farming, but for the other purposes. Generally speaking two sectors, industry and agriculture are very much important for promising the increase of GDP to strengthen the economy and assuring the security of survival respectively. However it can be found that they are organically connected each other. Industry contribute a lot in getting income from the trade of produced products, however the waste and the emission gas including carbon dioxide are mostly absorbed by agriculture. The author calls this relationship “Agri-Techno fusion”. One of the most serious problems Japan is facing now is the access for improving the economy. Including this, most of the problems can be possibly solved by organizing the national project to validate the possibility of Precision Farming and Robotics in Agriculture by use of those abandoned lands. Here shows the concrete process to follow to materialize the project.

1) Organize research project under the assistance of organization or government
2) Provide those lands for the experimental farm to validate above mentioned farming system
3) Invite researcher from university, industry and governmental organization
4) Grow rice on those lands after final completion of land rearrangement
5) Ethanol production by the plant introduced through whole year
6) Cost and management analysis for ethanol production and operation economy
7) Possibility assessment of produced ethanol as an alternative energy
8) Assessment of Carbon dioxide absorption by rice production

9) Project for the development of higher yield variety of rice by use of bio- and genetic-technology should be carried out simultaneously

As far as the author knows, South Korea is promoting a similar project under the provision of 10 thousands hectare of huge agricultural field by the assistance of central government. By the successful introduction of this project, the following merits can be found.

1) Construction for the rearrangement of those lands provide the job opportunity and improve the percentage of jobless laborer, and activates the Japanese economy
2) Vision and access not only for future agriculture, but also industry with high technology development can be clarified and shown
3) Access for global tetralemma can be proposed
4) Newly developed technology through the project can be highly competitive in the world market even rice produced too
5) Security for survival based on high self-sufficiency can be assured by the flexible rice production for food and energy combined with ethanol production system
6) Successful completion of high technology development and its application promotes the replacement of conventional rice mechanization by the precision farming
7) Both agriculture and industry can be promoted with harmonic balance

5. RESEARCH ORGANIZATION

The academic field of study involved or deeply related to both technologies of precision farming and robotics in agriculture are as follows.

1) Agricultural Engineering
2) Computer Engineering
3) Information Engineering
4) Electrical and Electronic Engineering
5) Telecommunication Engineering
6) Bio-technology
7) Genetic Engineering
8) Chemical Engineering specially for Fermentation Engineering
9) Mechanical Engineering
10) Energy System Design Engineering
11) Geographical Information System Engineering
12) Aerospace Engineering
13) Robotics and Artificial Intelligence
14) Cost Evaluation Engineering
15) And so on

As it can be seen from the above academic field of study, the participation of researcher and engineer from various and different field is extremely welcome. A big scientific group can be organized As the total integrated project and collaborative research can be conducted through the exchange of idea, opinion and information based on the mutual visit

and stay of the faculty and student at partner university or institute. Many researchers can join easily because the collaborative project involves so many academic area of study and the result of the program will do contribute in many sectors, not only in agriculture and industry, but also in the improvement of economy and social problems such as the creation of the opportunity for job condition.

6. CONCLUSION

It can be found from the discussion developed previously on the precision farming and robotics application in agriculture that one big collaborative research can be initiated and proposed by providing the opportunity for many researchers and engineers belonging to the different, various academic field of study from university, institute and industry. The author trust the result of the collaborative research project can surely bring many fruitful results which can contribute a lot, not only in Asia, but also in the world. The total food production in the world is almost 2.4 billion tons per year. Roughly to calculate the food per capita per year is almost 400 kg/capita/year. However we still can see so many people are dying because of poverty and hunger due to the unbalanced sharing of food. This research project focuses primarily on ethanol production (energy) from rice and secondary on food production, and thirdly the carbon dioxide absorption. One of the most unique and significant points of this collaborative research project are characterized by the concept of original idea to overcome or solve most of the problems which we human beings are facing now. According to the simple calculation based on the capability of carbon dioxide absorption of rice, almost 15 million hectares of paddy field will be enough to absorb the total amount of carbon dioxide produced in Japan (equal to three hundred forty million tons per year calculated based on carbon) and the memorandum of understanding for reducing carbon dioxide production to the level of six percent compared to the one in 1990 can be achieved at COP3 in Kyoto can be kept comparatively easier. The reason why the author recommend rice as one of the key resources is coming from the additional conditions that Japan has overproduction of rice and some of the effective countermeasure must be done for improving the situation such as the increase of consumption and demand. In Thailand the other resource can be listed up for ethanol production, however it can't be grown up in Japan except some tropical climatic area like Okinawa, because of geographic location. Compared with cassava, rice is raised up in most of the countries in Asia. Anybody can grow without any special high technology and average yield per unit area can be normally expected if nothing happened.

7. FOR FURTHER RECOMMENDATION

In conducting a collaborative research, financial support or budgetary funds are needed. Discussion how this project can be materialized for actual operation should be done more

in detail by the related people involved in the universities, institutes and industries. In Japan rice production is still under the control of central government even for the other purpose of rice production to support the developing country suffered under hunger and poverty. All of the rice production must be registered except the old rice stored more than one year for the purpose of social and food security.

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9. REFERENCES

In assembling this paper, the following reference was mainly cited and used.

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