HOW MUCH RICE CAN CONTRIBUTE TO SUSTAINABLE AGRICULTURE

Nobutaka Ito
Department of Bioproduction and Machinery
Mie University
Tsu, Mie 514, Japan

ABSTRACT

The four subjects which we human beings are going to face and negotiate toward the 21st century are (1) Population, (2) Food, (3) Energy and (4) Environment. In this paper, rice is recommended and proposed as one of the most valuable key resources for the purpose of covering those four subjects with harmonic progress and promotion of the economic development and growth. The historical background and the current status of rice production in world wide were reviewed. To meet those subjects, various methods of utilizing rice were introduced and proposed, how rice could be usefully utilized and processed as food, energy and the role played by rice plant in absorbing carbon dioxide produced.

Key Word : Agricultural mechanization, Rice mechanization, Food, Energy and environment

INTRODUCTION

The topical keyword "Sustainable Development" has become more popular in recent years and emphasized especially from the viewpoint of global environmental protection and conservation. However the exact meaning of sustainable development is not so well defined and clarified as this keyword is widely used, therefore it is not well understood as we know why the keyword became so popular and famous. Depending on the area of study the meaning of sustainable development is slightly different and intentionally changed in nuance. How the researchers can promote sustainable development depends on their own way of thinking and observing based on their academic specialties and many ways of conducting their researches for that purpose. However clarifying the common purpose or final target to achieve sustainable development is specifically important, otherwise we will loose the way and direction or misunderstand its real meaning.

Definition of sustainable development

Sustainable development is defined as the development of technology to meet the social needs and promote economic growth without destroying the capacity and potentiality in the resources involved, which are necessary and useful for future era. Or it can be defined as the technology to promote economic growth without giving the load onto the global environment. It means that both problems of economic growth to meet the social needs of mankind and the environmental conservation and protection to maintain the ecological balance must be considered. When it comes to think about these two problems,

it looks very much difficult to promote them simultaneously in parallel, without finding the harmonic compromise based on the human desire for comfortable living and the concern for the future generation. When we were born, we have to live and everybody wants to live comfortably and spend a happy life.

For promoting economic growth, which is necessary for those types of life, four subjects, which we are going to face must be essentially considered as follows; (1) population, (2) food, (3) energy and (4) environment. The first three subjects are deeply related to the economic growth for human beings to spend a comfortable living. Therefore the key for these subjects is to find the solution in discovering the key resources that will be more useful and hopeful, and how we can conduct economic development can promote an economic activity without jeopardizing the environment keeping its original potential capacity as much as possible.

Population It is a fact that the world population is now almost 6 billion and still drastically growing at a rate of one hundred million per year. More drastic increase of population can be found especially in the African countries and some of the countries in Asia, such as India, Bangladesh and Pakistan. Family planning and its related program should be extended for solving the population control problem. Anyway at this moment this trend looks extremely difficult to slow down effectively the rate of population increase world wide. Assuming that the world population will increase with the same or more higher rate than we have now, then according to this future aspect, the food production should be increased to take care of the increased population.

Food With the drastic increase of world population, we are necessarily forced to increase the food production. However we need to have a look at the current status of world food production how it is now. The total world production of five main grains i.e. rice, wheat, corn, sorghum and soy bean is almost equal to 1.5 billion tons per year. This excludes the amount of production for other crops such as vegetables, fruits and meats. Using the above figure of 1.5 billion tons per year, we can roughly calculate how much food could be provided per capita per year if it is distributed ideally to all the people in the world. Dividing the total amount of production of five main grains (ton/year) by the total world population, the grain as food can be obtained as 263 (kg/capita/year). Basically this figure of 263 kg of grains is enough for one man to live for one year. Besides as it is already mentioned, if the other crops are taken into account, the quantity of food available for one man to eat per year is more than enough to live. However poverty and hunger can still be found in many developing countries. This is due to the improper food distribution caused by so many factors such as economic, political and diplomatic problems or undesirable relationship between or among the nations sometimes. In addition it must be noted that in general the food flows from the developed countries to developing countries, because of the high quality control of the products and the reasonable inexpensive price based on the mass-production systems supported by the highly mechanized agricultural production systems. The world production for rice is around 0.5 billion (500 million) tons per year and more than 90 percent of it is produced in Asian countries. Only three percent of the total amount of rice produced is traded in the world market.

Energy Any kind of production activity more or less rely on the help of fossil fuel produced from Middle East and the other oil producing countries. Industrial productions including the electric generation totally rely on the oil. It seemed that the petroleum will be depleted sooner or later in the

future. In the past, whenever we encountered formally the oil crisis, the necessity for finding out new type of energy was emphasized so often, which is renewable and friendly to the environment. Various types of researches on energy programs were conducted and the possibility of using the new types of energy were investigated for practical use. However, with the frequent fluctuation and variation of oil price due to the imbalance between the demand and supply, most of those types of research programs were stopped or they were not continued any more for extension to the practical application. At present, preparation must be done earlier for the next coming era considering the energy problem which we have to face sooner or later. Biomass energy is one of the hopeful possibilities because it is renewable and the biomass resources could absorb the carbon dioxide, which leads to the clean-up of the global atmosphere.

Environment One of the greatest concerns for us is the global warming due to the carbon dioxide production, which is mostly produced from the industrial activity, cars and so on. The technology for the reduction or fixation of carbon dioxide is one of the most important necessary items for environmental protection. From this point of view, the environmental protection is also deeply related to the type of energy to be developed and used in the future. The car under development which can be operated on hydrogen is often exhibited and demonstrated at research level. However it would take more time for that to be ready for practical use because of the following reasons. Considering these backgrounds related to the above mentioned four subjects, the resource to be hopefully utilized for covering those four subjects should be found and proposed to overcome the trilemma or tetralemma coming from those four global subjects. The author recommends and proposes the rice as one of the most valuable key resource for solving most of the problems described above.

CONTRIBUTION OF RICE AS KEY RESOURCES

As already described in the former section, rice has been one of the most important and popular food especially for the people in Asia, who in 1990, contributed more than 90% of the total world production of rice. In Japan, for more than 25 years, the production of rice has been controlled by the government because of the overproduction, as a result of high production technology and mechanized farming. For 25 years, no technological innovation related to rice production has been done compared to the US who had successfully reduced the production cost. Now the production cost of Japanese rice is almost double and the price is more than five times compared to the US rice. In Japan, rice is just produced for domestic consumption. The reason why the rice production control has been done is to protect and stabilize the price of rice by protecting and supporting the farmers, instead of protecting the rice. Protecting the rice means to make the rice more competitive in the world market without any kind of governmental support. When the supply of the products exceeds more than the demand, there can be found two ways to improve the situation. One is to control the production and the other is to develop new market for expansion of the business. In Japan however only the former one was done because of the policy that the rice should only be limited to the domestic consumption. For more than 25 years of production control policy, what kind of improvement has been found ? More demerits can be pointed out than the merits such as the waste of budget for supporting farmers, the increase of the abandoned farm lands coming from the land bank policy, no technological innovations, the discouragement of the farmers to farming and the weak competitiveness of rice production agriculture. We learned that the production control didn't play any

effective roles for improving the situation, but forced the farmers to obey the non-productive and unnecessary labor activity of farming. Based on the result obtained from this background, the production control should be stopped immediately and more efforts should be done in looking for the possibility of developing new marketing strategy related to rice and its production. In so doing, rice should be considered from the different kinds of category on how it can be useful for human beings.

Table 1 Rice production in the world

year	1986	1990
Total in the world	470,684 (100 %)	520,524 (100%)
Asia	432,010 (91.8%)	480,881 (92.4%)
Africa	9,908 (2.1%)	10,771 (2.1%)
Central America	2,325 (0.5%)	1,960 (0.4%)
South America	14,744 (3.1%)	13,798 (2.7%)
North America	6,034 (1.3%)	7,026 (1.3%)
Europe	2,285 (0.5%)	2,656 (0.5%)
Oceania	959 (0.2%)	959 (0.2%)
Soviet Union	2,473 (0.5%)	2,473 (0.5%)

Unit: 1000 ton, Figures in bracket show the share in percentage. Source : FAO

It has been pointed out that rice is one of the staple and important main foods, especially not only for Japan, but also for Asia. Rice as food can be eaten continuously as it has been before. In addition to that, ethanol can also be produced from rice which can be used as alternative fuel for engines. It is also friendly to the environment since rice plant can play an important role in absorbing carbon dioxide while in its growing stage. From these different angles of observation, rice can be considered as one of the valuable natural key resources which contributes a lot in solving four subjects mentioned above. As already discussed in the first part of this paper, sustainable development means that the solution for the four subjects should be conducted and handled with harmonic balance in promoting the economic development without jeopardizing each other's subjects during the process of development. In Japan, almost 0.8 million hectare of the original area of paddy field is left idle and had not been used for the original purpose of growing rice. If we grow rice in this area and produce ethanol from the harvested rice, we can expect a considerable amount of production of ethanol enough to operate 2.4 million cars which is equal to almost 5% of the total number of cars in Japan.[2] This is a great help for Japan in saving oil while the increased area of cultivated rice can serve as a huge natural carbon dioxide digester, and we don't need to prepare special equipments and facilities for carbon dioxide fixation. Besides the ethanol blended fuel reduces the contents of hydrogen carbonate and carbon monoxide found in gas emission. If the ethanol blended fuel is magnetically treated in the process of being introduced into the engine cylinder and burnt, the specific fuel consumption and output horsepower are slightly improved.[3] This means that the rice is a precious key resource friendly to both energy and environment and needless to say, food for us. When it comes to think about these kinds of problems, we sometimes are trapped into the dilemma, trilemma or tetralemma. However as far as rice is concerned, it can tell us how we can be released from that trilemma consisting of the three subjects of food, energy and environment. The

following shows the capacity and balance on how much carbon dioxide is produced from rice cultivation starting from planting up to harvesting and how much of it can be absorbed by rice plant. Table 2 shows the total production of carbon dioxide in Japan.[4] It shows that most of the carbon dioxide produced are gone to the Ocean and the rest of them are absorbed by plant. One of the researches conducted by the famous automobile company in Japan was to look for suitable variety of tree which can absorb more carbon dioxide effectively.

Table 2 Total production of CO_2 per year in Japan

Source		Sink	
Industrial production activity	*34 %*	*Ocean*	*74 %*
Electric generation	*29 %*	*Plant*	
Automobile	*12 %*	*Forest*	*16 %*
		Cultivated land	*10 %*

Based upon the assumption that one car is owned for ten years and it can run about 150,000 km for that period, the total quantity of carbon dioxide produced is estimated at 9,000 kg including the process of producing the car itself. To absorb this amount of carbon dioxide, the research tells us that 60 to 70 trees are enough to do it, however the specie of tree which can do it was not described in the literature cited. [4] Based on this data, the following estimation can be derived. So to speak, the capacity for one tree to absorb carbon dioxide becomes 12.8 ton/year. For the forest its capacity is 80,000 ton/ha/year, assuming that 6,250 trees are planted per hectare. However this is only the population density of trees

Table 3 Comparison of ethanol productivity for various crops

Crops	① Yield (ton/ha/year)	② Ethanol (litre/ton)	③ Ethanol (litre/ha/year)
Sugar cane	50 - 90	70 - 90	3500 - 8000
Sweet sorgham	45 - 80	60 - 80	1750 - 5300
Sugar beet	15 - 50	90	1350 - 5500
Fodder beet	100 - 200	90	4400 - 9350
Wheat	1.5 - 2.1	340	510 - 714
Oat	1.2 - 2.5	250	300 - 625
● RICE	2.5 - 5.0	430	300 - 625
Corn	1.7 - 5.4	360	600 - 1944
Sorgham	1.0 - 3.7	350	350 - 1295
Potato	10 - 25	110	350 - 1295
Cassava	10 - 65	170	1700 - 11050
Sweet potato	8 - 50	167	1336 - 8350
Grape	10 - 25	130	1300 - 3250
Coconut (A)			2300 - 8000
Coconut (B)			1350 -

Source : Alcohol Fuels, NAS

planted at the beginning of the forest and half of this figure will be gradually cut by thinning for making a strong and high quality timber, in controlling the photosynthesis and to be fitted with the housing materials.

Forest has so many functions: a) for the environmental protection; b) in controlling the erosion of the soil; and c) the storage of the water in addition to obtaining the timber for housing. However once the trees were cut down, it takes more than 15 to 20 years to get to the same level of trees again. Although the forest can play an important role in environmental conservation and protection, however the flexible adaptability of that function is difficult and limited depending on the situational change such as the increased production of carbon dioxide caused by a drastic increase of oil energy consumption. Let us have a look at the same thing for rice, how much carbon dioxide can be absorbed by rice plant.

According to the data, it is said that the total carbon dioxide produced in the whole process of growing rice from planting to harvest is 820kg/ha/year, but the total amount of carbon dioxide absorbed by the rice plant in the same growing period is 19,500 kg/ha/year, which is almost 20 times more than the produced one. This calculation was based on the following data that the daily absorption capacity for rice is 30 ~40 g of carbon dioxide /m ^{2}/day and the whole growing period of rice is 130 days. Besides the adaptability to variable change of energy situation coming from the increased economic activity is more excellent compared to the tree or forest. Rice is grown up only once a year in Japan, but we can see three times a year of rice of cultivation in Thailand and some other tropical countries in Asia. The scale of cultivation can be so easily adjusted and the capacity of absorbing carbon dioxide can be increased by expanding the rice production.

Table 3 shows the comparison among various biomass resources on how much ethanol can be produced from a unit amount of raw material. As it is clearly observed from this table, rice shows the highest productivity expressed by the unit of 430 litre per ton. Needless to say, the ethanol produced from the other corps such as sugarcane and cassava, expressed by the unit litre/ha/year shows bigger numbers compared to rice. The area of cultivation and the yield (t/ha/year) for those crops are completely different. They are grown up widely in South America. One time when we encountered the energy crisis, the cars in Brasil have been operated on 100 % ethanol produced from those materials. As it can be seen from this example, ethanol has to be one of the most hopeful biomass fuels, therefore if it can be processed and produced economically, then it will be more closed up again. The idea of using ethanol for biomass fuel is not so new, and the concept of using ethanol produced from rice is the key point especially in Japan where almost 97% of oil is imported from the oil producing countries. Therefore if ethanol can be used as fuel, it leads to the saving of the imported oil and relaxes the energy problem which Japan has to always face in the future. On the other hand, the increased cultivation of rice encourages the farmer and the agriculture, and the related business will be more attractive and active. It will stimulate the economy not only in agriculture, but also in industry. Besides it is said that the higher quality of ethanol can be produced from rice than the other crops. Magnetized fuel has high potential in improving the specific fuel consumption and the gas emission. Some of the commercial products sometimes called "fuel economizer" or "exthergy" are now in sale. The mechanism why the magnetized fuel has such an effect is not officially explained, however the improvement can be obviously validated by the author's study. [5)]

ROLE OF JAPAN

The author believes that Japan has two main roles in the world at this moment, especially in Asia. They are; (1) Technology transfer and (2) Human resources development. The latter one should be promoted based upon the former one. As generally well known, Japan is the country defined as the nation supported by the power of high technology and economy, but less natural resources. Economic development is mostly depending on the high technologically mechanized industrial production. On the other hand, the agriculture has been nationally supported and protected for a long time and still under its support at present. However if the author's proposal for rice production strategy can be promoted, Japan will be able to contribute in many ways not only to Asia, but also to the world. The items of food and energy for covering the increased population are the necessary essentials for promoting the economic activity for better life, but in return the environment is also damaged by the promotion of economic activity. As what we have already defined as sustainable development, the economic activity must be promoted without giving any damage to the environment. Social needs must be satisfied with the promotion of economic activity without jeopardizing the environmental resources for future use. The author showed how rice can contribute to us, human beings as one of the important key resource for food, energy and environment. Japan has encountered the overproduction problem of rice, however no effective countermeasures have been proposed except the production control. What is the reason for that ? Rice has not been considered as a resource to be used for many other purposes, but as an important stable main food resource for the domestic people. It has been seen only from the economic viewpoint such as to stabilize the price for the domestic consumers. No effort has been done in looking for orher potential possibilities how rice can contribute to us or how it can play an important role as a resource. The concept of the author's proposal for rice production strategy might be one of the solutions, and the other idea might be found. Fortunately Japan has the high technologies not only in industry, but also in agriculture, especially rice production. The author believes that technology transfer and human resources development program will contribute much to the various type of stabilization and release the people from poverty and hunger due to food shortage. It looks much easier for Japan in doing, that because almost 90% of the rice in the world is produced in Asia and Japan is also one of the members in this area. Needless to say, the same kind of international program and activity can be applied to the other countries located not in Asia, which requires them. As already mentioned about the minimum access of rice agreed upon at GATT (General Agreement for Tariff and Taxation) Uruguay round, Japan has to import almost 0.4 million tons of rice from the outside countries by 1995, compared to the domestically produced rice, the rice coming from outside, although with less price is still evaluated lower because of the quality. Japan's import of cheaper rice can certainly stimulate the economy of the exporting country and those kinds of rice should be purchased much for the purpose of processing and ethanol production. Higher quality of rice should be eaten as the food. The economy of the exporting country actively and those kinds of rice should be purchased much for the purpose of processing and ethanol production. Higher quality of rice should be eaten as the food. In so doing, the followings can be derived;

(1) Japan can show the attitude respecting the international agreement
(2) The economy of rice exporting country is actively stimulated and the rice producing farmers will be more encouraged.

(3) Japanese rice will be more competitive in the world market and the rice production agriculture in Japan will be refreshed and restructured for new business.
(4) The opportunities for new business related to rice production will be increased.

COUNTERMEASURES

To add value to rice and to lower the production cost, new type of rice producing technologies should be developed and the same as the industrial products, they must be manufactured with less production cost and high quality. Electronic equipments and devices such as the video, TV, and compact disk are the examples of typical industrial products. As shown in these products, the price is drastically reduced, but in spite of this, the quality and the functions are highly improved and evaluated. Rice should follow and be produced in the same manner as far as it is one of the commercial products, otherwise it will not become competitive. Technological innovation should be promoted specifically in the developments of (1) Low cost production and (2) Value-added technologies to meet the purpose of making rice a more competitive product in the world market. The followings are some of the research programs categorized as the break-through technologies to be fitted with the requirements mentioned above, which the author has been conducting (see Fig. 1).

Direct sowing by use of coated rice [6)~8)]

Direct sowing method is still popular from the viewpoint of energy and labor saving, especially in the developing countries, however the yield per unit area is almost half compared with the developed countries. For the same purpose of saving energy and labor for both developing and developed countries, the direct sowing has been introduced. However the yield per unit area is different primarily because of the various factors such as the scale of farming, the level and the quality of mechanization, and the policy and the strategy of rice production. Compared with the transplanting method, direct sowing can eliminate the expenses calculated based on the preparation of nursery seedlings and its related labor required for the management of growing seedlings. To calculate roughly, the total expenses can be reduced almost one half to one third using direct sowing compared to the transplanting method. Coated rice with calcium peroxide is a new type of direct sowing method, in which the coated seed is sowed at 10 mm beneath the ground surface and the soil is covered over it. Then the following two problems can be solved basically by introducing this method: (1) damage due to the bird attack and (2) lodging problem when the seed is sowed at the ground surface. The weed control can be done by the new type of herbicide fitted with this type of direct sowing. Under the irrigated condition, the herbicide is applied only once, then most of the weed can be controlled completely. The water leakage reduces the effect of herbicide for weed control. Therefore the water management should be carefully considered from the viewpoint of weed control. The method of coating to the seed has the various potentialities to improve the rice mechanization system and the opportunities for the new type of business will be found.

Combine harvester equipped with hulling function [9)~11)]

A commercial combine harvester has normally two functions: cutting and threshing. Rice grains (rough rice) are removed from the straw through the threshing process. The harvested rough rice is dried until the moisture content becomes almost equal to 14% which can be well husked by the rubber roll type husker, then the brown rice can be obtained. It must be properly milled before distribution to the consumers. The impeller type rice husker has been getting popular in recent years because of its simple mechanism, higher husking performance and capability of husking high moisture content rough rice, and less residue inside of the machine after the completion of husking operation. By mounting this type of husking unit directly onto the combine harvester, the rice can be harvested as the brown rice from the paddy field. By the application of this concept, the following merits can be found.

(1) Three operations of cutting, threshing and husking can be done simultaneously, therefore the third operation of husking is not needed anymore as in the existing system after the completion of mechanical harvesting.

(2) Rice chaff and the brown rice are separated at harvesting stage, and rice chaff is thrown away and distributed uniformly on the ground surface of the paddy field during the husking process, and can be used as organic fertilizer for next growing season.

(3) The rice chaff occupies almost 15 to 20% in weight and 40% in volume for rough rice. Japan produces about 12 million tons of paddy rice in average, which means that almost 3 million tons of rice chaff is produced. If the rice chaff is thrown away at this stage, such amount of rice chaff doesn't need to be transported any more. It leads to the energy saving of transportation of unnecessary materials.

(4) For storage, as mentioned already, the additional brown rice can be filled up into the volumetric space where the removed rice chaff is supposed to occupy, which leads to the saving of the space of the storage facility.

(5) The moisture content of brown rice should be lowered for long term storage and the drying is therefore necessary. The drying of rice chaff is not needed anymore since the rice chaff is already taken away. Thus, the additional time and energy for drying the rice chaff can be saved. By proposing the new type of brown rice dryer, the heated air by use of crude oil is not necessarily used for drying the brown rice.

Brown rice dryer [12), 13)]

In the existing system of drying rough rice using circulating type rice dryer, normally the heated air obtained from the burning of the crude oil is used. For the brown rice, since the rice chaff is already removed, therefore the supplement of hot air produces crack on the brown rice, and the quality of rice is lowered. In addition, the bruise produced from the mutual rubbing of brown rice itself during the circulation has to be considered. Therefore a completely different type of dryer specially designed for brown rice should be proposed. The author proposed the cylindrical type brown rice dryer and constructed the prototype almost ten years ago, however the detailed data has not been obtained yet for the brown rice. By introducing and combining the technologies mentioned above into the conventional existing rice mechanization system, the production cost will be lowered almost 30% which leads to the increased consumption and the expansion of the rice market. For the development of value-added technology, the high technology application such as the image processing should be applied for the quality evaluation, for example.

EVALUATION OF PROPOSED MECHANIZATION SYSTEM

Fig.2 shows the detailed contents of CO_2 production from farming based on the medium scale mechanization system. The total value of CO_2, 726.7 (kg/ha) does not include the amount of CO_2 produced from production material here. It can be found that three main operations for producing CO_2 are shown as follows. They are (1) Drying and processing, (2) Harvesting and (3) Preparation for planting including the operations of tillage and puddling for land preparation. Needless to say, it is obviously found that the CO_2 production in mechanized rice production is mainly caused from the operation stage of Drying and processing, because the kerosene is popularly burnt for that purpose. Same amount of CO_2 is produced from each operation of preparation for planting and Harvesting respectively. As the author introduced and proposed new mechanization system consisting of the introduction of direct sowing, combine husker (combine harvester equipped with husking function) and brown rice dryer. If the existing rice mechanization system is replaced by the machines mentioned above, the production of CO_2 will be drastically reduced. By the replacement of transplanting by the introduction of direct sowing method CO_2 production from preparation for planting can be also reduced. In case of applying the combine husker, the reduction of CO_2 will be more than the existing system, because three operations of cutting of rice straw, threshing and husking can be completed simultaneously. In addition to the merits of saving energy of transportation of rice chaff which is not directly necessary except any specific purpose of usage, the useful utilization of rice chaff as the organic fertilizer, the shortening of operation stage due to the simultaneous combined operations and the space saving for storage due to the removal of rice chaff, the energy for drying can be saved much. So to speak for drying the brown rice, the heated air is not necessary. This simply means that CO_2 is not produced any more and normal air can be used for drying a brown rice. As shown in Fig.2, almost half of the carbon dioxide produced in rice production is produced in the stage of drying and processing. If the proposed combine husker is practically applied and the brown rice is dried out by use of the dryer especially designed for brown rice drying, the problem of carbon dioxide production is essentially solved. It can be concluded from this hat the proposed rice mechanization system can contribute not only for saving energy in various stage of operations, but also controlling the production of carbon dioxide. Roughly to calculate, almost 60% of carbon dioxide production or more than that can be reduced by applying the proposed rice mechanization system compared to the existing one.

As far as we follow the existing rice mechanization system, the problem of carbon dioxide production can not be solved, therefore a completely different type of mechanization system should be proposed and the effort must be done not to produce carbon dioxide from the viewpoins of energy saving and environment conservation. This kind of countermeasure really contributes to the action conducting "Sustainable Agriculture".

Direct sowing by use of coated rice

+

Combine with hulling function

+

Brown rice dryer

Fig.1 Newly proposed rice mechanization system

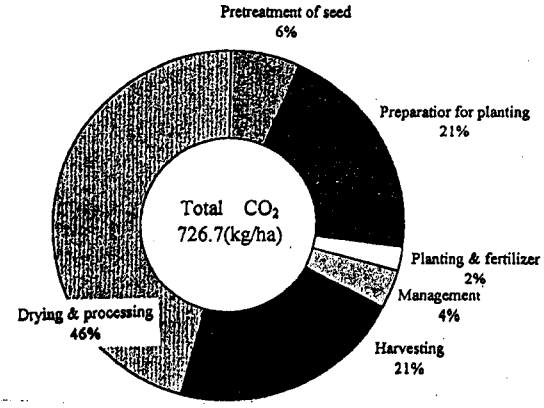

Fig.2 CO_2 production for various operations based on medium scale rice mechanization system

CONCLUSIONS

In the front part of this paper, the rice production policy and how it has been conducted in Japan was reviewed and the necessity of changing the policy was emphasized for improving the situation related to the rice production by showing the strategy how it should be handled for free market condition in the future. It was concluded from the discussion from the viewpoints of four essential items for sustainable development that the production control policy couldn't lead the rice production agriculture to the desirable direction for both of the nation and the rice producers. It was strongly pointed out that the protection of rice as one of the useful, strategic resource and the competitive products is more important than the one of the farmers based on the land bank policy (production control policy). The author proposed rice as one of the most hopeful key resources to cover the four subjects of population, food, energy and environment, which we human beings are going to face and negotiate toward the 21st century. The definition and the meaning of the term "Sustainable Development" was explained as the development and application of technology to promote economic activity to meet the social needs of human beings, without jeopardizing the environment. The estimation how rice can be useful for tetralemma problems based on the detailed calculation using the data is not completed yet, however some of the effect of rice production was introduced as in absorption and fixation of carbon dioxide compared with the case of tree and forest. It was found that the carbon dioxide produced during rice production from planting to harvesting is 820kg/ha/year in which this value of CO_2 production becomes 100kg/ha/year smaller if not considered the production materials to be used for farming, while the absorption of carbon dioxide by rice in the same growing period was calculated at 19,500 kg/ha/year based on the data that the absorption capacity of rice is 30 to 40 g/m ^{2}/day and one growing period is 130 days with the rice grown once a year. It can be said that the rice can absorb almost more than 20 times of carbon dioxide produced in one growing period. In parallel, the same calculation for tree was shown for comparison. According to that result, it shows that the absorption capacity of carbon dioxide for forest is 80,000 ton/ha/year calculated based on the data that the absorption of carbon dioxide per one tree is 12.8 ton/year, in which almost 6,000 trees are planted per hectare. Further study on this point is needed to derive the conclusion how rice is situated compared with the tree from the viewpoint of carbon dioxide fixation considering the factors such as the flexibility of cultivation and adaptability to the increased production of carbon dioxide due to the increased consumption of energy. Some of the break-through technological solutions showing the examples of the research programs which the author has conducted were introduced for improving the rice production status in lowering the production cost. Those research programs are still on progress and some of the prototype machines were previously constructed and demonstrated how they could be actually operated in actual use. It was obviously found that the proposed rice mechanization system consisting of three main break-through technologies such as direct sowing, combine husker and brown rice dryer can contribute really not for saving energy and improving the operation efficiency, but also for producuing extremely less production of carbon dioxide.

REFERENCES

1) Ienohikari kyoukai : Agricultural Year Book, 1993.
2) Hiroshi Fujimaki et. al : Biological and Environmental Resources in Japan, 164-165, 1991.
3) Nobutaka Ito et. al : Ethanol Blended Magnetized Fuel for Internal Combustion Engine, Proceedings of the Tri-University International Joint Seminar & Symposium, 77-80, 1995.
4) Article in Nikkan Kogyo Newspaper : TOYOTA's research program, 1993.
5) same to the reference 3)
6) Ito, N : Direct Sowing of Coated Rice under Submerged Paddy, Lecture Text No.12, Japan International Cooperation Agency (JICA), 1987.
7) Ito, N : Prospects of New Mechanization System including Direct Sowing Technology, Journal of JSAM Kansai Branch, Vol.53(35-39), 1984.
8) Ito, N : Rice Production Strategy and Highly Mechanized Farming -Japan's case-, Proceedings of International Symposium on Agricultural Mechanization and International Cooperation in high Technological Era, (501-507), 1987.
9) Ito, N : Development of the Combine Harvester Equipped with Hulling Function. Journal of JSAM Kansai Branch, 58(105-106), 1985.
10) Ito, N : Development of Combine Husker, Proceedings of International Symposium on Agricultural Engineering (89-ISAE), Potentialities of Agricultural Engineering in Rural Development, 1(316-321), 1989.
11) Ito, N : Effect of Husking Method on The Grain, Proceedings of the International Agricultural Engineering Conference, 2(669-674), 1992.
12) Kameoka, T, Ito, N et. al : Through Flow Rotary Dryer for Brown Rice, Proceedings of International Symposium on Agricultural Mechanization and International Cooperation in High Technology era, JSAM, (321-326), 1987.
13) Ito, N : Rice Production Mechanization System, Proceedings of the International Agricultural Engineering Conference and Exhibition, 3(355-362), 1990.

[Notice]: This paper was formerly prepared for ICAME'96 to be held on September 2-4, 1996 in Turkey and revised partly.