Biotechnology Contributes to Agriculture and Environment in Japan

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1. Asia and Japan after 15 years

In Japan, planning of agricultural policy up to 2027 was discussed at March in 2005. In the policy making on agriculture and environment, the period “10 years” is usually used as a goal, and the actual target is organized in the next “5 years (2012)”. But, generally speaking, within 5 years, we are liable to image the constant and stable situations compared with those at present, and cannot predict any drastical changes.

If the period of “15-20 years” is adopted, more remarkable changes will be predicted, in agriculture and environment, such as decrease of crop production, decrease of accessible fresh water resources, climatic fluctuation caused by global green house effects on the earth.

IPCC reported at 2001 that, during 20th century, the average temperature on the earth went up about 0.6℃, and predicted that, by the end of 21st, that will go up 1.4-5.8℃.

Fig.1 shows the actual changes of the annual mean temperature at the central part of Japan, Okitsu, Department of Citriculture, National Institute of Fruit Tree Science, which was established one hundred years ago(1). This record has been authorized as an official meteorological observation by the Meteorological Agency of Japan. Recording site is surrounded by the small forestry mountains and the Bay of Suruga. The population of this small town has been decreasing slowly. No remarkable changes affecting temperature artificially have been happened in this small town within hundred years. Therefore, the temperature change in Fig.1 seems to be the direct reflection of the global green house effect on the earth. In these five years, increase of the annual mean temperature is remarkable. At the citrus growing area in Japan, it is recognized that the temperature at the beginning of spring also go up and the flowering of citrus is hastier than before. These global climate changes will also greatly influence on agriculture and environment in the world.

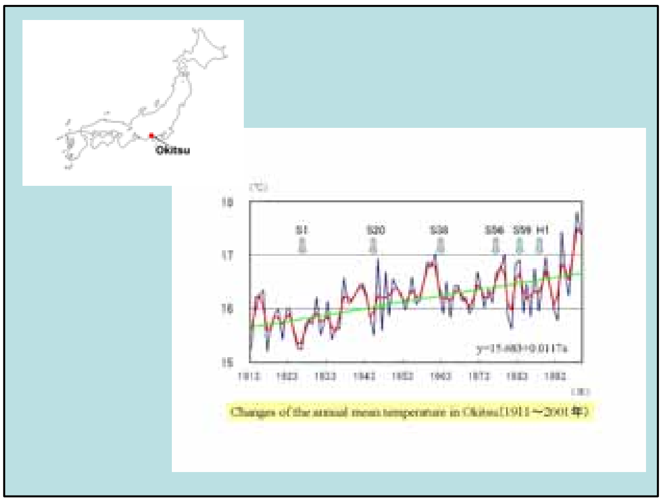


Fig. 1

World population now stands 6.3 billions, but will reach 8.9 billion by 2050 (Fig.2). Although that of Japan will be predicted 3.5 million decrease by 2022, only 15 years after, and such condition will be also observed in the developed countries except USA. However, the big burst of increase in population will be occurred in Asia. That will lead to the global food issue (food shortage). In general, people in Japan is not recognizing to be serious. On the contrary, the decrease of population in agricultural region was the serious problem at the planning of agricultural policy. As Japan is the big food importing country, the world food shortage problem will be also the serious problem for Japan.

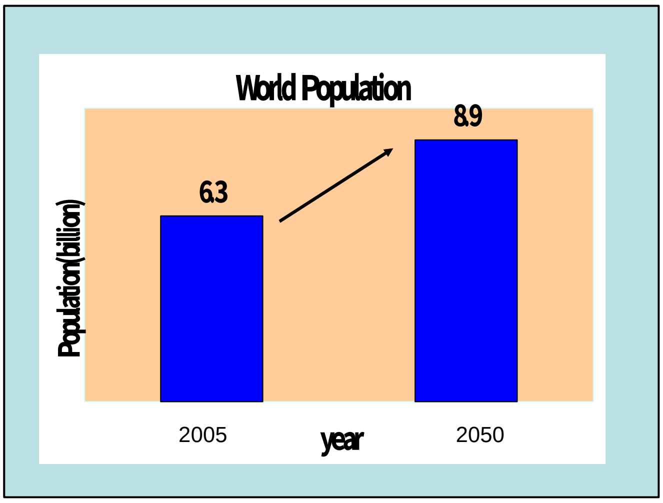


Fig. 2

2. Some symptoms of warming observed in crop production

(1) Damage to the rice quality

Climate warming in Japan has been recognized actually in agriculture. For example, the production of the high quality rice has been damaged at the famous rice producing region by the higher temperature at the beginning of summer than before. This leads to the decrease of actual income of farmers. At present, the practical improvement of cultivation, such as a delay of rice-planting, is recommended. In future, the main high quality rice producing region will be predicted to transfer to the northern area such as Hokkaido island.

(2) Pest and disease

Pest and disease problem is occurred in citrus industry. Citrus greening disease (Huang long bing (HLB)) (Fig.3), which is seen commonly in southeast Asia (2), is coming north from Taiwan to the south of Nansei island, located to the south of Kyushu island through Ryukyu islands (Okinawa) (Fig.4) (3). A notable number of citrus trees died by this disease in one year after the first infected trees was reported. This serious disease, HLB, is transmitted by the asiatic citrus psyllid. The main citrus producing region is located near these infested small islands. Fortunately, this psyllid cannot survive at winter at the southern part of Kyushu island at present. However, under the warmer condition, it will be able to survive. The Japanese government is sincerely afraid of spreading of HLB and psyllid according to the increase of Typhoon attack, which bring these pest and disease to the main citrus growing area. Recently, this disease is reported to be found in Brazil, and will be a big problem in American continent. Citrus industry in the world observes closely to this spread.

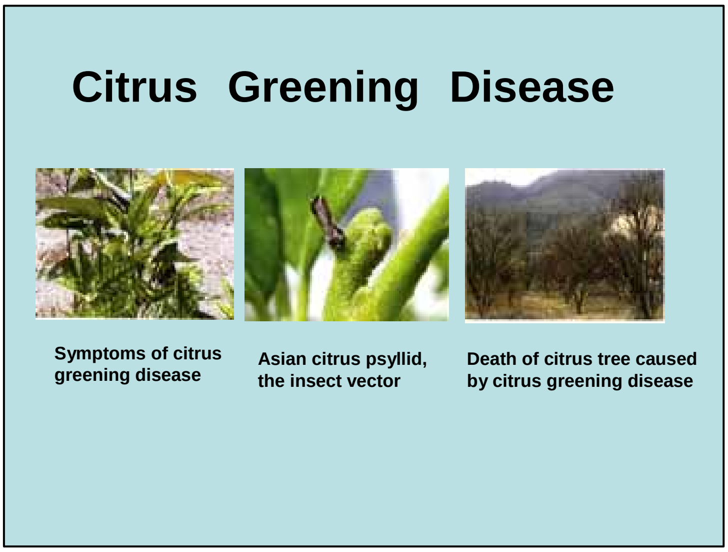


Fig. 3

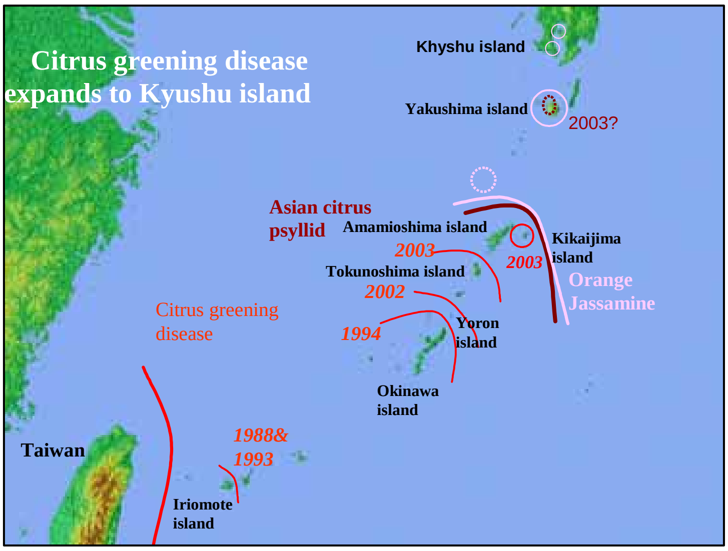


Fig. 4

(3) Abnormal fruit maturation

Fig.5 shows poor coloration, failure of red pigmentation, in red-skinned grape cultivar, under warmer climate. Recently, red coloration on the fruit skin of an apple also looks poorer at some region under the wormer temperature at the beginning of autumn when the pigmentation of anthocyanin starts. In future, 30 years after, producing area of an apple in Japan will transfer from the northern region of main island to the Hokkaido (4). Fig.6 demonstrates the distribution of favorable regions in apple production. At present, Hokkaido is too cool for the production of deciduous fruit including an apple, but in future, will be seemed to be a main growing area. Because the consumers in Japan prefer the red-skin type of apple compared with the yellow one, this symptoms have become the important economical problem for the apple growers.

Unshu-mandarin orange grown at the western part of Japan has shown the poorer fruit quality than before. Therefore, in future, the main producing region of unshu mandarin will transfer to the north from the western region to the central Japan, Kanto, near Tokyo (Fig.7) (4).

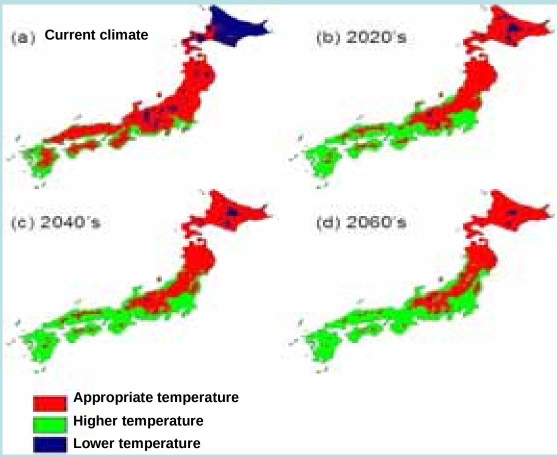
For the clearer evaluation of these worming effects on the agriculture in Japan, the cooperative research project "Evaluation of worming climate on crop production and animal industry, and development of its control" has been conducted, in fruit, vegetable, flower, tea, rice, wheat, soybean, and live stocks.

Temperature of appropriate for cultivation

Temperature above appropriate for the cultivation

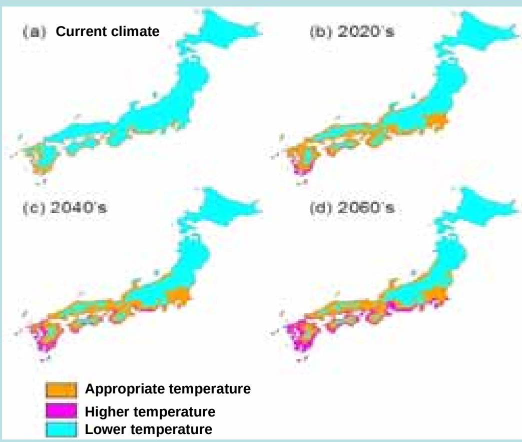
Poor coloration of grape cultivar ‘Aki Queen’ under warmer climate

Fig. 5



Changes in distribution of favorable regions for apple production

Fig. 6



Changes in distribution of favorable religions for satsuma mandarin production

Fig. 7

3. Current advances in biotechnology for crops

Under the global worming condition in near future, 2022-2027, improvement of crops should be promoted using new technology. Biotechnology, including preservation of genetic resources and genetically modification, has the strong potential for contribution to this problem. In this paper, the current advances and future plan of research works using biotechnology in Japan, specially on crops, are discussed.

Practical applications of biotechnology have been successfully developed in some crops. The cell and tissue culture are already practiced for the commercial propagation of seedlings and for breeding. The embryo culture and anther culture as well as mutants appearing in a cell culture are used for breeding. These methods are used in particular for the breeding of new cultivars of rice, vegetables and fruit trees. Seventy percents of strawberry seedlings are now produced virus-free. Some 150 facilities have been established for this purpose.

Oretachi, a new cross between orange（*Citrus* sinensis）and trifoliate orange（*Citrus* tirifoliate）, has been experimentally developed by using the cell fusion in Japan. Cultivars of tobacco and hiratake（an edible mushroom）improved through cell fusion are actually cultivated.

The reconbinant DNA（rDNA）technique is expected to bring about a great progress in the improvement of breeding technology and the development of new plant cultivars showing high quality and high yield, such as those with excellent pest and disease resistances, those with environmental stress tolerance etc. More than 9,000 field trials of transgenic plants had been already tested in the world by 1996.

In Japan, more than 40 transgenic plants have been already developed. A tomato cultivar resistant to tobacco mosaic virus（TMV）has been cultivated ordinary testing field since 1992. Two rice cultivars resistant to rice stripe virus（RSV）and a petunia cultivar resistant to cucumber mosaic virus（CMV）have also been cultivated in ordinary field since 1994. Other virus-resistant melon, tobacco, potato cultivars as well as a low protein rice cultivar and a low allergen rice cultivar, two late ripening tomato cultivars, long-life carnation cultivar, three herbicide-tolerant canola cultivars, and other herbicide-tolerant soybean and maize cultivars have been tested in confined fields for the assessment of their effects on the environment（Innovative technology home page MAFF JAPAN, http://www.s.affrc.go.jp/docs/sentan/index.htm）.

4. Contribution of biotechnology to rice production

（1）Rice genome project

In Asia, a rice is a major crop. So, rice cultivars showing higher yield, greater yield stability and adopt to changing global climate change should be developed. In addition to conventional breeding system including hybridization and selection, molecular breeding and genetic engineering are useful for developing rice cultivars（5）.

High quality sequences of rice chromosomes has been published by the Japan's Rice Genome Research Program Team, which had been managed by International Rice Genome Sequencing Project（IRGSP）(6,7）. Fig.8 is one of the results. Finally, IRGSP declared last year the completion of sequencing of 370 million base pair. The team calculated that the chromosome contains 6,756 predicted genes（http://www.dna.affrc.go.jp/misc/bank/index.html）. Post rice genome research project has started in Japan using the informations of genome analysis, named as

“Functional analysis of genes relevant to agriculturally important traits in rice genome”. In this project, the following five targets are demonstrated. Elucidation of genes that improve the rice quality. Elucidation of genes that produce sophisticated materials. Elucidation of genes that enhance photosynthetic capability. Elucidation of genes responsible for stress tolerance.

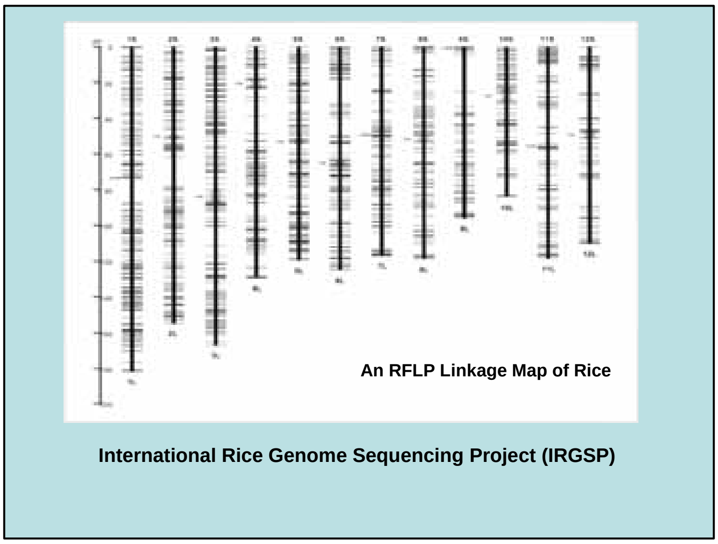


Fig. 8

(2) Four successful results reported on rice

The following remarkable results have been already released. Under hostile environment, various environment resistant genes develop in plants. Genes regulating these ones have been discovered and were introduced into rice by genetic engineering techniques(8, 9). This success is expected to be applied to create crops and trees showing the adaptability to global environment deterioration, such as draught, salt and freezing. International collaborative research projects are now conducted, applying to rice, wheat, corn and soybeans between Japan International Research Center for Agricultural Sciences (JIRCAS) and some international institutes belonging to Consultative Group on International Agricultural Research (CGIAR) such as IRRI.

Practical success was also reported in this February. Private Institute, Plant Genome Center, published that new type of rice cultivar, semidwarf cold hardy one with high quality, was conventionally bred (10). From the data base of rice genome program, a semidwarfing gene was identified (11), and local cultivar with this gene was selected and crossed with the high quality cultivar “Koshihikari” of which northern producing limit is the southern part of Tohoku region of main island of Japan. After several times of back crossing with “Koshihikari”, high quality rice cultivar “New Koshihikari” showing cold hardiness was bred out and was released without GM technology. This breeding period was 3 years, one fifth of the traditional one. This cultivar seems to be accepted by the consumer and by the anti GM parties and is predicted to become the main cultivcar in Hokkaido, where the production cost of rice is 80% of that at the main island.

Third one was just released from National Agriculture Research Center (NARC). Stress tolerant rice type has been obtained by GM technology introducing heat shock protein gene (Fig.9) (12). This transgenic rice shows the salt tolerance, drought tolerance and chilling tolerance. We hope that this transgenic rice will be used for breeding material of complexed environmental stress tolerance.

Another type of results was also released from Hokuriku Res.Center, NARC about the Rice blast disease resistant rice through GM technology using defensin gene obtained from leal mustard（Fig.10）（unpublished photo）.

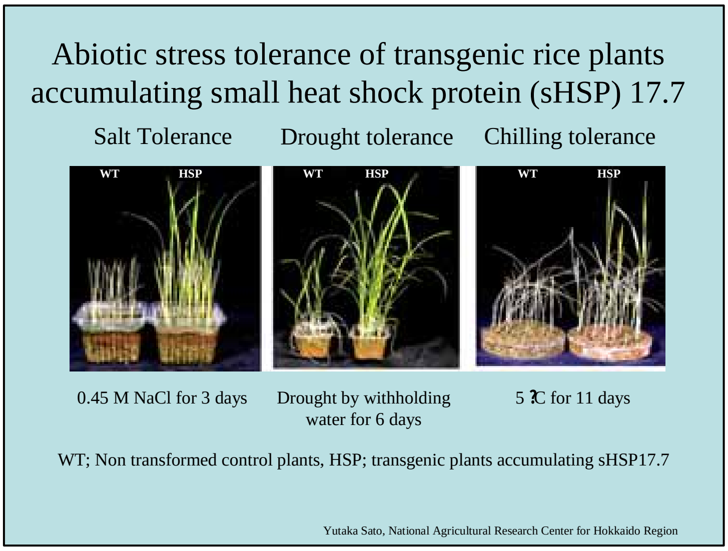


Fig. 9

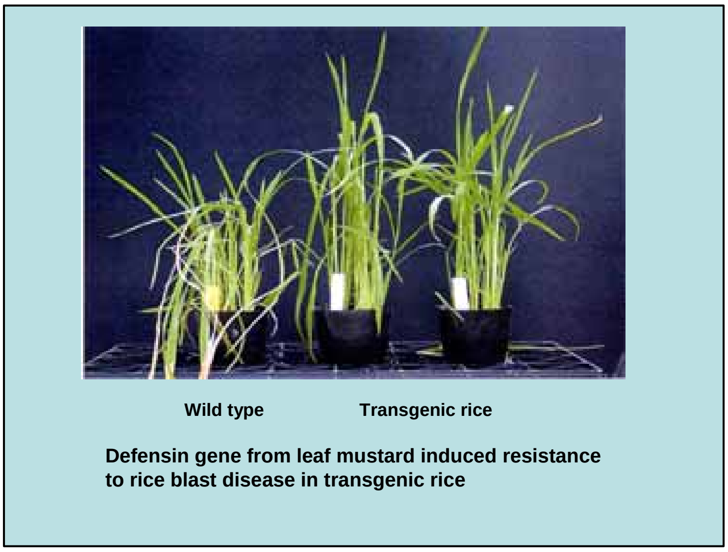


Fig. 10

5. Conclusion

It should be informed to a people and the government about the prediction on the global warming, global increase of population, and global food issue. And science, specially biotechnology, will contribute to these issues. The preservation of genetic resources should be quickly managed before global changes of environment. Biotechnology should be improved and developed, and will contributes to food issues in Asia.

Abstract

The global changes on the earth after 15 years were discussed, such as increase of population, warming and food issues. The following symptoms of warming have been observed in Japan. 1: Damage to the rice quality. 2: Citrus greening disease. 3: Abnormal fruit maturation. These changes seem to induce the transfer of the growing region to the north.

To solve these problems, biotechnology should be developed. Rice genome analysis has been finished under the management by IRGSR. Using the data base of rice genome, two remarkable results has been reported. Gene regulating various environment resistant genes was introduced into rice by genetic engineering techniques. Genes of cold hardiness was selected and was introduced into the high quality rice cultivar by the conventional breeding systems.

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