주제-03

Present Status, Challenges and Future Perspective of Crop Production in Japan

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The food self-sufficiency of Japan is 39% in at calorie basis and that of rice, wheat and soybean are around 95, 10 and 5%, respectively. With this situation, the basic plan for food, agriculture and rural areas (Ministry of Agriculture, Forestry and Fishery, 2015) raises food security as the first concern in the basic policy. The production potential depends on crop yield and the area of arable land, and the former has two aspects, the potential and stability or predictability. The land area can't be sustained without the support of by local community and consumers and also by the national consensus, as well as farm managing efforts. Considering those things, the issues on crop production would be classified into three aspects, (1) production potential, (2) production stability and (3) multifunction of agriculture. I would like to describe present status and challenges of crop production in Japan through picking up subjects related to crop science on the three aspects.

1. Production potential

Evaluating how much can potentially be produced now and future with climate resource is one of the important contributions of crop science and this requires integration of knowledges. The crop simulation model to predict yield in Japan has been developed mainly for irrigated rice. In the early attempts, rice yield of was predicted under changing climate assuming the environment is optimal except for air temperature. They indicated future climate will affect rice yield positively in northern Japan and negatively in southern and western Japan. Since genotype by environment (G by E) interaction is crucial for understanding productivity, the model has been expanded to enable quantification of the effect of various plant traits on future rice yield. In this context, combining the genetic model that predicts plant phenotypes based on genome information with crop simulation model (traits to crop performance) is the current challenge. As for wheat and soybean, the model development is behind and the existing models from the western region can't be easily applied. This is due to the unique cultural condition in Japan; drained paddy fields under the monsoon climate with frequent heavy rainfall in warm seasons. Thus model development/improvement for upland crops is still necessary.

Potential productivity is limited by soil fertility as well as climate. Recently the concern is growing in Japan. This is because evidence is increasing for on-going reduction of soil carbon in the paddy fields. In the tropics, declines of soil fertility had been experienced and resulted severe yield reduction in many areas. Although the paddy fields in Japan were considered well sustaining soil fertility, this may not be the case after over 40 years of the converted use of paddy fields with rice and alternative crop rotation to cause soil aeration. Increasing temperature also may be accelerating this trend. In order to ensure present high productivity of rice in the future, we need to predict the future change of soil fertility quantitatively.

The strongest threat for future potential productivity is decreasing land area for crop production. The population of farmers is declining and becoming older in age, causing a rapid increase of un-cropped farmlands. Labor saving technologies are demanded not only for economic competitiveness but also for maintenance of agricultural lands for the future. Development of field robotics such as self-operation machines and the information and communication technologies (ICT) is being developed by collaboration of researcher of different areas and the role of agronomists should be important for designing the new "smart" production systems efficiently.

2. Production stability

Crop production is frequently disturbed by extreme weather events, such as high or low temperature, drought, and storms, which is expected to increase or become severer with ongoing climate change. Under the monsoon climate, where rainfall can be excess during warm season, management of water condition in the field is important to avoid both water deficit and excess. Combination of plant developmental traits and cropping season should be optimized to avoid more-or-less predictable occurrence of stressful events. In addition, for the upland crops on the drained paddy fields, the water condition can be adjusted by the "Farm-Oriented Enhancing Aquatic System (FOEAS) that enables adjustment water table through effective drainage plus sub soil irrigation facility. For the on-time management practices, the short-term and the micro-scale weather forecasting is demanded and being progressed as the regional climate models. Regarding water controlling technology, the local water

management system is being developed for the scale of agricultural area (hundreds hectare) and optimizing water use and its partitioning among fields, combining existing water delivery system with developing technologies such as remote monitoring field condition and automated operation of irrigation facilities. Those technologies would be integrated in the near future to help regional water management that will stabilize production and reduce loss of water and operation cost of water management. In order to fully utilize weather forecasting, however, crop responses to changing water should be understood quantitatively.

Abiotic stresses also deteriorate stability of crop production. Although the contribution of breeding for disease and insect resistances is no doubt great, the increase of alien species and northward spread of insects, pathogens and weeds require more integrative pest managements. Regarding this issue, quantification of environmental factors for development and spread of pests and pathogens for ecological and agronomical controls are demanded and this would be a great challenge of crop production technology for the future and collaborations are desired of crop science with entomology/plant pathology/weed science and agricultural meteorology.

3. Multifunction of Agriculture

The problems regarding multifunction of agriculture would include promotion of environmentally sound production, maintenance of landscape, local community, etc. The influence of agriculture on local/global environment is concerned for minimizing pollution load to local environment, mitigating GHG emission. The environmental concern is also for satisfaction of local consumers on security/safety, that promotes "local production for local consumption" and hence activation of the local economy. This would contribute production potential through maintenance of land area for agriculture. The contribution of crop science has been prominent in development of fertilization methods for efficient use of nitrogen, employing slow release urea localized application of fertilizer. Various non-chemical practices also is being developed as the IPM, e.g. seed sterilization by warm water and mechanical weeding for rice production, but that for upland crop production is still challenging.

In order to maintain multifunction of agricultural lands such as conservation of local environment and landscape, particularly in the hilly and mountainous areas, high labor cost of land management such as weeding the ridge between fields is a severe constraint. Any technology that reduce labor cost would be important. Development of the robotics should be employed for weeding machines to assist maintenance of small fields.

The Japanese Journal of Crop Science has published 90 and 43 articles a year in the periods of 1985 to 1987 and 2015 to 2017, respectively. The main reason of decrease is establishment of Plant Production Science (English journal) in 1998. I classified the subjects of the papers into the above three categories, productivity, production stability and multifunction of agriculture and found that the proportions of the three categories were 72, 14 and 2% for the earlier and 65, 13 and 16% for the latter periods, respectively. This indicates that, although the research subject is being diversified, the primary concern of crop scientists is still enhancing productivity. As described above, crop science is expected to contribute to all the three issues of future crop production and thus production stability and multifunction of agriculture will become more important. It must be noted that collaboration between agronomists and other research fields is essential for solving any of the problems and, having the common background of the monsoon climate and culture, regional collaboration for future crop production is particularly meaningful in East Asia.

Reference

Ministry of Agriculture, Forestry and Fisheries 2015. Basic Plan for Food, Agriculture and Rural Areas (http://www.maff.go.jp/e/policies/law_plan/attach/pdf/index-2.pdf).

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