AgBioForum, 20(1): 54-66. ©2017 AgBioForum.

Modern Biotechnology for Innovation of Agricultural Development in the Developing World: What Role can Japan Play?

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Genetically modified organism (GMO) technology is among a wide range of modern agricultural biotechnologies that is undergoing research and development (R&D) for developing countries in Japan, although GM crops have not been adopted in Japan itself. A semi-structured interview based on 52 stakeholders revealed the perspectives of scientists and other relevant participants inside and outside Japan on biotechnology R&D partnerships between Japan and developing countries and on the future delivery of biotech products such as GM crops in developing countries. This study examines domestic challenges associated with the potential adoption of GM crops and the impact of the domestic position on its partnerships with developing countries, as well as discusses some approaches to address the problems. The article argues that partnership between the Japanese government and their scientists is key to decision making on GMO policy. More importantly, the government needs to demonstrate more commitment by engaging relevant stakeholders including scientists, farmers, consumer organizations, and the private and public sector on important issues relating to GM technology R&D, application, and effective communication of GM products.

Key words: agricultural development, developing countries, Japan, modern biotechnology.

Introduction

The importance of modern biotechnology including genetic modification (GM) technology in agricultural development cannot be overemphasized due to a rapidly growing population that could worsen food insecurity, malnutrition, and poverty problems in developing countries (Conway & Toenniessen, 1999; Vasil, 1998). As a result of these growing challenges, there is a significant effort among various organizations and industrialized countries to generate new innovation to address low agricultural productivity in developing countries.

The Science and Technology Research Partnership for Sustainable Development (SATREPS) is a Japanese government-sponsored program that engages in international collaborative research in tackling global challenges of this nature (SATREPS, 2014). The Japan International Research Center for Agricultural Sciences (JIRCAS) is one of the leading domestic partner research institutions under SATREPS and is where GM technology is among a wide range of modern agricultural biotechnologies that is undergoing research and development (R&D) for developing countries. Despite the advancement of modern biotechnology in Japan, GM products have yet to be commercialized in the country, partly due to controversy surrounding the use of GM technology around the world (Carter & Gruère, 2003). The controversial debate about the use of GMOs in solving some of the agricultural and food insecurity problems in developing countries may continue for a long time due to a lack of consensus among relevant stakeholder groups. Hence, the needs and requirements of all stakeholders must be identified and effectively managed to better facilitate and explore the potential uses of new technology.

Research efforts in developing new GM traits that target developing countries are led currently by many research institutions in developed countries and international research centers. Yet, there is little or no literature about decision-making processes among relevant stakeholders that can facilitate development of GM products for developing countries (Adenle, 2014). Understanding the views of various stakeholders is therefore an important research direction in this regard.

The current regulation of GMOs in Japan is modeled on a framework similar to EU GMO policy, making their GMO standards restrictive to meet the demands of Japanese consumers for food safety and quality (Carter & Gruère, 2003; McCluskey, Grimsrud, Ouchi, & Wahl, 2003). One important question asks whether Japan's GMO policy influences the decision to adopt new GM products in developing countries. Given the lack of adoption of GM products in Japan, it is worthwhile to look into the procedures and planning efforts of the country on GM technology R&D and how the new technology will be transferred to developing countries, by interviewing relevant stakeholders. Moreover, plant genetic resource R&D projects have been of special interest to the Japanese research institutions, where they have ongoing collaborative research with developing countries. These are important reasons why we have conducted this research study. This is one of the rare case studies where a significant effort was made to interview important stakeholders in Japan, as their system can be very bureaucratic (Curtis, 2004), thereby making it difficult to access the right person.

To our knowledge, there is no study that has examined stakeholder views in Japan on biotechnology R&D for developing countries. In view of this important research effort led by the Japanese research institutions, our study has been designed to evaluate modern biotechnology R&D among relevant stakeholder groups inside Japan. The study is supplemented by interviews with international organizations that focus on agricultural development. Semi-structured interviews revealed stakeholder views on key issues regarding development of GM crops for developing countries and domestic challenges in adopting the new technology. This article describes obstacles to the use of GMOs in Japan and in the developing countries with which they collaborate. In order to gain insight into the nature of the problems and challenges, this study addresses the following questions:

1. What factors drive biotechnology R&D collaboration between Japan and developing countries?
2. What is the status of GM technology R&D for developing countries in Japan?
3. How do public safety concerns affect the implementation of GM technology R&D overseas?

The detail of methodology is described in the next section, focusing on data collection and the selection of the participants for the interviews. The following section provides insight into biotechnology R&D collaboration between Japanese and foreign research institutions. The same section discusses the role of JIRCAS and other Japanese research institutions, as well as challenges that are associated with the biotechnology R&D and future delivery of GM products in developing countries. Also discussed are some approaches to addressing the challenges, folled by a summary of the study's findings.

Materials and Methods

Study Selection

A qualitative interview study was chosen to help understand complex issues relating to development of GM technology in Japan that targets developing countries. The main reason for choosing this approach was grounded in the argument by Yin (2003, p. 111), that a case study design should be considered when "the focus of the study is to answer how and why questions" and when the researcher wants to "cover contextual conditions" that are believed to be relevant to the phenomenon. Our study was designed to assess the perception of relevant stakeholders as described in the list of participants (see Table 1).

The involvement of a variety of stakeholders including from governments and research institutions can help in sharing of experiences and knowledge and providing a selection of better solutions for development and transfer of new technology (Alcon, Tapsuwan, Martinez-Paz, Brouwer, & de Miguel, 2014; Gass, Biggs, & Kelly, 1997; McAdam, Miller, McAdam, & Teague, 2012). Therefore, the participants were chosen from relevant research institutions, universities, government institutions, and the private sector. Scientists, government officials, and other relevant stakeholder groups that are working or familiar with agricultural biotechnology were selected for the interviews. In addition, literature and agricultural biotechnology related coverage was screened for additional relevant actors as informed by the policy network approach for the stakeholders' selection (Laumann & Knoke, 1987).

The study was supplemented by interviews with scientists from the International Maize and Wheat Improvement Center (CIMMYT) of the Consortium Group of International Agricultural Research (CGIAR). The interviews with the scientists from CIMMYT were conducted during the September 2013 12th International Wheat Genetics Symposium in Yokohama. These scientists were selected for the interviews simply because they have ongoing collaborative biotechnology R&D projects, including GM technology with some of the Japanese research institutes where the interviews took place. Prior to the interviews, we wrote to individual organizations and explained the objectives of our meetings. Only 11 agreed to be interviewed out of 17 organizations that were contacted.

Parts of the interviews were also conducted during the Sustainable Agriculture Seminar that was organized by Monsanto in November 2013. Six respondents were

Table 1. List of participating organizations.

Institutions & organizations	Role/expertise	Interview date	Number
International Research Center for Agricultural Sciences (JIRCAS)	Plant genetic resources, plant breeding and genetic engineering	October 30, 2013	8
National Institute of Agrobiological Sciences (NIAS)	Plant genetic resources, molecular biology & genetic engineering	January 9, 2014	6
University of Tokyo	Transgenic plants & animal, biochemistry and molecular biology	November 26, 2013	6
University of Osaka	Recombinant DNA technology, plant breeding and bioscience	December 2, 2013	4
University of Kyoto	Plant genetic resources, transgenic plants, molecular biology and biochemistry	November 11, 2013	7
Ministry of Agriculture, Forestry and Fisheries (MAFF)	Agriculture research and development and biotechnology	February 14, 2014	5
Consumer Union of Japan (CUJ)	Food science, organic farming and biotechnology	February 14, 2014	2
International Maize and Wheat Improvement Center (CIMMYT)	Genetics, planting breeding, and bioscience research and development	September 12, 2013	6
Monsanto	GMOs, sustainable agriculture	September 5, 2013	2
Ministry of Environment	GMOs and biosafety	November 27, 2013	3
Tokyo University of Agriculture	Agricultural science and plant breeding	November 27, 2013	2
University of Philippine	Biotechnology	March 12, 2014	1
Total			52

interviewed during the seminars. Apart from six respondents that were interviewed during this meeting, this study also benefitted from the contents of questions and answers from various stakeholder groups that attended the seminar; this included media, private sector, ministries, and universities in Japan. Some of the questions that were asked among participants related to decision making and factors affecting the application of GMOs in the country. Here, we focused on relevant questions and answers that emerged during the meetings, and notes were taken simultaneously. Those who participated in the interviews include professors, directors general, directors, presidents, managers, policymakers, and consumer representatives from the organizations that are listed in Table 1. All the interviews required travel to meet respondents in different locations in Japan. We ensured that those organizations that participated fit the interest of our study before the interviews to avoid sampling bias. Participants' views were reported anonymously except in a few cases where permission was sought to identify the participant organization.

Interview Method

The stakeholder interviews employed in this study were divided into two types—individual (face-to-face) and focus group discussion. The arrangement of the meetings as agreed between the interviewers and the participants determined how both methods were used to interview participants. The interviews with stakeholder groups were based on semi-structured questions that included an informal checklist (see Appendix) of issues to guide and elicit the participants' opinions. The line of our inquiry was focused on the following three broad themes—training of foreign students and scientists in the field of biotechnology, development of agricultural biotechnology for developing countries with a focus on GM technology, and domestic issues regarding the adoption of GM technology.

Focus Group Discussion

Focus group discussion was used to interview groups of 5-8 participants from JIRCAS; National Institute of Agrobiological Sciences (NIAS); the Japanese Ministry of Agriculture, Forestry, and Fishery (MAFF); and the University of Tokyo. Prior to the interviews, all the participants (except two directors who chaired the meeting, while the lead author coordinated the focus group discussion) made a short presentation of their research work for about 10 minutes. After all the presentations relating to developing countries had been made in their respective organizations, participants were asked questions based on the checklist (see Appendix). Those participants that did not make a presentation also participated in the focus group discussion.

Individual Interviews

Individual interviews were used for the rest of the organizations. Only one interview was conducted over the telephone outside Japan. In-depth interviews were conducted with Japanese scientists, foreign scientists, consumer representatives, and private-sector representatives on issues relating to biotechnology R&D and adoption of GM crops. The face-to-face interviews gave us the opportunity to find out more about the experiences relating to research and training in Japan. For example, the interviews with the CIMMYT scientists helped us understand their relationship and experience with the Japanese scientists on a wide range of issues, such as knowledge exchange and training of researchers. Apart from this group of scientists, foreign scientists who work at Japanese research institutions also participated in the interviews and contributed to all the relevant aspects of the discussion.

Justification

A qualitative approach was chosen, as it offered the opportunity to explore a wider range of issues regarding these themes; it is an effective way of gaining an understanding of different stakeholder groups in an effort to achieve a particular objective, as they have very different degrees of power to control decisions that can impact policies and institutions (Mayers, 2005). The integration of focus group and individual interview data through a qualitative method triangulation can be important, as it guides the exploration of individual accounts and enriches the conceptualization of the phenomenon by enhancing trustworthiness of findings (Lambert & Loiselle, 2008). One disadvantage of a focus group is that a participant may be reluctant to express his/her views due to the presence of the boss or another participant. Bias in the interpretation of findings may occur, particularly when the focus group method is applied (Yeung, 1995). To minimize this, we stick as much as possible to the relevant points during the interviews while eliciting the opinions from the participants, for example, beginning with open-ended questions—how do you collaborate with foreign researchers and why?

Data Analysis

The interviews were tape-recorded and contemporaneous notes taken. The interviews were conducted both in English and Japanese and lasted from 30 to 90 minutes. The translation of Japanese into English was carried out by a native Japanese speaker. All pieces of key information and important quotes from the interviews were put together for this article. Following the interviews, audio recordings of more than 30,000 words were transcribed immediately and coded systematically (using qualitative data analysis software, Hyper Research 2007). Interview transcripts were read and re-read carefully by focusing on important text to define themes and distinct concepts using the open coding (Braun & Clarke, 2006). After working through the transcripts, a number of themes were identified based on interview responses. These themes were further explored in terms of differences and similarities from stakeholders' interviews as described by (Strauss & Corbin, 1990), leading to identification of the following categories that form a barrier to the introduction of GMOs: 1) limited field trials, 2) regulatory logjam, 3) safety concerns, and 4) lack of data. We focused on negative instances where each category was mentioned as an obstacle to use of GMOs in Japan with spillover effect on biotech R&D collaboration of Japan with developing countries. Using the hyper research coding system, the number of responses that applied to each category was counted to generate a frequency count. The results and discussion section presents the outcome of data analysis based on the responses from stakeholders' interviews.

Limitation

While the participants interviewed may or may not represent all the groups that were targeted, we tried as much as possible to ensure that those included were stakeholders that are relevant to this study. Apart from scientists that participated from the CGIAR center and one scientist from the University of Philippines, attempts were made to speak to scientists from national research institutes in developing countries that work directly with the Japanese research institutions. Our inability to speak with many scientists from national research institutes is one limitation of this study, although their views may not necessarily be different from scientists interviewed who have worked with the local scientists in developing countries.

Results and Discussion

Biotechnology R&D Partnership between Japan and the Developing World

Respondents discussed what motivates biotechnology R&D collaboration between the scientists from developing countries and Japan. Some respondents mentioned that the interest of the Japanese government in agricultural development in developing countries encourages joint biotechnology R&D collaboration, as most of the research funding comes from the Japanese government. This kind of interest helps identify partner institutions in developing countries, many of which come from Asian countries, particularly Southeast Asia. One respondent mentioned that a focus on Southeast Asia is one of the strategies of the Japanese government, where promotion of education and biotechnology R&D has remained the hub of collaboration for many years. Access to genetic resources, cultural ties, and the presence of good educational schemes between the Southeast Asian countries and Japan was mentioned as one of the reasons for the strong partnership in training students and researchers in biotechnology from this region. The lack of proper educational programs and limited facilities in other Asian countries to promote biotechnology R&D results in their low participation. And the lack of demand from countries such as China and India is due to their relative advancement in biotechnology R&D. However, the limited number of students and researchers in biotechnology from other developing countries was attributed to language barriers. Some respondents argue that many Japanese young researchers do not feel the need to have a good command of English, as they are comfortable with their language for professional development and for long-term job security in the country; therefore, this limits their ability to engage in productive biotechnology R&D and capacity building in developing countries. According to one respondent, Japan is still focusing very much on an early investigation of biotechnology R&D for developing countries in spite of their strong capability to develop good technologies. He argues further that communication problems can be a serious challenge in the exchange and knowledge transfer for research-related activities. This finding is consistent with another study (Okamura, 2006) that analyzed the use of English language between junior researchers (lecturers) and established researchers (professors) in Japan. The author showed that junior researchers usually lack interest in gaining a good command of English due to limited interaction with English-speaking researchers, whereas the established researchers seemed to come from extended interactions with English speakers through research participation abroad, and as a result enhanced their speaking and writing skills in English. This study concluded that "junior researchers may need different guidance than more experienced personnel and at some stage in their career they need to be shown the implication for human interaction in impersonal language" (Okamura, 2006, p. 78).

What lessons can be learned from the interviews that will enhance partnership and biotechnology R&D training between developing countries and Japan? One key lesson is that developing countries with interest in training students and researchers in the field of biotechnology at the Japanese institutions must have clear educational and research programs that encourage bilateral partnership with the country. One respondent explained that Mexican and Kenyan governments visited the Gene Bank Center in Japan and valued the importance of training provided for improving plant genetic resources, and this led to bilateral projects for knowledge and technology transfer. This two-way approach is considered to be very significant if any country shows interest in biotechnology R&D partnership with Japan. However the limited use of an international language such as English still represents a significant challenge in benefiting from the wealth of knowledge and experience in biotechnology in Japan. One respondent argued that the country should do more by addressing the language barriers on a long-term basis as there is no reason why Japanese cannot learn better English. Some respondents suggested that the Japanese government needs to invest in a special language program (including other international languages) that encourages the young generation of scientists to develop their career both domestically and internationally. For example, provision of incentives would encourage young scientists to work both at home and abroad for a period of time to develop their written and communication skills. This argument is reinforced by the fact that young or junior researchers need to be encouraged to have regular contact with other researchers in English (Okamura, 2006).

GM Technology R&D for the Developing World

Apart from the general biotechnology R&D program as described above, one of the main aims of the JIRCAS and other Japanese research institutes is to develop a wide range of transgenic crops that targets low agricultural productivity in developing countries. The interviews in JIRCAS revealed ongoing R&D of transgenic stress-tolerant crops utilizing DREB (dehydration responsive element binding) gene technology to develop plants resistant to abiotic stress (Kasuga, Liu, Miura, Yamaguchi-Shinozaki, & Shinozaki, 1999) and their collaboration with certain Consortium Group of International Agricultural Research (CGIAR) centers and national research institutes, as described in Table 2. Over the past decade, most of the GM projects that tar-

Table 2. Status of development of GM crops and other biotech product for developing countries in Japanese research institutions.

Crops	Target traits	Types of biotechnology	Stages of development	Country partners or collaborators	Commencement of R&D (Year)
Soybean	Drought tolerance, soybean rust-disease resistant	Genetic engineering, marker assisted selection (MAS)	R&D ongoing, greenhouse lab experiment, field trial	Brazilian Agricultural Research Corporation (Embrapa), Brazil	2003
Groundnut	Drought tolerance	Genetic engineering	R&D ongoing, greenhouse lab	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	2001
Wheat	Drought tolerance	Genetic engineering	R&D ongoing, greenhouse lab	International Maize and Wheat Improvement Center (CIMMYT), Mexico	2001
Rice	Drought tolerance	Genetic engineering	R&D ongoing, greenhouse lab	International Rice Research Institute (IRRI), Philippines & International Center for Tropical Agriculture (CIAT) Colombia	2001
Yam	High yielding varieties	Genomic analysis/ breeding	R&D ongoing	International Institute of Tropical Agriculture (IITA), Nigeria	2010
Jatropha	Drought tolerance	Genetic engineering	R&D ongoing, greenhouse lab, await field trials	National Institute of Agriculture, Mexico & University of Philippines	2008
Sweet potato	Micronutrient improvement	Genetic engineering	R&D ongoing, greenhouse lab, await field trials	Indonesia Legumes and Tuber Crops Research Institute (ILETRI)	2001

The primary survey combined products where genetic engineering and other type of biotechnology tools have been used to improve different agronomic traits in Japan that target developing countries as described above. GM products such as soybean, groundnut, wheat and rice as well as genomic analysis of yam are being developed at the Japan International Research Center for Agricultural Sciences (JIRCAS) and collaboration with the EMBRAPA and Consortium Group of International Agricultural Research (CGIAR) centers. GM Jatropha and GM sweet potato are being developed at the University of Osaka and University of Tokyo respectively.

get developing countries are still in the R&D stage. According to the scientists, only drought-tolerant GM soybeans have been successfully implemented up to the field-trial stage in Brazil. Moreover, efforts are being made to continue transgenic soybean field trials in China and Indonesia, and a range of important crops are undergoing R&D and greenhouse lab experiments to enhance stress responsiveness with the use of DREB.

The interviews in the universities and other research institutions also revealed that scientists are carrying out some biotechnology R&D activities, including genetic engineering relating to bioenergy crops in developing countries, but none of these has yet undergone field trials despite some progress. For example, a scientist from the University of Osaka argues that his lab was the first to carry out genome-wide analysis of Jatropha (biofuel plant) that led to the discovery of plant families with high potential DNA markers for biodiesel production (see Sato et al., 2010). He reported that in the same lab, a drought-tolerant GM Jatropha has been developed in collaboration with the Mexican National Institute of Agriculture and University of the Philippines. This respondent stated that an attempt to do the field trial in the Philippines after successful evaluation of GM Jatropha in the greenhouse experiment had suffered setbacks due to strict regulation by the Philippines government. As another example, a scientist from the University of Tokyo stated that he has also developed GM sweet potato with iron and zinc biofortification, and that the effort of his research team over the past 13 years has led to the production of 40 times the level of iron and zinc compared with non-GM sweet potato. This scientist has apparently made some efforts to carry out field trials both inside and outside Japan, but according to him, none has been successful. Moreover, he stated that he approached Monsanto but failed to get enough support, as he was told that there are enough ongoing transgenic sweet potato field trials in Africa. He felt that there could be further possibility of conducting field trials in Indonesia (where he visited recently) but the regulation could be a hindrance. Given that about 100 million yen ($100,000) is currently spent by SATREPS on a research project per year, it would not be sufficient to conduct field trials.

A good number of studies (Bayer, Norton, & Falck-Zepeda, 2010; Kalaitzandonakes, Alston, & Bradford, 2007; Pellegrini, 2013) have shown that high costs of regulation of GMOs can prevent field trials and commercialization of GM crops. For example, Pellegrini (2013) argues that the high cost of regulatory procedures hinders the development of local GM technology in Argentina. The cost of regulatory approval in 10 GM importing and GM producing countries including China, Argentina, and the Philippines was estimated to be between US$7 million and US$15 million for the approval of Bt maize (Kalaitzandonakes et al., 2007). The authors argue that the cost ranging between US$7 and $15 million would be difficult for many public-sector institutions to bear, particularly in developing countries. A different study has arrived at a similar estimate of US$1.7 million (Bt maize), US$4 million (Bt soybean), and almost US$1 million (Bt maize) in the Philippines, Brazil, and Kenya, respectively, for meeting government biosafety regulatory compliance (Bayer et al., 2010). Regulatory and development processes differ from country to country, which may affect overall level of costs, and the regulatory cost may be declining within the countries as more experience is gained and more new products are released.

While regulatory problems pose a serious challenge to the development of GM crops in these countries, stakeholders felt that there seems to be little effort on the part of the Japanese government to engage with national governments in order to strengthen the collaboration on GM technology R&D programs with participating countries. Some of the scientists interviewed questioned the commitment and partnership of JIRCAS in terms of investment for GM technology R&D programs in developing countries. For example, as explained by one scientist, there are no clear statistics available for public spending on GM technology R&D in terms of collaboration between the Japanese research institutes and participating countries. However, this argument is disputed by another Japanese researcher who explained that funding targeting agricultural development R&D is often channeled through various government ministries, thereby leading to delays in releasing this kind of information.

Use of GMOs in Japan

GM Technology R&D and its Regulation. An important question as to what motivates the development of GM products for developing countries in view of the lack of social acceptance of GMOs in Japan was raised

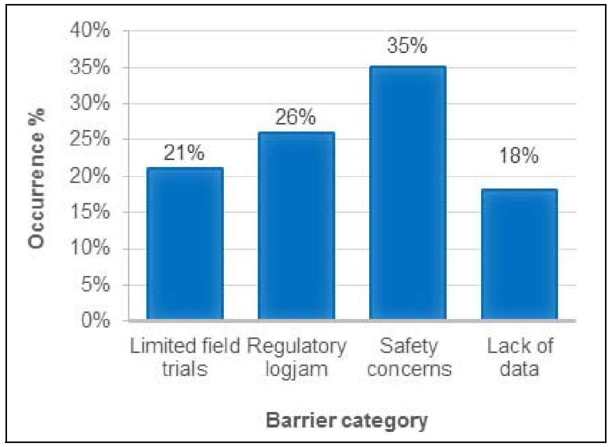

Figure 1. The percentage of respondents mentioning the barriers.

among respondents. A representative from the Japanese MAFF mentioned that GM technology has great potential for agricultural improvement and industrial purposes, an area where a lot of effort is focused on R&D in the country. He also felt that there is increasing support among scientists for the idea of using new innovations like GM technology to overcome constraints in agricultural and pharmaceutical production not only in Japan but in other countries. As a result, in 2013, 70% of 90.3 billion yen (approximately US$90 million) allocated for agricultural development is committed into science and technology including agricultural biotechnology R&D. Despite the investment, more than 15 locally approved GM food products, including GM rice, corn, and soybean, are still in various stages of R&D programs in the country. As of June 2015, according to the US Department of Agriculture, Foreign Agricultural Service (USDA FAS, 2015), 302 GM events (including stacked events) and 148 events in 9 crops have been approved for the purpose of food use and environmental release, respectively. Yet none of the GM food crops approved for environmental release have been commercialized due to public safety concerns. As shown in Figure 1, safety concern (35%) was seen as the biggest challenge, particularly among consumers. The concerns of consumers regarding the safety issues of GMOs and the role of the Consumer Union of Japan (CUJ) and hundreds of activist organizations continue to play a significant role in development and lack of acceptance of GMOs in Japan. The representative of CUJ mentioned that their organization and other activists have strong international networks that provide information about the risk of GMOs which enables them to take action when necessary. For example, a well-coordinated effort by this

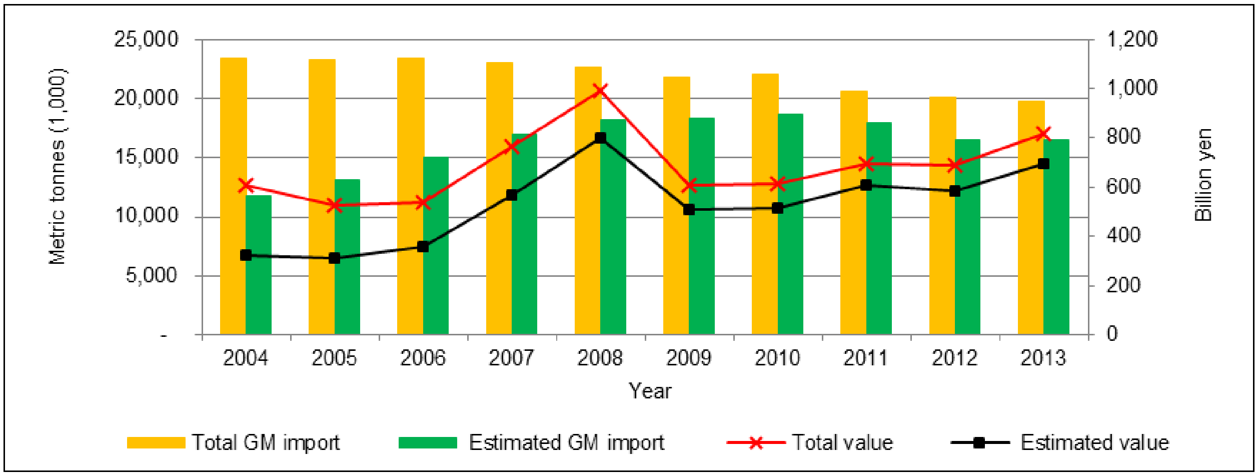

Figure 2. Total estimate and value of four GM grains (maize, soybean, canola, and cotton seed) imported to Japan (2004-2013).

Source: Japan Trade Statistics, ISAAA, and USDA

group led to the stoppage of GM soybean field trials in the southern and northern part of Japan, where 30 farmers were experimenting with the new crop 14 years ago. Farmers can grow GMOs but must be willing to adhere to tough government rules, which often discourage them, one respondent mentioned. In fact, this is true as farmers in Hakkaido are required to pay 314,760 yen (approx. $3,150) as a processing fee before their application for commercial production of GM crops can be reviewed, and failure to do so could result in penalty of 500,000 yen (approx. $4,065) or one year imprisonment (USDA FAS, 2015). Another respondent explained that any GMO field trial is a strictly controlled research study in Japan where there are designated GMO-Free Zones and non-GMO-Free Zones and that stringent permission is required to conduct field trials. As part of these challenges, respondents mentioned that obtaining permission to conduct GMO field trials in Tokyo Metropolitan area can be very difficult due to strict government regulation. Apart from the public concerns, some respondents explained that little effort is put into GMO field trials by the government partly due to political pressure. One respondent argues that GMOs have become a political weapon to discourage voters during the election. In view of the limited efforts by the government, an effort led by Monsanto in the country often brings public, media, activists and government officials together two or three times in a year to look at the open GMO field trial in one of the non-GMO-Free Zones to familiarize them with the new technology and allay concerns about its potential risks. Despite Monsanto's effort, the barrier imposed by limited field trials represented 21% of concerns that were raised during the interviews. This has been attributed to strict regulation imposed by various government ministries. This compares with 26% of concerns that related to barriers caused by the regulatory logjam. Currently, five different ministries (Figure 2) play different roles regarding GMO field trials in the country. Each of these ministries has its jurisdiction over the regulation of GMOs and imposes different levels of restriction using Type 1 ordinance (used for containment measure for industrial use) and Type 2 ordinance (which regulate research and development; Umeda, 2014). According to Umeda (2014), Type 1 and Type 2 ordinances are applied by different ministries to ensure safe handling of GMOs, including for research purposes. For example, the Ministry of Environment (MOE) and MAFF can apply Type 1 and Type 2, respectively, to impose restriction. This could be the reason no data has been available for GMO field trials since 2001 (van Beuzekom & Arundel, 2006). Problems with data—as it relates to the presence of GM products in feed and food production—still remain unresolved as suggested in Figure 1. Moreover, some Japanese scientists felt that the regulatory logjam caused by government ministries represents a significant challenge to confined field trials, thereby affecting R&D and commercialization of GM crops. In view of this fact, it is believed to have a knock-on effect on the government's GM technology R&D program for developing countries. As a result, it can be difficult to help developing countries create a clear regulatory framework to adopt GM crops. Among these projects are GM soybean and GM sweet potato, where significant efforts

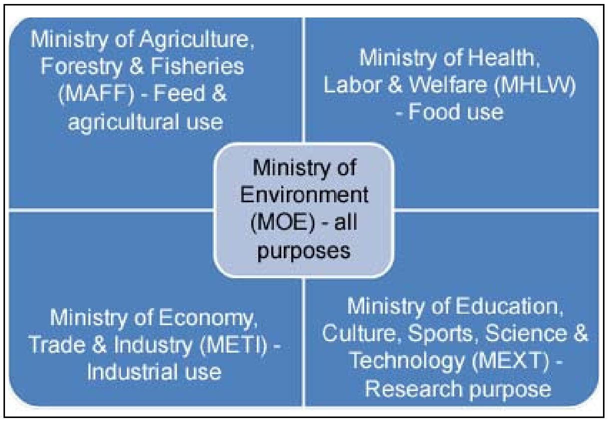

Figure 3. Ministries responsible for current regulation of GMOs in Japan.
Source: Survey and ministry websites

have been made to complete the key trials but have failed on a number of occasions partly due to a regulatory policy problem.

Consumption and Labeling of GM Products. In spite of the lack of adoption of GM crops, an average of more than 20 million tonnes of GM products have been imported and used for either processed food or animal feed at an average total cost of more than 600 billion yen (approximately US$6 billion) in the past decade (Figure 2). One respondent claimed that consumers eat GM foods without their knowledge. Another respondent argued that four pillars of safety assessment—such as basic research, industrial use, food use, and feed use—are regulated by the five ministries as described in Figure 3. This provides adequate and safe evaluation of GMOs and ensures that the regulatory body is satisfied before GMO products are released into the environment or circulated into the market. One respondent emphasized that the efficiency and competence in safe evaluation and quality-control practices is paramount to the government so as to avoid adverse effects that may result from the use of GM products. The two key ministries—Ministry of Health Labour and Welfare (MHLW) and MAFF—would play a significant role if GMOs were to be commercialized as described by a participant. Among key reasons why the importation is necessary is that less than 4% of soybean is produced in the country and soybean is very important in traditional diets. Consumers enjoy the cost advantage of GM products such as soybean oil and canola oil, where GMOs represent more than 90% of their ingredients; both products come with two-fold price reduction at the markets when compared to non-GMOs, as explained by one of the respondents. In contrast, anecdotal evidence suggests that 80% of consumers from Seikyou would choose non-GM noodles over GM noodles despite the discount of 50% for the latter (McCluskey et al., 2003), although the authors acknowledged that their findings may not be representative of the whole Japanese population. Seikyou is an agriculture-supported community, therefore their responses may be biased against GM agriculture.

Moreover, some respondents mentioned that government needs to respect the right of Japanese people to have access to information about the food they consume. Still, the fact remains that Japan is among countries alongside the European Union that have enforced a strict GM-labeling regulation (Carter & Gruère, 2003). However, the loopholes in labeling policy also draw respondents' attention. They argued that a labeling threshold set at 5% (labeling is not required for adventitious GMOs that contain up to 5% of the total weight [MAFF, 2014]) can be confusing and controversial, particularly for the processed products. According to one respondent, the labeling of GM products is contested since the GM soybean oil and GM canola oil are excluded due to non-detectable DNA and protein present in the final food products. Differing cultural, social, and political values (as in the case of anti-GMO countries including Japan) remain a serious challenge to develop clear GMO-labeling policies in many developing countries. This challenge continues to hinder the harmonization and implementation of international labeling policies for GMOs (Carter & Gruère, 2003; Lucht, 2015).

Strengthening Collaborative Efforts for GM Technology R&D

The lack of proper coordination in targeting new innovations may undermine the development of agricultural technology for developing countries. The reported inability of a scientist to conduct field trials after development of biofortified GM sweet potato with great potential to solve malnutrition problems in developing countries suggests an inefficient coordination in introducing new crop varieties that may benefit millions of malnourished people. In view of growing international efforts to address the challenge of malnutrition problems in developing countries, particularly in South East Asia and Africa, it is important to encourage every new and upcoming innovation that can be part of the solution. Apart from a virus- and weevil-resistant GM sweet potato variety that is undergoing field trials (Karembu, Nguthi, & Ismali, 2009; Sweet-potato Action for Security and Health in Africa [SASHA], 2014) and a rural household randomized trial of biofortified (beta-carotene) orange-fleshed sweet potatoes through conventional plant breeding (Low et al., 2007), in Africa, no biofortified GM sweet potato has been field tested. There is a need to encourage and support scientists that are working on the development of modern biotech products that may benefit humanity. A group of scientists—including those from CIMMYT—argue that the coordination of biotech research, particularly under JIRCAS, requires more effort to support other Japanese scientists in biotechnology R&D projects and their research activities including field trials so as to facilitate the development of new crop varieties that may benefit developing countries. Specifically, they mentioned that supporting scientists in developing countries where new biotech products will be introduced, particularly in terms of training and capacity building, is very important to introducing the new technology. This argument is in line with the previous efforts of developed country such as the United States, particularly in supporting the development of agricultural biotechnology in developing countries. For example, the United States government under the US Agency for International Development (USAID) initiated the Agricultural Biotechnology Support Program (ABSP) in some developing countries for capacity building that targets implementation of effective biosafety regulatory systems (USAID, 2002), and the University of Michigan has trained many participants from 58 developing countries on extension programs related to agricultural biotechnology under the USDA FAS (Maredia, Guenthner, & Webbadde, 2012).

Some respondents argued that Japan could do a lot better to support developing countries in this regard rather than focusing on collaboration with the CGIAR centers alone. But a joint program between the CGIAR centers and Japanese research institutes that integrates national research institutions could be a good option whereby the new technology can be assessed and released to the farmers with training programs that target their needs (Adenle, Walter, & Bamidele, 2014). One respondent recommends that if Japan wishes to see GM technology or other modern biotechnologies developed in-house and utilized in developing countries, it would be better to select a range of target countries where the benefits would be greatest, and provide all the necessary assistance from field demonstration to adoption of the new technology. He emphasized further that Japanese scientists could work with the national programs to adapt the technology for local adoption. All of these arguments are reinforced by the fact that success of Japan's efforts in introducing modern biotechnology including GM technology will depend on the degree to which results of biotechnology R&D programs are transferred to national research institutions and the kind of support provided before any meaningful impact can be felt in developing countries. Otherwise it becomes yet another abandoned project, as in the case of previous efforts in introducing agricultural biotechnology to developing countries.

Moreover, there is a need to clarify terms and conditions that are associated with the intellectual property rights (IPRs) of GM technology. The lack of detail regarding the IPRs for DREB technology used in producing stress-tolerant soybean could represent a significant challenge in many developing countries due to weak IP management as described by some respondents. Little information exists on patented GM products developed by the Japanese scientists with their counterparts from developing countries. As described in Figure 1, lack of data (18%)—including relevant information on patents—can be a serious challenge due to the involvement of various parties in the country. Our efforts to obtain relevant information regarding GM products from domestic private companies failed. However, the information obtained from one of the research institutes indicates that 16 joint patents belong to partnerships with domestic private companies, out of 36 recorded for GM products in 2012. It is also not clear whether patents resulting from the government-funded projects or patents from the cooperative R&D will either end up with the Japanese universities or the private companies. Previous evidence suggests that competition for biotechnology projects exists among different ministries due to central role of government in commercialization of biotech products (Muller & Fujiwara, 2002). It will be important to clarify if the JIRCAS partnership with developing countries aims towards R&D development for humanitarian purposes through the public sector so that the delivery of the technology to developing countries will not be hindered by IPR constraints. One Japanese scientist mentioned that their research institute would be interested to work with the private sector in development and dissemination of the new technology in developing countries, particularly where public institutions are less efficient. More training in terms of technical expertise can be offered to developing countries, particularly where IPRs remain a major problem. Exploring the existing partnership for technology transfer can be useful. For example, public-private partnerships such as the African Agricultural Technology

Foundation (AATF, 2014) could be an important option in view of their efforts to introduce the new agricultural technology in this region. This is yet to be placed on JIRCAS agenda.

Despite the leading role of JIRCAS, there still exists little interest toward acceptance of GM technology in Japan. The lack of adoption or commercialization of GM crops in the country raises a serious concern among some respondents, particularly with regard to the genuineness of developing GM crops for developing countries. Some respondents felt that Japan needs to demonstrate a good example to developing countries by itself adopting GM crops. While the interviewed Japanese scientists appreciate the potential benefits of GM technology, they felt government needs to do more to engage the public on balancing risk-benefit aspects of the new technology as the country has the competent authority to manage GM products safely, which has been demonstrated for many years. Some of these scientists believe that it will not take long to commercialize GM crops if there is less opposition among consumers and politicians, but government needs to take a proactive approach toward addressing this fundamental challenge. Two different respondents mentioned that transgenic artificial blood vessels and transgenic cosmetic products made with silk thread have been successfully developed and are being managed by private companies for commercial production subject to approval, but these attract little attention from politicians and the public. For scientists, the concern is that there is little information on GM products, which further heightens consumers' fears of GM products. The need to gain better understanding about consumer behavior and attitude toward GM foods is fundamental to developing market strategies (McCluskey et al., 2003). However, the lack of official data on what percentage of citizens agree to the use of GM products represents a significant challenge, as this can help policymakers make appropriate decisions regarding GMOs. In addition, lack of recent data does not allow for a well-informed analysis regarding the attitude of Japanese people toward GM products. A study analyzed Japanese attitudes toward modern biotechnology—particularly GMOs—between 1997 and 2000, and showed that GMOs (54% in 1997, 59% in 2000) were favored less than computer and information technology (77% in 1997, 82% in 2000; Macer & Ng, 2000). While the authors argue that some Japanese—particularly scientists—believe GM technology has great potential to improve the quality of life, lack of trust in government due to discovery of bovine spongiform encephalopathy (otherwise known as "Mad Cow Disease") in Japan continues to give bad publicity about GM foods (McCluskey et al., 2003). Overall, they felt there is a need to create more awareness, encourage demonstration of field trials, and provide more facts about the use of GM products in food and feed production. One respondent mentioned that citizens need a sense of security rather than safety alone, and it can only work if policymakers are more transparent about the use of GMOs. He described further that government needs to prove to the public how many GM products have been circulated and what science is saying about the products, as Japanese people appreciate practical demonstration of new technology (i.e., 'seeing is believing'). By doing so, it will not only allay concerns about the potential risks of GMOs but will also demonstrate the safety of these products and make the public feel more secure.

The fragmented policies among various ministries could be a hindrance to adoption of GM technology in the future. For example, different guidelines set by different ministries in coordinating and regulating current GM products can be cumbersome. Moreover, past experience suggests that the involvement of several Japanese ministries in biotechnology regulation can result in a delay in decision making (Motohashi, 2004). Therefore, there is a need to harmonize efforts that will facilitate integrated policy among these institutions.

Conclusion and Policy Implication

First and most importantly, the Japanese government—especially the key ministries—needs to demonstrate more commitment by engaging relevant stakeholders including scientists, farmers, consumer organizations, and the private and public sector on important issues relating to GM technology R&D, application, and effective communication of GM products in the light of issues raised among respondents. Government needs to pay more attention to awareness creation, particularly in educating the Japanese public about the benefits and potential risks that are associated with GMOs. Most Japanese academic experts agreed that scientists have an important role to play in conducting safety tests on GM products and providing the relevant data on the use of GMOs to the public. Here, partnership between the government and scientists is key to decision making on GMO policy, as emphasized among respondents. The involvement of various ministries in regulatory processes of GMOs appears to be a serious obstacle; shifting tasks to a few ministries with the specific responsibilities could be more efficient and at the same time produce better results to facilitate the use of GMOs. In light of compelling evidence of GMO safety based on lack of harm to the environment and health in 20 years of GM cultivation, a flexible Japanese GMO policy can be a viable model for developing countries and can enhance future delivery of GM products in the countries where there is ongoing collaboration. A reality of this will lie in Japanese ability to demonstrate to the public that GMOs are safe for human consumption, which is where Japanese scientists' efforts are needed to strengthen their GMO policy.

In summary, the analysis of interviews discussed here indicates that there is a need to provide a coherent framework for biotechnology R&D projects targeting developing countries, as well as supporting researchers both from Japan and countries where the final biotech products may be targeting. Given the role of JIRCAS in implementing the objectives of biotechnology R&D projects under SATREPS—particularly GM technology—their efforts need to focus on training of local researchers in participating countries, integration of projects into national programs, and the involvement of the private sector to facilitate developments of new technology that may benefit target countries. This must be recognized and supported by the Japanese government in order to make ongoing GM technology R&D programs a reality in developing countries.

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Acknowledgments

All interview participants are gratefully acknowledged for their valuable time and contributions. I am extremely thankful for the contribution made by Prof. Govidan Parayil (former Vice-Rector of United Nations University) and Dr. Yamane Seiichiro (President, Monsanto Japan Limited) in developing the research plan and preparation of the manuscript. I am also grateful to my intern, Mr. Nishizawa Arashi, for interpreting and transcribing the interviews. Special thanks to Dr. Jane Morris for helpful review and constructive comments on an earlier version of the manuscript. The views expressed by the author do not necessarily reflect the views of the United Nations University-Institute for Advanced Studies of Sustainability and organizations that participated in the study.

Appendix

4. Introduction and explanation of the reason for the interviews on agricultural biotechnology
5. Agricultural biotechnology (e.g., GMOs) research and development (R&D) for developing countries in Japan—when and why?
6. Collaboration on biotechnology R&D—where and why?
7. Training of foreign students and researchers in the field of biotechnology—how and why?
8. Factors affecting training in biotechnology—why?
9. Potential adoption of GMOs in Japan—when and how?
10. Decision making for application of GMOs—by whom?
11. Factors affecting the use of GMOs—how?
12. Handling of importation of GMOs—by whom?