



R&D and Policy Directions for Effective Control of *Fusarium* Wilt Disease of Cavendish Banana in the Asia-Pacific Region¹

Albert P. Aquino, Genny G. Bandoles, and Virma Anne A. Lim²

Introduction

As a major staple food crop, banana is widely cultivated in the Asia-Pacific region. Asia-Pacific countries such as India, China, the Philippines, Indonesia, Thailand, Vietnam and Papua New Guinea are among the world's top producers of banana. Suitable for year-round production, banana contributes to food security. It also generates foreign exchange earnings for countries with competitive advantage in production.

However, virulent diseases constantly pose challenges to sustainable production. *Fusarium* Wilt, caused by *Fusarium oxysporum* f. sp. *Cubense* (*Foc*), is recognized as the most destructive banana disease. The disease has destroyed the Gros Michel banana plantations, particularly of Central America, in the early 20th century.

The most virulent strain of *Foc* (Tropical Race 4 or TR4) capable of attacking Cavendish has been reported in Asia. In a survey conducted by the Banana Asia Pacific Network (BAPNET) among 12 tropical countries in Asia in 2006-2009, *Foc* Tropical Race 4 was confirmed present in China, Indonesia, Malaysia, the Philippines, and Taiwan while *Foc* Race 1 was found in Bangladesh, Cambodia, India, Sri Lanka, Thailand, and Vietnam. No *Foc* infection was found in Papua New Guinea (Molina, 2013).

With the commitment to promote awareness and spearhead the formulation of sustainable solutions for effective control of *Fusarium* wilt, the Food and Fertilizer Technology Center (FFTC) for the Asian and Pacific Region and the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) organized a consultation-workshop on the socio-economic impacts of *Fusarium* wilt disease of Cavendish banana in the Asia-Pacific region, in collaboration with Bioversity International and the Banana Asia Pacific Network (BAPNET). Conducted on 11-15 November 2013 in Davao City, Philippines, the consultation-workshop aimed to: generate information on and document the economic and social impacts of *Foc* TR4 at the industry level in the Asia-Pacific region; discuss the mechanisms, approaches or initiatives adopted by various organizations and countries in addressing the problem on *Foc* TR4; and explore possible collaborative strategies or institutional arrangements on minimizing or arresting the spread of *Foc* TR4. The consultation-workshop was attended by researchers,

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² Philippine Point Person to the FFTC Project on Asia-Pacific Information Platform in Agricultural Policy and Director, Science Research Specialist, and Science Research Analyst, respectively, of the Socio-Economics Research Division-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (SERD-PCAARRD) of the Department of Science and Technology (DOST), Los Baños, Laguna, the Philippines

government agency heads, and technical experts from Australia, China, Malaysia, Indonesia, the Philippines, Taiwan, and Vietnam.

This paper synthesizes the findings of such consultation-workshop. It discusses the extent of *Fusarium* wilt disease incidence and impact in the aforementioned countries, identifies the existing policy and technological solutions for disease control, assesses the identified R&D and policy options and directions, and considers possible institutional arrangements and collaborations for effective disease control.

The banana industry in the Asia-Pacific region

Among the Asia-Pacific countries represented in the consultation workshop, China, the Philippines, Indonesia, and Taiwan produce bananas in relatively larger quantities (Table 1). However, due to high local demand, most of China's produce are intended for local consumption. The bananas produced in Australia and Indonesia are also mainly for local consumption.

Table 1. Volumes and values of banana produced, exported and imported in 2011

Country	Production (tonnes)	Export Quantity (tonnes)	Export Value (1000\$)	Import Quantity (tonnes)	Import Value (1000\$)
Australia	202,751	1	8	122	720
China, mainland	10,400,000	10,241	6,968	818,675	401,728
Indonesia	6,132,695	1,735	1,012	1,631	850
Malaysia	334,302	22,864	8,087	2,084	838
Philippines	9,165,043	2,046,743	471,152	0	0
Taiwan R.O.C.	305,740	10,284	13,512	16	29
Vietnam	1,523,428	39,545	6,054	no data	no data

Source: FAO, 2013

Countries keen on exporting bananas are the Philippines, Taiwan, Malaysia, and Vietnam where at least 3% of the respective local produce are intended for export. According to Chao (2013), banana is the number one export-oriented crop in Taiwan. Cavendish is the dominant variety and banana fruits are exported mainly to Japan (Peng et al., 2013).

In the Philippines, banana, of the Cavendish type, is the second most important agricultural export next to coconut oil in terms of value. It accounts for about 8-9% of the total value of all agricultural exports and is shipped to about 36 countries worldwide. The major export markets include Japan, China, South Korea, Iran, Singapore, United Arab Emirates, New Zealand, Hong Kong, Kuwait, and Saudi Arabia (Aquino et al., 2013).

Banana is also economically significant in Malaysia where it is the second most widely cultivated fruit. About 50% of the bananas produced are of Pisang Berangan and Cavendish varieties. Banana fruits are exported mainly to Singapore, Brunei, Hong Kong, and the Middle East (Tengku Ab. Malik et al., 2013).

***Fusarium* wilt disease incidence and impact**

Fusarium wilt is considered widespread in Indonesia where an average of 2.11 million mats of banana was devastated per year from 2003 to 2007 (Sukirno, 2009 as cited by Hermanto, 2013). It has also

become prevalent in areas previously considered to be most suitable for banana growing in China, the Guangdong and Hainan provinces, which now have incidence of up to 70% (Chen *et al.*, 2013). High levels of incidence were also recorded in Taiwan, when approximately 4,000 hectares out of 7,000 hectares of commercial Cavendish banana production areas in the central and southern parts were found to be affected in 2002 (Hwang, 2002 as cited by Peng *et al.*, 2013).

A countrywide survey conducted in Malaysia in 2008-2009 revealed that nearly 883 hectares of its banana production areas were affected by *Fusarium* wilt (Tengku Ab. Malik *et al.*, 2013) while an ongoing survey in the Philippines found that at least 634.7 hectares were affected in the Davao region which is currently the top Cavendish banana-producing region in the Philippines (DA-RFU XI, 2013 as cited by Herradura, 2013). An outbreak of *Fusarium* wilt caused by *Foc* TR4 was observed in the Northern Territory of Australia in the 1990s but there is paucity of information on the actual areas affected.

All of the seven countries had confirmed cases of *Foc* TR4 infection except Vietnam. However, figures specific to *Foc* TR4 infection are not available. Some of the surveys were also conducted many years ago. Thus, an extensive survey to determine the current incidence and distribution of *Fusarium* wilt, especially that which is caused by *Foc* TR4, is necessary.

Having wiped out plantations in some parts of Indonesia, Malaysia, Taiwan, China, and Australia, the impact of *Fusarium* wilt in these countries were significant. The economic losses of Indonesia, Taiwan, and Malaysia were estimated at USD121 million (Hermanto *et al.*, 2011 as cited by Hermanto, 2013), USD253.3 million (Peng *et al.*, 2013) and USD14.1 million (Tengku Ab. Malik *et al.*, 2013) per year, respectively. In a survey of sample Philippine farms affected by *Fusarium* wilt, Aquino *et al.* (2013) estimated that the annual cost of disease borne by the farms due to production loss and additional costs amounted to at least USD9.17 per infected banana plant.

In general, the tangible impacts of *Fusarium* wilt disease, at the farm level, were in terms of additional investment and operating costs (due to eradication, sanitation, use of disease-free planting materials, and/or moving to new production areas) and reduced income (due to production loss). On the other hand, the intangible impacts include decreased value of assets (e.g., land and farm machinery) and higher production/market risk. In Australia, the fear of banana growers about the spread of the pathogen resulted in other intangible impacts such as isolation from the farming community and loss of markets.

Current technological solutions for disease control

The current technological solutions for *Fusarium* wilt are somewhat limited. These solutions mainly focus on preventing the spread of the pathogen. At present, quarantine is deemed the most effective method of managing the disease. Quarantine through exclusion (i.e., prevention of spread of the pathogen from one area to another), eradication (i.e., removal of all infected plant material in an area), use of disease-free planting materials, and/or sanitation (i.e., thorough cleaning of materials to prevent contamination, or reducing the amount of inoculum in an infested area) is being emphasized, in varying degrees, in countries such as Australia, the Philippines, Malaysia, Indonesia, and Vietnam. The quarantine practices of Australia are deemed the most effective due to strictly enforced policies as well as use of accurate diagnostic tests (e.g., VCG analysis) in determining the disease strains.

In China and Taiwan, the development of resistant varieties can be considered a promising technological solution at present. Developed by the Institute of Fruit Tree Research (IFTR) in China and the Taiwan Banana Research Institute (TBRI) in Taiwan, the new varieties have moderate or limited resistance to *Foc*. However, their development is a good step towards finding a long-term solution to the *Fusarium* Wilt problem. The moderately resistant Cavendish somaclone variant 'Tai-Chiao No. 5' released by the TBRI in 2007 has been well-accepted by banana growers and exporters in Taiwan as well as by Japanese importers (Peng *et al.*, 2013) while the varieties developed in China are not yet widely used because their commercial cultivation is still difficult (Chen *et al.*, 2013).

Bioorganic fertilization or application of biocontrol agents and formulated organic matter on infested soil is also practiced especially in China and Indonesia while cultural management practices like intercropping and crop rotation is recommended in Malaysia and Taiwan. Intercropping with Chinese leeks, although somewhat effective, is less preferred by farmers in China because of labor intensiveness.

Some solutions did not focus on disease control but on ways of preventing the likely impact of *Fusarium* wilt on land area for banana production. In China, the development of production technologies (e.g., covering double membranes) that minimize plant damage caused by winds and winter chill have helped farmers extend banana production to the less suitable and cooler northern lands, so that area for banana production may not decrease.

Current R&D initiatives

The development of disease-resistant varieties is currently pursued in countries such as Taiwan, China, Australia, and Malaysia. Indonesia conducts studies to evaluate the resistance of its different banana varieties, while the Philippines is testing the adaptability of disease-resistant somaclones from Taiwan. The development of cold-resistant varieties is also pursued especially in China, where banana farming in the disease-free but colder regions prevents decrease in production area due to *Fusarium* wilt.

The development of disease-suppressive soils is another R&D initiative in almost all of the countries represented in the consultation-workshop. The use of biological control agents (e.g., *Trichoderma harzianum*, *Gliocladium*, *Bacillus subtilis*) is being explored in developing soil suppressiveness.

Other researches are on developing disease-tolerant varieties, enhancement of tolerance through various disease management factors, development of rapid diagnostic methods for all strains, effectiveness of different chemicals in sanitation and eradication, and cultural management practices such as crop rotation and addition of organic amendments to the soil. National survey of infected areas and evaluation of local germplasm were recommended to countries which are currently not conducting such activities.

At the regional level, research needs identified during the consultation-workshop are on the development of early diagnostic tools for soil, water, and plants; extensive regional survey to map the existence of Foc TR4; and mutation breeding.

Currently under implementation is a genetic diversity study using banana accessions from the International Transit Centre (ITC) in Belgium. The ITC is a genebank holding the International *Musa* Germplasm Collection, which is considered the world's largest collection for bananas. ITC materials are being evaluated for their reaction against Foc TR4 (Herradura, 2013).

Existing policies for disease control

Current policies for disease management focus on quarantine. In the Asia-Pacific region, plant quarantine systems exist at the national level but quarantine policies dealing specifically with *Fusarium* wilt are limited. Policies are sometimes inadequate in some countries, and also not effectively enforced.

Harmonized and strictly enforced quarantine procedures can be observed in Australia, where regulations on movement of bananas and diseases exist both at the national and state levels, with guidelines for voluntary restrictions at the farm level. A national biosecurity system exists to manage risks and minimize the impact of pests and diseases while facilitating the movement of materials to, from and within the country. At the state level, the movement of bananas is being regulated especially in Queensland through legislations like the Plant Protection Act 1989 and the Plant Protection Regulation 2002 (currently being updated) which declare *Fusarium* wilt a notifiable disease and which stipulate the actions to be taken

when the disease is detected. An on-farm biosecurity manual is also developed to protect farms from entry and spread of pests and diseases. Procedures are enforced with compliance monitoring and imposition of penalties on non-compliance (Pattison *et al.*, 2013).

In the Philippines, the Department of Agriculture- Bureau of Plant Industry (DA-BPI) issued Special Quarantine Administrative Order No. 01 Series of 2012, which places under quarantine all the provinces where the disease exists, to prevent spread to non-affected areas. At the local level, the province of Davao del Norte, which is the top Cavendish banana-producing province in the country, enacted Provincial Ordinance No. 2012-004 otherwise known as Provincial Quarantine Protocols of all Banana (*Musa* sp.) Growers in Davao del Norte, and issued Executive Order No. 21 which establishes the implementing rules and regulations of the ordinance. Strict policy implementation/enforcement is yet to be observed in all affected local areas.

Stringent quarantine procedures for importation of planting materials are established in Malaysia. To prevent the spread of *Fusarium* wilt within the country, the government has developed the Standard Operating Procedure (SOP) for banana farming. The SOP outlines recommended practices on sanitation, use of disease-free planting materials, eradication, and regular surveillance for early detection of the disease, among others. Several banana industry fora were organized by the Malaysian Agricultural Research and Development Institute (MARDI) in partnership with the Malaysian Department of Agriculture to create awareness on the SOP (Tengku Ab Malik *et al.*, 2013).

Although R&D initiatives are currently pursued, policies specific to *Fusarium* wilt and quarantine measures are very limited in other countries. Some of the reasons given are the presence of equally/more important crops and prioritization of other pressing concerns. In general, the policy issues identified during the consultation-workshop are on: lack of understanding and appreciation of the importance of banana to the national economy as well as of the importance of collective and concerted efforts to address *Fusarium* wilt; harmonization of policies (e.g., quarantine protocol) at the national and local levels up to the barangay/village level; need for strong monitoring of *Fusarium* wilt incidence and strict enforcement of penalties for non-compliance with regulations; and need for more R&D and effective public extension service.

To address these issues, especially in the Philippines, a continuing collective and concerted awareness and advocacy campaigns regarding *Fusarium* wilt detection and control involving all major stakeholders, was recommended. Policies on quarantine should also be finalized, implemented, and monitored at all levels (national, local, village). Effective policies may be replicated in other Asia-Pacific countries with similar conditions and serious disease prevalence. For an effective public extension service, the capacity of local government units should be strengthened. Further, an information platform (e.g., website) may be developed for information sharing and technical assistance.

The private sector has been clamoring for more intensive R&D efforts on *Fusarium* wilt. Among the options considered is greater industry engagement in research design and implementation through participation in the government's R&D programs, and creation of an independent R&D institution dealing specifically with banana and *Fusarium* wilt. These options need further evaluations for appropriate arrangements, and nature and level of commitments.

Possible institutional arrangements and collaborations

At the national level, the roles of both public and private institutions regarding provision of technical, logistical, and financial support in finding R&D and policy solutions need to be further clarified. The availability of resources and the commitment to provide support would influence the design of sustainable and efficient institutional arrangements and collaborations within countries.

At the regional level, managing the disease requires regional efforts that can be spearheaded by organizations with authority and ability to perform the necessary functions. To prevent the further spread

of *Fusarium* wilt through a regional quarantine system, the organizations that could possibly be involved include: Bioversity International and BAPNET, for the formulation of R&D initiatives and quarantine policies; ASEAN quarantine office and/or FAO, for the implementation of quarantine policies; and FFTC, for information-sharing and capability-building.

Conclusion

The economic loss estimates based on actual *Fusarium* wilt disease incidences, as well as estimates of potential losses should the disease problem worsen, provided values against which the costs of solving the disease problem may be compared, to determine the worthiness of disease control investments. Results of studies showed that controlling the disease is urgent and worthwhile especially in countries where the banana industry, especially of the Cavendish type, has significant contributions to the economy.

A multi-strategy and integrated approach is necessary in controlling the disease. The development of better diagnostic methods and effective management techniques, together with the development and effective enforcement of appropriate policies, are needed to prevent further spread of the disease.

Similar R&D initiatives can be observed in several Asia-Pacific countries. The sharing of information will help reduce cost, and advance knowledge and technology on disease control.

Harmonized policies, especially on quarantine, have to be developed at the regional, national, and local levels. Regional agencies with authority and capacity should spearhead regional efforts in disease control. The cooperation and collaboration of countries are necessary especially in areas such as capacity building, information sharing, R&D, and formulation and enforcement of policies. The private sector's contribution and compliance with protocols and regulations will facilitate the success of the aforementioned endeavors.

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