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Mitigating the threat of Fusarium Tropical Race 4 in the Philippines

In the Philippines, Fusarium wilt infection in Cavendish plantations has been reported as early as the 1970s, with more than 30 000 documented cases for the period spanning 1974-1991. These infections were tested and identified to be VCG 0122, 0123, and 0126. Although these infections may be classified as Race 4, it is believed that these VCGs were not as virulent as VCG 1213/16 (Tropical Race 4, or TR4), which were causing *Foc* epidemics in Indonesia and Malaysia, and were not considered as a major production constraint. However, in 2002, a heavy outbreak of Fusarium wilt was observed in a banana farm in Calinan, Davao, an area situated about 350-500 meters above sea level and newly planted with a Cavendish variety intended to produce "sweet bananas". But even before 2002, an unpublished report documented that a commercial farm in this area, which was planted to Lakatan (AAA), a native cultivar popular in the local market, was abandoned because of severe epidemic presumably caused by *Foc* Race 1. This common pathogen also causes severe infection in Latundan (silk variety), another local variety. However, it was not specifically determined as to what VCG group this epidemic belonged. In the period 2004-2005, new incidences of *Foc* infection were observed in some traditional lowland Cavendish farms producing export bananas. Believed to be TR4, the new infections appeared to be more aggressive than previous occurences of Fusarium wilt. TR4 poses a very significant biological and economic threat as all varieties that succumb to *Foc* Race 1 also give in to TR4. It is believed that *Foc* and its major clonal lineages coevolved with its diverse hosts in Asia. Thus, the virulent TR4 is obviously endemic to the region.

(Top) A Fusarium wilt-infected plant in a commercial Cavendish plantation in Davao, Southern Philippines; *(bottom)* Burning rice hull to kill *Foc* pathogen in the soil being tested under commercial plantation conditions.

To verify the identity of the recent *Foc* infections, 30 infected plant samples were collected from highland and lowland Cavendish farms in Davao from September to December 2005 and were sent to the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, South Africa for VCG testing. *Foc* was isolated from all the samples, nit-mutants were generated, and the Philippine isolates were crossed with known VCG testers using the technique described by Puhalla in 1985. The *Foc*-infected Cavendish samples confirmed that the recent infections of Fusarium wilt in Cavendish in the Philippines were caused by VCG 01213/16 complex, the VCG associated with TR4. This finding is highly significant since the Philippines is the leading banana exporting country in Asia since the late 1960s. In 2006, the country registered its highest export volume of 2.04 million MT, making the Philippines the world's third largest banana exporter. For this reason, the Philippine government, private banana companies, and Bioversity International are collaborating to manage the disease and to prevent the further spread of *Foc* TR4 within the country and beyond its borders.

Concerned about the TR4 situation in the Philippines as well as in other Asian countries, the Bioversity-coordinated Banana Asia-Pacific Network (BAPNET) initiated a regional collaboration to survey, characterize and map the distribution of the various VCGs in Asia and the Pacific. Based on the findings of these survey

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and characterization missions, Bioversity hopes to develop a geographic distribution map of the various forms of *Foc* and detailing the varieties they affect in each country. The output of this activity will provide a rational basis for developing and implementing intra- and inter-country quarantine policies. Part of this initiative is the development and validation of banana disease control tactics and improved production systems by adapting the experiences of Taiwan particularly in the successful use of tissue culture and selection and use of resistant somaclonal variants. Additionally, some of the varieties included in the International *Musa* Testing Programme (IMTP) of Bioversity are being evaluated throughout the region through the National Multiplication and Repository Centres established in each BAPNET member country. Some of the FHIA varieties and somaclonal variants of Cavendish provided by the Taiwan Banana Research Institute (TBRI) showed some resistance to TR4. Bioversity is taking a holistic approach to manage the disease, including prevention, exclusion, cultural management and appropriate use of cultivar resistance and diversity.

Fusarium wilt-infected banana plants of Latundan, a local variety.

The unfortunate demise of Gros Michel due to Panama wilt in Central America in the 1950s forebodes the potential danger of TR4. Although it is recognized that *Foc*, particularly TR4, is a real and significant threat to the banana industry mainly to the monoculture commercial Cavendish production, the present situation is quite different from what it was then. Major concerns are the ability of the *Foc* pathogen to survive in the soil for a long time and the absence of an effective treatment to destroy the pathogen in the soil. Opening up new areas to establish new plantations today is not a feasible option as there is simply not enough available land, unlike during the Panama wilt era. However, new technologies such as the use of disease-free planting materials provide fresh opportunities to manage this disease even on existing plantations, while the movement and exchange of germplasm are now safer with virus indexing techniques that complement tissue culture technology. With the present available knowledge and state of the art technology, it is now easier and more effective to implement quarantine policies thus preventing the spread of pathogens.

Additionally, the Philippines could also learn from the experiences of other countries burdened with the same problem. The prevention of the spread of *Foc* TR4 in Australia was successful only because of the government's strong political will to strictly implement quarantine policies and the availability of diagnostic and tissue culture technology. In Taiwan, the annual cropping of banana was made possible with the use of tissue culture seedlings and had proved effective in reducing disease potential. While overall production costs are expected to increase as a result of additional management strategies, it is likely that, in the long run, the local Cavendish banana industry will survive and rebound.

Fusarium wilt in history

The devastation brought about by the Panama wilt epidemic in the 1950s wiped out the Gros Michel plantations in Latin America, causing the disappearance of the variety as the traditional export banana and demonstrated the destructive damage potential of the disease. Cavendish varieties, which were highly-resistant to *Foc* Race 1, eventually replaced Gros Michel. Up until today, the Cavendish remains unaffected by Panama wilt in Latin America. However, the occurrence of a virulent form of *Foc* in Asia that also affects Cavendish presents an imminent threat to the region's mainly Cavendish-based banana industry. This virulent form of *Foc* in Asia has been identified to belong to the vegetative compatibility group (VCG) 01213/16, which is associated with severe field epidemic of Panama wilt on Cavendish in Indonesia and Malaysia. Known as Tropical Race 4, this pathogen has been observed in several countries in Asia where Cavendish is an important cultivar for both the local and export markets.

Stopping the wilt!

When Cyclone Larry crossed the northeastern coast of Australia in March 2006, it destroyed most of Australia's commercial banana crop and sent consumer prices rocketing. The cyclone cost Australia's banana growers almost $500 million in lost production and re-establishment costs. So imagine the devastation if a disease such as Fusarium wilt, especially the virulent Tropical Race 4 (TR4) strain, were to hit northern Queensland. An outbreak of the disease would require eradication and regrowth of clean crops, putting even more financial strain on the region.

When TR4 hit the Northern Territory's banana growers, wiping out most of their production in 1997, the rest of Australia's production area was understandably nervous.

Fusarium wilt is caused by a fungus, which turns the outer leaves of a banana plant yellow before it moves to the younger leaves. When the stem at the base of the plant is cut, brown streaks are visible where the invading fungus releases toxins, blocking the water-conducting vessels of the plant and killing it. Fusarium wilt affects almost all varieties of banana, including the popular Cavendish.

A bunch of bananas cut open to reveal symptoms of blood disease.

Fusarium wilt and a second wilt disease,blood disease, have devastated banana crops for smallholder farmers and backyard growers in Indonesia, where export income from bananas fell from a high of $22 million in 1996 to just $150 000 in 2002. Blood disease is caused by the blood disease bacterium (BDB), which is carried to the plant by insects visiting the male flowers. The bacteria multiply in the flowers and grow down the stem of the plant towards the fruit, turning the flesh into red ooze. Generally, the symptoms of wilting and yellowing appear first in the youngest leaves of the plant.

Indonesia project staff taking samples from a fusarium wilt-infected banana plant in West Java.

Dr Siti Subandiyah, from Indonesia's Gadjah Mada University, says the two wilt diseases are still the most severe disorders affecting bananas in Indonesia, and have spread across many provinces. "The last severe infection was in late 2006 in South Kalimantan when most banana crops, especially the cultivar Kepok, were severely damaged by BDB," Dr Subandiyah says. Given that bananas are Indonesia's most important horticultural crop and an important staple food, these sorts of disease invasions are devastating.

The need to protect unaffected countries and regions, as well as to find better ways of managing the diseases once they do invade, is driving two ACIAR projects in Indonesia and Papua New Guinea.

"It is important that every country in the region knows what kind of wilt diseases they

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"Wilt diseases have devastated banana crops in Indonesia. Two ACIAR projects are attempting to manage the invasion - and protect unaffected neighbours."

have and where they are distributed," says Dr Agustin B. Molina, ACIAR project coordinator and Bioversity International's *Musa* Programme regional coordinator for Asia and the Pacific. "This knowledge leads to the development of rational inter-country as well as intra-country quarantine policies to prevent the further spread of diseases. For example, many of the important banana varieties grown in Papua New Guinea may be susceptible to TR4. Knowing what disease types are already present in PNG, and neighbouring Indonesia, helps to prevent TR4's invasion."

Bob Williams of the Queensland Department of Primary Industries and Fisheries (QDPI&F), the ACIAR project leader, believes it is important to know how to live with such diseases if they do strike Australia. "By working in Indonesia and PNG we're getting a better indication of the movement of disease, and how and when it might arise and what path it might take," Mr Williams says. "We can better understand how we could live with the disease if it did come to Australia, what management practices will minimise impacts, and how to change production practices and make conditions unfavourable for disease."

The first ACIAR project began in 2005 at the request of the Indonesian Government, which was concerned about smallholder banana growers dealing with the devastating effects of wilt diseases. Project leader Dr Peter Taylor believes the Indonesian research will also help Australia if any of these diseases enter the country. "We have made considerable progress in understanding these diseases. And we now have improved diagnostic tests for detecting them," Dr Taylor says. The project has improved the robustness of a polymerase chain reaction (PCR) test aimed at detecting BDB even if plants have not started to visibly 'ooze'. "We have established best-practice management options for wilt diseases," Dr Taylor says. "We'll be working with extension agencies and the Indonesian Banana Wilt Task Force to get these results out to farmers through existing networks and farmer discussion groups." The project has also set up field trials to test biocontrols against Fusarium wilt and to use as demonstration plots for BDB control measures.

Mr Malin, a farmer in Baso, Sumatra, and chairman of a local group of farmers, says nearly 70% of the bananas have been infected by wilt diseases in his region since 2002. Most attempts to re-establish banana crops in the region have failed, but Mr Malin says that the ACIAR banana plants were "higher and healthier" than other plants in the region after three months. The second ACIAR project, managed by Dr Molina, began last year to complement the first project and focus specifically on various forms of Fusarium wilt disease. It aims to map out the geographic spread of the various forms of the disease, validate diagnostic tools and produce a diseasemanagement manual of farmer-evaluated methods. In particular, it aims to promote national strategies that improve the region's capacity to exclude, contain and control Fusarium wilt.

The project has already surveyed the major banana-producing areas of Indonesia and collected infected plants. A similar survey is about to start in PNG. The project has also selected sites in Lampung and East Java in Indonesia to develop and test disease-management methods that are appropriate for local conditions. The 'best-bet' methods recommended by researchers will be packaged to include resistant plant varieties, biocontrol, use of low-cost tissue cultures for planting, routine monitoring and eradication, and use of annual cropping systems. These will be compared with farmers' existing practices.

Symptoms in the pseudostem of a banana plant with Fusarium wilt show rotting of the vascular tissues that eventually leads to wilting of the plant

Dr Molina believes it is essential to involve farmers in such tests. "By involving farmers right from the start, in a participatory approach to developing or validating disease-management strategies, we are able to improve the relevance of our project, making sure that it answers their needs. It makes them own the project. Then the farmers can serve as effective 'extension agents' to other farmers."

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The work in Indonesia, and now PNG,is just the start of regional and even global efforts to manage threats to banana growers from diseases such as Fusarium wilt and blood disease.

*- by **Jenni Metcalfe**, as excerpted from the July-October 2007 issue of the "Partners in Research for Development" magazine produced by the Australian Centre for International Agricultural Research, pp 17-19. The magazine could also be downloaded from ACIAR's Web site at http://www.aciar.gov.au.*

Partner Countries: Indonesia and Papua New Guinea
Projects: CP/2005/136 - Mitigating the threat of banana Fusarium wilt; CP/2004/034 - Diagnosis and management of wilt diseases of banana in Indonesia
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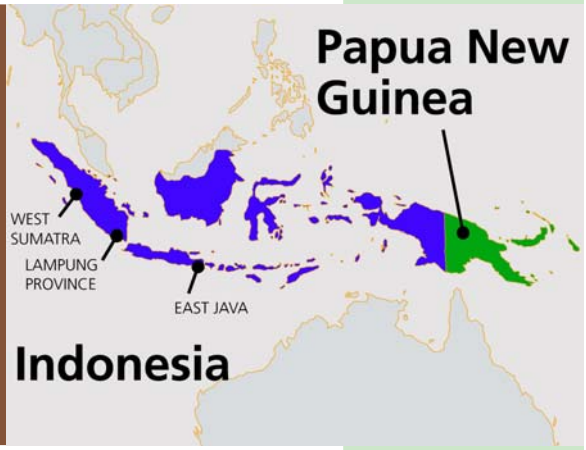


Public-Private Sector Partnership – Does it work? The case of banana R&D in the Philippines

Does partnership in crops R&D really work? In the case of the banana sector in the Philippines, it does. On 23 August 2007, Dr. Agustin B. Molina, Asia-Pacific Regional Coordinator of Bioversity International's *Musa* Programme, discussed a novel scheme of revitalizing the country's threatened small-scale and export banana industries though a networking model espoused by Bioversity International involving public-private-government-NGO partnerships, which could also be adapted in other Asian countries experiencing the same problems. Entitled "Public-Private Sector Partneship - Does it work? The case of banana R&D in the Philippines", the seminar was held at the Havener Auditorium, Chandler Hall, International Rice Research Institute (IRRI) in Los Baños, Laguna, Philippines.

Dr. Agustin B. Molina, Asia-Pacific Regional Coordinator of Bioversity International's *Musa* Programme, emphasizing a point during his talk on partnerships in banana R&D in the Philippines held at IRRI's Havener Auditorium on 23 August 2007.

The seminar highlighted a novel scheme of revitalizing the country's threatened small-scale and export banana industries though a networking model espoused by Bioversity International involving public-private-government-NGO partnerships, which could also be adapted in other Asian countries experiencing the same problems. As a primer, the seminar underscored the genetic vulnerability of banana as a crop that is handicapped by poor reproductive variability to respond to the dynamic variation and evolution of pests and pathogens that prey on it. Approaches in banana pest and diseases management, including advances (or the lack of it) in conventional and biotechnology-based plant breeding techniques, were discussed as well.

Bananas, one of the world's most important fruit crop, is an important source of food, nutrition and livelihoods for millions of small-scale growers in the Philippines. The country's banana industry contributes about US$ 400 million in vital foreign exchange earnings annually. However, this economically-important industry, as well as the livelihoods of Filipino smallholder farmers, is in danger of going under because of the onslaught of new diseases that are threatening the crop. Other banana-growing countries in Asia are similarly at risk.

The seminar was delivered as part of IRRI's regular Thursday discussion series given by scientists and researchers of the Institute or of collaborating/hosted organizations to keep constituents and other interested parties abreast of ongoing activities or projects as well as to provide a forum in which prospective collaborative work between and among the organizations could be formed and fostered.

Bioversity-AP conducts banana training for Philippine tobacco technicians

In connection with a collaborative project between the Philippines' National Tobacco Administration (NTA) and Bioversity International, Bioversity's Asia-Pacific Office conducted a training workshop on Nursery and Field Management of *In-vitro* Propagated Bananas for six tobacco technicians of NTA from 18 to 20 September 2007. The training was held at Bioversity-AP's office at the GS Kush Hall, International Rice Research Institute (IRRI), and at the Institute of Plant Breeding (IPB), University of the Philippines Los Banos (UPLB), Laguna. Four banana and plantain specialists served as resource persons during the workshop, including Dr Agustin Molina (Bioversity-AP); Drs. Felipe Dela Cruz and Olivia Damasco (Crop Science Cluster - IPB); and Lavernee Gueco (Crops Science Cluster - IPB).

Topics covered during the training-workshop included identification of different banana cultivars, nursery management of *in vitro* propagated bananas, management of banana pests and diseases; and field management of *in vitro* propagated bananas, specifically field layout, field planting, irrigation, drainage system, fertilization, weeding, mulching, desuckering, harvesting and other field cultural practices. The sessions included classroom lectures, hand-on field applications and visits to IPB's nurseries and screenhouses and to Bioversity-AP's banana field demonstration trials.

(Top) Dr Felipe Dela Cruz, Assistant Professor of the Institute of Plant Breeding - UPLB, explaining a point on identifying different banana cultivars to the NTA workshop participants; *(Bottom)* Some of the training participants trying their hand at transferring banana meriplants into polyethylene bags for hardening in one of IPB's screenhouses.

This capacity-building activity is part of Bioversity's commitment on providing technical support and backstopping to the Bioversity-NTA collaborative project on "Banana production and processing to complement the livelihoods and increase the incomes of small-scale tobacco growers in the Ilocos Region, Philippines." The project aims at improving the plight of marginalized tobacco farmers in the Ilocos Region, Northern Philippines, who in recent years have suffered from the dwindling prices of their main crop due to the decreasing demand for tobacco-based products coupled with the skyrocketing cost of farm inputs. The project would help these small-scale farmers improve their farm productivity and increase their incomes through crop diversification, particularly the integration of banana as a complementary high-value crop to tobacco, their traditional main produce. Additionally, these farmers would also be taught on how to process banana into marketable and value-added products like chips and catsup, thereby providing them alternative and additional sources of income. As a research component, Bioversity would also be evaluating the perfomance of improved FHIA varieties that would be introduced under the project, specifically their performance as processing bananas compared to local varieties like Saba. Hopefully, the results of the performance evaluation would give farmers more productive and profitable options as to the choice of bananas to plant. The NTA technicians trained by Bioversity would serve a valuable purpose in this project, especially in the effective selection and integration of banana as a high-value complementary crop in the small-scale, tobacco-based farming systems in the Ilocos Region.

Feature

Pseudomonas fluorescens as promising biocontrol for Fusarium wilt in Malang, Indonesia

"These are plants that have been treated with the biocontrol *Pseudomonas fluorescens* (Pf)", Mr. Koliadi proudly explained in the local dialect while showing a plot of healthy banana plants to other farmers and participants of the Bioversity-sponsored Participatory Planning Workshop conducted at Srimulyo Village, Malang, East Java in March 2007. The workshop is one of the major activities under the ACIAR-funded Fusarium wilt project in Indonesia and Papua New Guinea, which aims to find best-bet options for the effective management of Fusarium wilt in the two countries. Koliadi, who is an extension worker of BPTPH (Institute for Food and Horticulture Crop Protection) - East Java, is also the coordinator of the local banana farmer group, *Bumi Mulyo*. Established on 1 May 2005, the group is mainly responsible for conducting banana Integrated Pest Management Farmer Field School (IPM-FFS) in the village.

According to the online reference site Wikipedia (http://en.wikipedia.org/wiki/Pseudomonas_fluorescens), some *P. fluorescens* strains present biocontrol properties, protecting the roots of some plant species against parasitic fungi such as *Fusarium* or *Pythium*, as well as some phytophagous nematodes. It is not clear exactly how the plant growth promoting properties of *P. fluorescens* are achieved, but theories include:

- That the bacteria might induce systemic resistance in the host plant, so it can better resist attack by a true pathogen;
- The bacteria might out compete other (pathogenic) soil microbes, e.g. by siderophores giving a competitive advantage at scavenging for iron; and
- The bacteria might produce compounds antagonistic to other soil microbes, such as phenazine-type antibiotics or hydrogen cyanide.

(Top) A banana plot in Srimulyo Village, showing healthy plants treated with Pf (right row) and untreated plants with symptoms of Fusarium wilt; *(Right)* PiFi, a locally-produced Pf agent, is used by farmers to treat their banana plants.

In Srimulyo Village, Koliadi explains that farmers generally apply the biocontrol Pf four times during banana cultivation. In the first application, Pf is mixed with the planting medium in polyethylene bags during the preparation of the planting material (sucker). The presence of beneficial microorganisms in the mix of organic matter in the planting medium serves as the initial 'capital' for the biocontrol agent, contributing to its effectiveness and persistence in the soil. The second application is given mixed with organic fertilizer and applied to the planting hole. In the third application, the Pf agent is injected directly into the one-month old banana plants in the field. When the plants are three months old, the last application of Pf is given by drenching and spreading the Pf agent on the soil around each of the plants. From the experiences of the farmers who implemented this control measure, they were able to obtain a bountiful harvest of fruits from the mother plant as well as from the first sucker.

Based on the results of using Pf as biocontrol agent against Fusarium wilt in Malang, the Indonesian Fruit Research Institute (IFRURI), the government agency tasked to implement the Fusarium wilt project in the country, is seriously considering including the technology as part of the package of best-bet disease management options that would be employed and evaluated in the demonstration plots in the two project sites in East Java and Lampung. It is hoped that this technology would present a cost-effective measure to control Fusarium wilt in Indonesia.

*- by **Dr Catur Hermanto**, Country Project Leader, Indonesian Fruit Research Institute (IFRURI).*

Announcement

Farewell to an institution

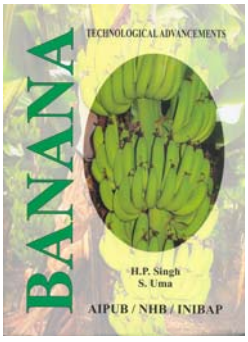
Ms. Versalynn N. Roa, Programme and Administrative Officer of Bioversity International's Asia-Pacific Office in the Philippines, has relegated her post after 17 years of dedicated and fruitful service to the organization. Considered as an "institution" in her own right, Vers, as she is fondly known to colleagues and friends alike, ended her colourful career with Bioversity effective 31 October 2007 to join her family in the United States. In recognition of her untiring service and achievements, spanning from the then International Network for the Improvement of Banans Plantain (INIBAP) until it became known as Bioversity International, Vers was conferred a "Special Pisang Raja Award" by the Banana Asia-Pacific Network (BAPNET) during its 5th Annual Steering Committee meeting held in Cambodia. Bioversity-AP also held a farewell and recognition dinner for her on 5 October 2007 at IRRI, Los Banos, Laguna.

During her tenure at INIBAP/Bioversity, Vers significantly contributed to the successful coordination, organization and conduct of BAPNET's annual Steering Committee meetings since its establishment in 1991as ASPNET. She has also actively participated towards the development and implementation of BAPNET's and Bioversity's information exchange and capacity building activities in the region. Additionally, she has significantly contributed to the documentation, completion and dissemination of 12 volumes of BAPNET meeting proceedings, a good number of training-workshop manuals and documents, and several issues of the Regional Information System for Banana and Plantain (RISBAP) Bulletin, Bioversity's official *Musa* R&D newsletter for Asia and the Pacific. Vers also served as the regional focal person for information exchange between the region and the global *Musa* Information and Documentation System of INIBAP. Through the years, she has also provided invaluable logistical and financial management support in coordinating and monitoring many BAPNET/Bioversity-AP collaborative projects.

Versalynn is known among colleagues for her commitment to INIBAP's practice of working with partners, and among friends for her her ever-pleasant personality and readiness to lend a helping hand.

Bioversity-AP and BAPNET wish her all the best in her future undertakings, and bid farewell to a dear friend and colleague.

Off-the-press



Singh, HP and S Uma (editors). 2007. Banana: Technological advancement. Association for the Improvement in Production and Utilization of Banana (AIPUB), National Research Centre for Banana, Trichy, India. 583pp.

The book is a compilation of the scientific presentations made during the Global Conference on Banana and Plantain held in Bangalore, India on 28-31 October 2002 and organized by the AIPUB on various themes including national and international status of banana and plantain, genetic resource management, breeding and biotechnology, production systems, nutrition and water management, pests and disease management, post-harvest management, product diversification, and trade and markets. It also covers techniques in interfacing with small-scale farmers to articulate their technological needs, as well as the strategic recommendations that emerged from the conference. It is envisioned that this compilation will contribute towards the fine-tuning of research, development and policy-formulation that would guide the Indian banana industry towards a brighter future. The book is produced in collaboration with the National Horticulture Board of India, the Agricultural and Processed Food Export Development Authority (APEDA), Small Farmers' Agribusiness Consortium (SFAC), the Indian Council of Agricultural Research (ICAR), Bioversity International - Asia-Pacific, and the Banana Asia-Pacific Network (BAPNET).

Copies could be obtained from AIBUP, c/o National Research Centre for Banana (ICAR), No. 44, Ramaling Nagar, South Extension, Vayalur Road, Trichy 620 017, India. Or email hpsingh@icar.org.in.

RISBAP - The Regional Information System for Banana and Plantain - is a regional mechanism to improve the dissemination, utilization and access to information on banana and plantain in Asia and the Pacific. The *RISBAP Bulletin* is published by Bioversity - Philippines. For article contributions or inquiries, write to us at: Bioversity - Philippines (formerly INIBAP-AP), c/o IRRI, Khush Hall, College, Laguna 4031 Philippines; Tel/Fax. (+6349) 5360532; E-mail: inibap.bapnet@cgiar.org; Web site: http://www.bioversityinternational.org

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