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BANANAS & PLANTAINS IN SOUTHEAST ASIA



INIBAP NETWORK FOR ASIA AND THE PACIFIC

The International Network for the Improvement of Banana and Plantain (INIBAP) was created in 1984. Its headquarters are in Montpellier, France. Regional networks have already been established in West and Central Africa, East Africa, Latin America and the Caribbean, and the Asian and Pacific regions.

The objectives of INIBAP are, as follows:

- to initiate, encourage, support, conduct, and coordinate research aimed at improving the productivity of banana and plantain;
- to strengthen national and regional programs and facilitate the interchange of improved and disease-free genetic material by assisting in the establishment and analysis of regional and global trials of new and improved cultivars;
- to coordinate and support the collection and exchange of documentation and information related to banana and plantain;
- to coordinate and support training for researchers and technicians from developing countries.

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International Network for the Improvement of Banana and Plantain

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Red Internacional para el Mejoramiento del Banano y el Plátano
Réseau International pour l'Amélioration de la Banane et de la Banane Plantain

BANANAS & PLANTAINS IN SOUTHEAST ASIA

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Commissioned by:

**International Network for the Improvement of Banana and Plantain
International Development Research Centre**

Funded by:

**Australian International Development Assistance Bureau
Australian Centre for International Agricultural Research**

INIRAP NETWORK FOR ASIA AND THE PACIFIC

1st printing 1990, Philippines

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ISBN 971-20-0165-2

Bibliographic Citation:

Valmayor, Ramon V.; Jones, David R.; Subijanto; Polprasid, Pairoj; and Jamaluddin, Siti Hawa. Bananas and plantains in Southeast Asia. Montpellier, France: International Network for the Improvement of Banana and Plantain, 1990.

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- | | | |
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Foreword

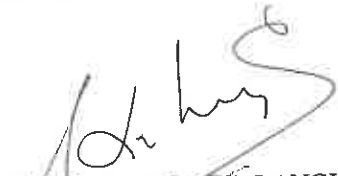
The International Network for the Improvement of Banana and Plantain (INIBAP) was established in November 1984 by a group of donor countries and organizations in answer to a growing concern over the neglect of the two crops and the alarming spread of diseases affecting them.

INIBAP was designed to work through regional networks established in regions where banana and plantain are crops of socioeconomic importance. These structured regional networks will conduct thematic research activities, keeping in mind both INIBAP's and the region's research priorities on banana and plantain. Regional networks are now in place in West and Central Africa, East Africa, and Latin America and the Caribbean.

In Asia, banana production is both complex and diverse. Of the total annual world production of 68 million tons, nearly 17 million are harvested in Asia. Moreover, being its center of origin, this region is the repository of a wide range of banana cultivars. It is for these reasons that INIBAP has proceeded cautiously in developing a research network in this region.

The first step was initiated during the 1986 Cairns Workshop on Banana and Plantain Breeding Strategies. This was followed by the consultative visits of the task force composed of regional scientists in 1988. This task force led by Dr. Ramon V. Valmayor, an INIBAP Board Member, visited the most important *Musa*-producing countries in the region to evaluate the present status of banana production and assess the prospects of regional coordination of R and D activities for the improvement of banana and plantain.

The Task Force report describing the status of banana agriculture in Southeast Asia is featured in this publication. It contains information on the importance of banana and plantain, commercial cultivars and germplasm collections, production systems, domestic marketing and export trade, postharvest technology, processing and utilization of these fruits, and effects of typhoons, drought, and other natural calamities on these crops in the different countries in Southeast Asia. This valuable document served as benchmark information for the succeeding activities geared towards the establishment of the INIBAP Network for Asia and the Pacific.



EDMOND A. L. DE LANGHE

Acknowledgment

The Banana Task Force members are grateful to the heads of the national research systems and research agencies of Indonesia, Malaysia, Thailand, the Philippines, and Australia for nominating and permitting their senior officials to contribute to the accomplishment of the Task Force's mission. We also extend our sincere gratitude to these officials, as well as to the staff of the various institutions visited, for their gracious hospitality, sincere cooperation, and warm encouragement.

We likewise acknowledge the valuable contributions of the following PCARRD staff:

Ester L. Lopez, Mildred M. Burgos, Joselito A. Payot, and Tita A. Raynera for helping in the preparation of this report;

Salud B. Geronimo, Bethilda E. Umali, and Pura J. Lastimosa for their editorial assistance; and Eduardo V. Oro and Simeon R. Manahan for the cover design.

Most of all, we are grateful for the valuable vision of INIBAP, which sponsored the mission to Southeast Asia, and for the support provided by ACIAR, AIDAB, and IDRC; for with them our job was no drudgery and without them our labor would have been in vain. Like our commitment to the tasks ahead, our gratitude is deep-rooted and far-reaching.



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Bananas and Plantains in Southeast Asia

Introduction

The great importance of bananas and plantains as staple items of diet among the poor populations of Southeast Asia has long been recognized. The significant complementary role of bananas in smallholder cropping systems is also well established. However, the relative ease of growing these crops and the certainty of realizing decent yields following traditional low-input production systems led to their neglect by many agricultural research and development institutions.

Recent developments in the field have contributed to a change in attitude among researchers and research administrators. The emergence of virulent forms of diseases in Southeast Asia and the South Pacific, and their rapid spread to Latin America and Africa, now threaten the production of bananas and plantains in many developing countries of the tropical world.

Small and commercial banana farms are suffering from the devastating effects of Black Sigatoka and banana bunchy-top virus. These have alarmed several scientists and research managers worldwide. Suddenly, banana production and the control of banana diseases have become priority research areas. Many research and development programs have been prepared but their implementation is slow. Funds, research manpower, and facilities are insufficient in most developing countries.

It recently became evident that pooling of resources and complementation of efforts are essential to solve common problems among poor nations. Thus, INIBAP (International Network for the Improvement of Banana and Plantain) was established with headquarters in Montpellier, France. INIBAP's mandate includes coordination of research efforts, dissemination of research information, and generation of funds to

support priority research and development activities on bananas and plantains.

In recognition of the complexity of problems affecting banana and plantain production in the various tropical regions of the world, and to ensure relevance and flexibility in its program thrusts, INIBAP decided to set up regional networks in Latin America and the Caribbean, West and Central Africa, and East Africa. Each regional organization will determine its priority research and development programs.

The first two regional networks are now operational and the East African network will soon be activated. Through the initiatives of INIBAP/IDRC and AIDAB/ACIAR, the Southeast Asian Banana Task Force was organized to evaluate the present status of banana agriculture in the region and assess the prospects of regional coordination of activities on banana improvement.

Importance of Bananas and Plantains in Southeast Asia

Southeast Asia is the center of origin of bananas. Banana production has a long history in the region and banana remains as its most important fruit. It is the most widely grown fruit commodity in the Philippines, Thailand, and Indonesia and ranks second only to rambutan in Malaysia (Table 1).

Table 1. Areas planted to major tropical fruits in Southeast Asia.*

Country	Fruit	Area (ha)	Rank	%
Philippines	Banana	331,440	1	62
	Pineapple	60,070		
	Mango	41,280		
	Others	99,250		
Thailand	Banana	208,300	1	28
	Mango	163,490		
	Pineapple	127,840		
	Others	248,410		
Indonesia	Banana	170,410	1	35
	Mango	77,390		
	Citrus	66,230		
	Others	176,270		
Malaysia	Rambutan	15,550	2	19
	Banana	14,000		
	Durian	13,500		
	Others	36,000		

*Asian Productivity Organization 1985.

In terms of production volume, banana outranks all other tropical fruits of the region. Its big production volume and nonseasonal fruiting habit make banana an important item of domestic trade. An interesting information item in the *FAO Production Yearbook* (1986a) is the significant volume of banana production in Vietnam (Table 2).

To date, very little is known about banana germplasm resources, commercial cultivars, pest problems, as well as banana research and development projects in Vietnam. With peace now a possibility in Indochina, more contacts with Vietnam must be attempted through the Food and Agriculture Organization (FAO).

Table 2. Banana production in Southeast Asia (1,000 t).*

Country	1984	1985	1986
Philippines	3,851	3,705	3,821
Indonesia	2,759	1,700	1,900
Thailand	1,545	1,580	1,596
Vietnam	1,200	1,300	1,381
Malaysia	475	477	480
Burma	363	370	370
Kampuchea	84	92	93
Laos	13	15	16
Brunei	1	1	1

*Food and Agriculture Organization 1986a.

Plantains, which belong to a special group of cooking bananas, command premium prices in many local markets of Southeast Asia, particularly in Java. However, in spite of its attractive prices, farmers are hesitant to grow plantains due to their high susceptibility to pests. Because of problems with plantains, selection has resulted in the popularization of cooking banana cultivars belonging to the Saba and Pisang Awak groups which are resistant to pests, hardy against drought, and highly productive.

Although banana is grown primarily for domestic markets, the Philippines, Malaysia, and Thailand also export the fruits. Thailand exports bananas to Hongkong and Singapore but is facing serious competition. Malaysia supplies bananas to Singapore and is developing an export market for its exotic Pisang Mas in Europe.

The Philippines is a major banana-exporting country and devotes more than 21,000 ha to Giant Cavendish, Grande Naine, and Umalag for international trade. It is the major supplier of banana to Japan and the Middle East and is expanding its markets in China, Korea, Hongkong, and New Zealand. The banana export industry contributes some US\$120 million annually to the Philippine economy. Table 3 presents the volume and value of banana exports of Southeast Asia.

Table 3. Volume and value of banana exports of Southeast Asia.*

Country	Volume (t)			Value (US\$ 1,000)		
	1984	1985	1986	1984	1985	1986
Philippines	800,271	789,994	855,143	122,996	114,291	130,222
Malaysia	33,628	27,158	58,955	2,358	2,309	2,558
Vietnam	8,000	8,000	8,000	1,200	1,450	1,500
Thailand	4,403	3,987	2,000	974	839	500

*Food and Agriculture Organization 1986b.

Commercial Cultivars and Major Banana Germplasm Collections in Southeast Asia

Commercial cultivars. Southeast Asia is the center of diversity for bananas. The region possesses the greatest wealth of banana germplasm and has contributed practically all the commercial banana cultivars of the world. In city and village markets in the region, the consumers are offered a wide selection of dessert and cooking bananas. Commercial and exotic cultivars vary from country to country; in fact, preferences differ in different areas within a country.

Cultivar selection has been based on productivity, consumer preference, adaptability to local growing conditions, transport and handling qualities, and resistance to pests and diseases. The important commercial cultivars in Southeast Asia are presented in Table 4.

Germplasm collections. Every country in Southeast Asia has demonstrated great interest in banana germplasm conservation and utilization. Indonesia, Malaysia, Thailand, and the Philippines cooperated actively with the International Board for Plant Genetic Resources (IBPGR) in the collection, characterization, performance evaluation, and conservation of banana germplasm materials.

The banana exploration missions undertaken by national scientists and funded by IBPGR assembled large accessions of local banana varieties collected in the four countries of Southeast Asia. These valuable germplasm banks supply information and propagation materials in support of banana improvement projects of the national research and development systems.

Regional cooperation has a good performance record in Southeast Asia. Through the auspices of the Southeast Asian Plant Genetic Resource Committee, a Regional Banana Germplasm Resource Center was established in Davao, Philippines. This regional banana germplasm bank holds a duplicate accession of the national collections from the four countries of Southeast Asia (Appendix A). In assembling the regional banana germplasm collection, known synonyms of

Table 4. Important commercial banana cultivars of Southeast Asia.

Country	Domestic Market		Export Market
	Dessert varieties	Cooking varieties	
Philippines	Lakatan	Saba	Giant Cavendish Grande Naine Umalag Señorita
	Latundan	Sabang Puti	
	Buñgulan	Turangkog	
	Inarnibal	Matavia	
	Amas	Tindok*	
Indonesia	Morado	Laknau*	Pisang Mas
	Pisang Ambon	Pisang Tanduk*	
	Pisang Raja Sereh	Pisang Oli	
	Pisang Raja**	Pisang Nangka*	
	Pisang Barangan	Pisang Kosta	
Malaysia	Pisang Mas	Pisang Kepok	Pisang Awak Pisang Raja** Pisang Nangka* Pisang Tandok* Pisang Abu
	Pisang Susu		
	Pisang Mas		
	Pisang Rastali		
	Pisang Embun		
Thailand	Pisang Berangan		Kluai Hom Thong
	Pisang Masak Hijau		
	Pisang Lemak Manis		
	Kluai Hom Thong	Kluai Namwa**	
	Kluai Khai	Kluai Hakmuk	
	Kluai Lep Mu Nang	Kluai Lep Chang Kut	

* Plantain.

** Eaten fresh or cooked.

Philippine cultivars were not introduced to Davao. Only distinct accessions were collected from the national banana germplasm banks of Indonesia, Malaysia, and Thailand.

Recently, duplicates of the large and very valuable banana collection in Laloki, Papua New Guinea were also introduced to the Philippines. The major banana germplasm collections in Southeast Asia are presented in an updated listing below. The following list and those presented in Appendices A to D exclude synonyms and represent distinct cultivars.

Philippines

1. Southeast Asian Banana Germplasm Resource Center
Bureau of Plant Industry, Department of Agriculture,
Bago-Oshiro, Davao City*

*Details are presented in Appendix A.

Curator/Person In Charge	:	Mr. Orlando C. Pascua	
A. Philippine Banana Accessions	:		80
1. Acuminata cultivars	:	43	
a. Diploid, AA	:	18	
b. Triploid, AAA	:	25	
2. Acuminata x Balbisiana hybrids	:	26	
a. AAB	:	16	
b. ABB	:	9	
c. ABBB	:	1	
3. Balbisiana cultivars	:	10	
a. Diploid, BB	:	1	
b. Triploid, BBB	:	9	
4. Unclassified	:	1	
B. Malaysian Accessions	:		29
C. Thai Accessions	:		35
D. Indonesian Accessions	:		16
E. Papua New Guinea Accessions	:		148
F. <i>Musa</i> Species and Related Genera	:		10
1. <i>Musa</i>	:	9	
2. <i>Ensete</i>	:	1	
II. U.P. at Los Baños Banana Gene Bank University of the Philippines at Los Baños, Laguna*			

Curator/Person In Charge: Dr. Rene Rafael C. Espino

The U.P. at Los Baños collection holds a complete duplicate of the Davao banana germplasm bank. Losses in one varietal collection are routinely replenished with materials from the other.

Quarantine restrictions: Materials must pass through quarantine. Import permit from the receiving country is required.

Availability for exchange: These are freely available on exchange basis; export of commercial cultivars is restricted.

Evaluation: Evaluation of Philippine cultivars is carried out on horticultural characteristics,

Documentation:

genome composition, cytology, and reaction to pests and diseases.

Most of the Philippine cultivars have been classified and described by Valmayor, R.V., et al. (1981) in *Philippine Banana Cultivar Names and Synonyms* (IPB Bulletin No. 3, U.P. at Los Baños).

Thailand

- I. Kasetsart University, Pak Chong Student Training Farm, Nakhon Rachasima *

Curator/Person In Charge: Ms. Benchamas Silayoi

A. Thai Banana Accessions	:		39
1. Acuminata cultivars	:	17	
a. Diploid, AA	:	9	
b. Triploid, AAA	:	8	
2. Acuminata x Balbisiana hybrids	:	21	
a. AAB	:	10	
b. ABB	:	10	
c. ABBB	:	1	
3. Balbisiana cultivars	:	1	
a. Triploid, BBB	:	1	
B. <i>Musa</i> Species and Related Genera	:		10
1. <i>Musa</i>	:	3	
2. Acuminata sub-species	:	5	
3. <i>Ensete</i>	:	2	

- II. Tha Chai Horticultural Experiment Station, Department of Agriculture.

Curator/Person In Charge: Aroonpairot

No. of accessions: 60, unclassified.

Quarantine restrictions: Materials must pass through quarantine.

Availability for exchange: Accessions are freely available.

* Details are presented in Appendix A.

* Details are presented in Appendix B.

Evaluation: These are freely evaluated, cytological studies carried out, and genome composition determined.

Documentation: These are fully documented by Silayoi and Babprasert (1983) in *Banana Genetic Resources Exploration in Thailand* (Kasetsart University, Bangkok).

documented by S. H. Jamaluddin (1986) in *Characterization, Evaluation, and Utilization of Banana Germplasm in Malaysia* (pp. 315-329. Prosid. Simp. Buahbuahan Keb., Serdang).

Malaysia

Malaysian Agricultural Research and Development Institute (MARDI) Serdang, Malaysia*

Curator/Person In Charge	:Ms. Siti Hawa Jamaluddin	
A. Malaysian Banana Accessions	:	54
1. Acuminata Accessions	:	30
a. Diploid, AA	:	15
b. Triploid, AAA	:	15
2. Acuminata x Balbisiana hybrids	:	20
a. AAB	:	12
b. ABB	:	6
c. ABBB	:	2
3. Balbisiana cultivars or Acuminata x Balbisiana hybrids	:	4
BBB/ABB	:	4
B. <i>Musa</i> Species and Related Genera	:	8
1. <i>Musa</i>	:	7
2. <i>Ensete</i>	:	1

Quarantine restrictions: Restrictions for import are stringent, especially from Latin America for fear of introducing rubber diseases.

Availability for exchange: These are available on exchange basis.

Evaluation: These are fully evaluated on horticultural characters.

Documentation: The collection is fully

Indonesia

I. Center for Research and Development in Biotechnology, Banana Germplasm Collection, Cibinong*

Curator/Person In Charge : Mr. Endi Ruhendi

A. Indonesian Banana Accessions	:	35
1. Acuminata cultivars	:	18
a. Diploid, AA	:	9
b. Triploid, AAA	:	9
2. Acuminata x Balbisiana hybrids	:	15
a. AAB	:	9
b. ABB	:	6
3. Balbisiana cultivars	:	2
a. Triploid, BBB	:	2
B. <i>Musa</i> Species	:	2
1. <i>Musa acuminata</i>	:	1
2. <i>M. balbisiana</i>	:	1

II. Purwodadi Botanical Garden, National Biological Institute*

Curator/Person In Charge: Dr. Soejono

No. of Accessions: 59 cultivars of bananas and plantains, unclassified.

III. Bogor Botanical Garden, National Biological Institute**

Curator/Person In Charge: Dr. Rusdy Nasution

* Details are presented in Appendix D. Classification by genome is preliminary. Banana accessions of Purwodadi Botanical Garden are also shown in Appendix D.

** The Bogor Botanical Garden specializes in wild *Musa* species.

* Details are presented in Appendix C.

List of Accessions

- | | |
|-----------------------------------|-----------------------------|
| 1. <i>Musa acuminata</i> | f. <i>cerifera</i> Backer |
| | f. <i>rutilifera</i> Backer |
| | f. <i>acuminata</i> Backer |
| 2. <i>M. halabanensis</i> Meijer | 7. <i>M. zebrina</i> Houtte |
| 3. <i>M. sumatrana</i> Becc. | 8. <i>M. ornata</i> Roxb. |
| 4. <i>M. salaccensis</i> Zoll. | 9. <i>M. coccinea</i> |
| 5. <i>M. lolodensis</i> Cheesman | 10. <i>M. velutina</i> |
| 6. <i>M. banksii</i> F. v. Muell. | |

Quarantine restrictions:	Materials must pass through quarantine.
Availability for exchange:	All are freely available.
Evaluation:	Evaluation is in progress.

Production Systems

Banana production in Southeast Asia can be categorized basically into four systems. These are the backyard production system, mixed-crop production system, commercial smallholder production, and corporate farms or agribusiness plantations. Among the four production systems, backyard production is the most commonly observed in Southeast Asia because of the ease of establishment and availability of area around the farmhouse.

In the backyard production system, the growers produce bananas primarily for home consumption. The choice of cultivars grown is dictated by family requirements (i.e., dessert or cooking), quality preferences of the household members, prevalence of pests and diseases, climatic conditions, and ease of production.

Backyard production does not require cash outlays as labor is supplied entirely by family members. No commercial fertilizers or pesticides are applied; only compost and animal manure are used.

As a component of a systematic mixed-crop production system, banana can be a primary crop or a secondary crop, a permanent crop or a temporary crop. As commonly practiced in Indonesia, Malaysia, Thailand, and the Philippines, banana is planted to serve as a nurse crop to shade-loving plants such as young cacao, coffee, black pepper, nutmeg, etc. In some cases, it is planted under a primary crop.

In the Philippines, where there are vast areas planted to coconut, it is a natural consequence to utilize the area under rows of coconut by planting other crops. Banana is one of the popular choices; since it is relatively easy to grow and provides both food and cash requirements for the household. In Thailand, bananas are sometimes planted in established mango orchards.

In Malaysia and Southern Philippines where plantation crops are extensively grown, banana is raised as a temporary intercrop to the young rubber trees and oil palms. Banana serves as an early source of

cash income while the permanent crops are still growing. However, once the primary crops are established or when banana interferes with the growth of the primary crop, it is cut and taken out of the area.

Banana is also planted together with other perennial and annual crops in an almost unlimited combination. Among the crops planted in combination with banana are coffee, cacao, papaya, citrus, lanzones, rambutan, coconut, cloves, cassava, pineapple, ginger, gabi, corn, mungbean, bush bean, sweet potato, and many vegetable crops.

In some parts of the Philippines, like Cavite Province in southern Luzon, mixed production schemes have developed into a crop production technology in which the cropping pattern and distance of planting crops are identified (Figure 1).

Another type of production system which is commonly practiced in Southeast Asia is the commercial smallholder plantation where banana is grown as a monocrop in areas ranging from 2 to 20 ha. This production system proliferates near centers of population where market demand for this fruit is strong and sustained.

The choice of varieties to grow is limited by consumers' preferences and suitability to the prevailing agroclimatic conditions of the location. Management practices employed include fertilizer application, weeding, replanting, and pest control but these are done less extensively as in agribusiness plantations.

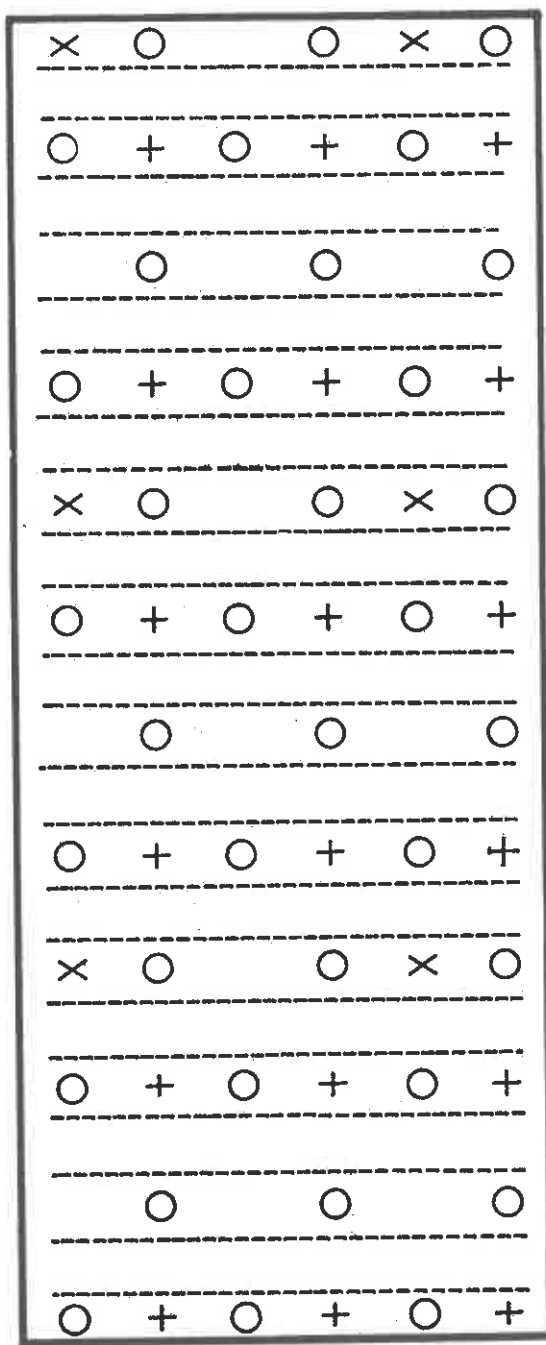
Large commercial banana plantations that grow fruits for the export markets are also found in Southeast Asia, specifically in the Philippines. Recently, Malaysia's commercial plantations are turning their attention to this crop and may pursue establishing banana agribusiness plantations. In Indonesia and Thailand, big banana plantations are currently nonexistent.

The Philippines' modern plantations cater to the exacting requirements of the banana export trade. The enterprise is capital-intensive and involves heavy investment in plantation infrastructure such as roads, packinghouses, airstrips, piers, and residential and service buildings. Production practices are applied at optimum levels and yields are high. Quality of the produce is of primary consideration.

Domestic and Export Markets

Domestic market. The domestic markets of Indonesia, Malaysia, Thailand, and the Philippines absorb most of their banana produce; although the Philippine export trade gets a significant proportion of about 20% of the country's total banana output.

In general, the domestic marketing channels of the four countries of Southeast Asia follow similar market flows. Schematically, it is presented in Figure 2.



Legend:

- O - coffee (3 m x 3 m). + - papaya (3 m x 3 m).
- X - banana (6 m x 6 m). : - pineapple (100 cm x 30 cm).

Figure 1. Coffee + banana + pineapple intercropping pattern, Silang, Cavite, Philippines

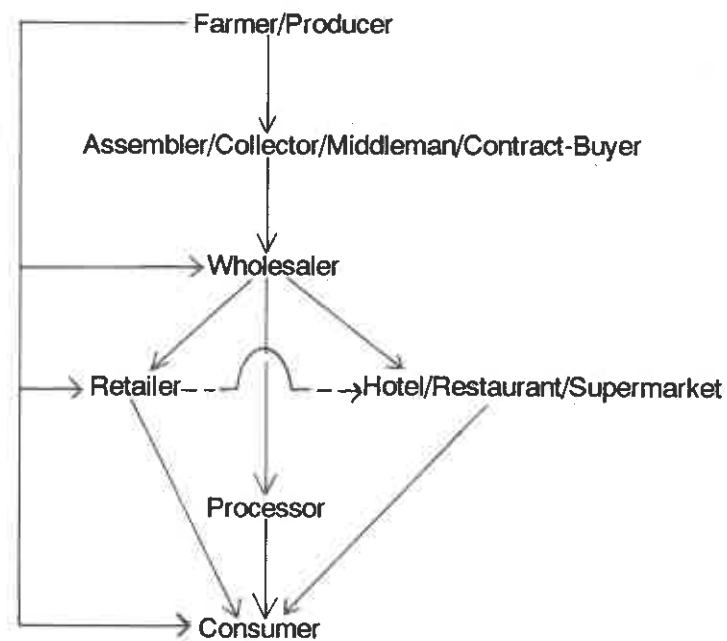


Figure 2. Domestic market channels for banana in Southeast Asia.

From the farmer, banana can go to any of the following outlets. It may go directly to the consumer if the farmer decides to sell his produce in the local market. Such a case is the simplest mode of market flow. The produce may also go to the assembler/collector/middleman/contract-buyer, wholesaler, or to the retailer. The point of marketing contact with the farmer determines the complexity of the marketing system.

A common feature in the Southeast Asian domestic marketing system which is worth mentioning is the presence of the assembler/collector. This is a logical consequence of the proliferation of small farms involved in banana production. Since transporting bananas in small volumes to the towns or cities is an added burden to the farmers/producers in terms of time and expense, they opt to sell their produce to the assembler/collector who in turn sells the produce to the wholesalers. Subsequently, the wholesaler caters to the retailers,

processors and hotels, restaurants, and supermarkets. At the end of the line is, of course, the consumer.

Export market. Among the Southeast Asian countries, only the Philippines has a significant fresh-banana export trade. Malaysia and Thailand have a modest volume of export trade mainly with Singapore and Hongkong. On the other hand, Indonesia has apparently not made any concerted effort to develop banana into a potential dollar-earner since World War II.

Large-scale banana producers in the Philippines export their products through the multinational fruit firms. Although a few of these producers export on their own, the majority of the producers of large-scale banana plantations have tie-ups in the form of production and marketing contract arrangements. The local producers are responsible for production while the multinationals are in charge of marketing the commodity. The arrangement assures the local grower with technical and financial assistance from these multinational companies.

STANFILCO (Standard Fruit Corporation, Philippines), the longest established banana export company with the biggest area planted, operates mainly through independent producers divided into growers with an average of 8-10 ha of banana. STANFILCO buys from growers at a certain rate per CWT (hundred weight) of fruit delivered to packinghouses which it operates, and sells at F.O.B. (free on board), excluding cost of cartons, to Standard Fruit (Japan) which bears the freight cost plus cost of the imported cartons.

Del Monte, on the other hand, has contracted local companies operating on a plantation scale. Del Monte buys F.O.B. (excluding cost of cartons) and also transfers F.O.B. to its Japanese affiliate which pays for freight and cartons.

This arrangement is similar to that of United Fruit which has entered into a purchase contract with TADECO (Tagum Agricultural Development Corporation), a Filipino corporation. It buys from TADECO on a cost-and-freight basis. United Fruit (Japan) provides and pays for the cartons and TADECO acts as producer and exporter.

Davao Fruits Corporation, Hijo Plantation, and Twin Rivers Plantation (DAHITRI) are the only Filipino-controlled producers and exporters of bananas. DAHITRI handles about 20% of the Philippine banana-export industry. The remaining 80% is almost equally divided among the three multinational corporations.

The selling system of Japan is on consignment basis, wherein the multinational takes the trading risk up to a certain point in the distribution system. They also take the risk of fruit rejection at the Port of Destination by the importer. Ripening, rotting, and fruit damage can cause rejection of the shipment.

Figure 3 shows the multilayered distribution system in the Japanese market, Japan being the largest importer of Philippine

bananas. The grower-exporter grows and packages the product while the multinational firm ships and sells the fruits to the export market. The importer receives the shipment, distributes the banana fruits to the dealers, and arranges quarantine, customs, and unloading requirements.



Figure 3. Multilayered distribution system of bananas for the Japanese market.

The wholesaler-dealer negotiates the selling price of the shipment (port price) with the ripeners who store and ripen the fruits for distribution to the retailers. The retailers in turn sell the fruits to the consumers.

In some cases the importer can also be a wholesaler-dealer, and a wholesaler-dealer can at the same time be a ripener.

Postharvest Handling Technology

Postharvest handling technology employed for banana in Southeast Asia ranges from simple to sophisticated.

Commercial banana plantations geared for the fresh-fruit export market, such as those in the Philippines, practice a set of systematic postharvest handling procedures. These are undertaken in a packinghouse where bunches of bananas are taken after having been carefully transported from the field. The postharvest handling procedures include deflowering or removal of dried floral parts at the distal portion of the finger, dehanding, washing and sorting, fungicide treatment to control crown and finger rotting, labelling, and packaging.

Quality control and grading are undertaken at several stages throughout the packaging operations. The fruits are carefully inspected, placing emphasis on physical appearance. Overmature, undersized, oversized, and blemished fruits are sorted out and discarded.

On the other hand, small-scale farmers usually dehand harvested banana right in the field with a bolo or knife. In some cases, bunches are taken to a place designated by the assemblers where the bunches are dehanded. Defective and mechanically damaged fingers are removed at this point. There is no effort to control postharvest diseases.

Washing of fruits depends on the availability of water. In Thailand, the fruits are submerged in canal water. Sorting is also practiced. Big hands are separated for the domestic market while small hands are set aside for family consumption or livestock feed.

Bananas for export are labelled, neatly packed in boxes, and are kept under low temperature, modified atmosphere storage, or combined low temperature and modified atmosphere storage. For the domestic market, bananas are transported in a wide variety of materials such as jute sacks, bamboo baskets, cardboard boxes, or simply piled in trucks, carts, jeepsneys(Philippines), or boats (Thailand).

Handling of bananas for the domestic trade, however, is not always done in small scale. The assemblers/collectors who play an important role in local banana marketing in Southeast Asia usually handle bananas in bulk. Bulk handling of banana produced and harvested in different farms presents peculiar postharvest handling problems for the assemblers/collectors. This is due to the fruit's exposure to a variety of preharvest conditions and the farmer's different perceptions of harvest maturity indices, thus resulting in a mixture of fruits of various quality and maturity. Research in bulk handling of banana is currently being undertaken.

Hastening the ripening of fruit is practiced both at the commercial and small-farm level. The use of calcium carbide (CaC_2) as a source of acetylene (C_2H_2) is commonly resorted to by small banana growers because of its low cost and availability. Some commercial farms practice dipping in or spraying with ethephon or Ethrel. Another method used is the introduction of ethylene gas into a temperature-controlled room containing boxes of bananas. The temperature inside the box is maintained at 20°C .

Postharvest diseases of banana commonly encountered in Southeast Asia are crown and finger-stalk rot and black-end diseases. They cause significant losses in the domestic banana trade because of poor postharvest handling by the small and backyard growers. Moreover, the small banana growers are not directly concerned about postharvest diseases since they usually sell their produce right after harvest and therefore seldom encounter this problem. The retailers usually face losses from fruit rotting, but recover these by increasing the price of the relatively blemish-free bananas for sale.

In commercial plantations, postharvest diseases are a constant threat to the maintenance of high-quality produce; but these are not considered problems because of the high-input preharvest and postharvest handling technologies being employed to prevent their occurrence. The preventive measures practiced are washing and disinfecting dehanded fruits in wash tanks containing 10 ppm chlorine and treating fruits with a recommended fungicide.

Processing and Utilization

Unlike other major fruit crops such as pineapple, orange, grape, and apple, the bulk of the banana produced for the world market does not undergo processing. The reason is that banana is mainly traded in fresh form and consumed as such. However, plantains and cooking bananas, which form a large portion of total production, are cooked just prior to consumption. The world market reflects the Southeast Asian situation where a relatively small volume of total production goes to the processing sector. Nevertheless, a number of food products are produced from this small volume.

The two most important processed food products from banana are banana chips and dried bananas or banana figs. Mainly derived from plantains and starchy bananas, such as Saba, banana chips are popular snack items in Southeast Asian countries. The Philippines exports banana chips to Europe, Japan, Canada, and the United States of America. On the other hand, banana figs are preferred processed food products in Thailand. Banana chips and dried bananas are also available in Indonesia and are being developed for export.

Other major food products derived from banana are banana catsup and processed baby food. Banana catsup is popular in the Philippines; probably even outranking tomato catsup, since it is much cheaper than

the latter. The high digestibility and substantial mineral and carbohydrate contents of the banana make it a suitable raw material for baby food.

Among the intermediate food products from banana, banana puree, flour, and powder exhibit a growing demand in the world market. Banana puree, which is derived from Giant Cavendish alone or in combination with Saba, is used in various food preparations. The processing of banana into puree form is costly and requires sophisticated equipment; but it can absorb excess production, particularly of the Giant Cavendish banana.

Also derived from fully ripe Giant Cavendish or Saba, banana powder is used as the primary base for the preparation of banana catsup. It is also used as flavoring and additive.

Other minor food products from banana available in Southeast Asian markets are canned banana slices mixed with other fruits (fruit cocktail), jam, wine, and vinegar.

In addition to its uses in processed food preparation, banana is also utilized as feed for livestock. Both the fruit and the pseudostem are used for this purpose. In backyard farms of Thailand and the Philippines, the pseudostem of banana is chopped and fed to pigs and cattle. Rejected unripe or ripe fruits are also fed to livestock. In commercial large-scale farms in the Philippines, part of the Giant Cavendish banana rejects is converted to animal feeds. The utilization of bananas as feed for broilers is also being investigated.

Some of the potential uses of banana which are being explored by Southeast Asian countries are the production of ethyl alcohol from pulp and peel; dye, biogas, charcoal, floor wax, shoe polish, and paste from peel; cork board, paper, and dye from corm and true stem; paper and dye from leaves; and fiber from pseudostem.

Pest Incidence

The occurrence of pests and diseases poses a major constraint to banana production in Southeast Asia, the center of origin of banana. The problem may be more pronounced in the region since a number of pests and diseases have co-evolved with the crop. The emergence of virulent forms of diseases in this part of the globe and their rapid spread to other countries now threaten world production of bananas and plantains.

Sigatoka diseases. The Sigatoka leaf spot and black leaf streak are caused by two related fungal pathogens, namely: *Mycosphaerella musicola* Leach ex. Mulder and *M. fijiensis* Morelet. A new disease, Black Sigatoka, observed to be closely similar in symptoms and virulence to Sigatoka disease is caused by *M. fijiensis* var. *difformis* Mulder and Stover.

In Indonesia, both forms of Sigatoka disease are present: Yellow Sigatoka which affects susceptible varieties in areas of high rainfall in Western Indonesia, such as in the hills of West Java; and Black Sigatoka which is present in Eastern Indonesia. The diversity of cultivars grown in these areas minimizes the problem caused by these diseases.

In Malaysia, Yellow Sigatoka is an important disease affecting Pisang Berangan and Pisang Mas; however, the extent of its damage is considered to be tolerable at present. Similarly, in Thailand the disease does not cause too much damage even to susceptible varieties, such as Kluai Hom Thong and Kluai Khai.

However, the situation is not as good in the Philippines. Both Yellow and Black Sigatoka are present, the latter causing serious damage. In Mindanao, the Black Sigatoka problem is so serious in commercial Cavendish cultivars that aerial spraying of fungicides is essential and is done at an average of 30 times a year to control the disease. However, no spraying of backyard and small-scale plantations is undertaken. The dessert varieties, Lakatan and Bungulan, are very susceptible to Black Sigatoka; but Latundan and the popular Saba and Cardaba cooking types are resistant.

These diseases are kept under control in commercial plantations by the use of fungicides and other cultural practices such as maintaining optimum plant population, upkeep of drainage canals, and removal of sources of inoculum.

Panama and Moko diseases. Fusarium wilt or Panama disease caused by *Fusarium oxysporum* f. sp. *cubense* and bacterial wilt or Moko caused by *Pseudomonas solanacearum* (race 2) are two of the most destructive field diseases of banana.

Panama disease is a very serious problem in Malaysia, Thailand, and the Philippines. It is also considered a major disease in Indonesia, particularly in Java.

It has affected Pisang Rastali and Pisang Embun in Malaysia so much that local supplies of these bananas have decreased in the past years. Recently, an outbreak of Panama disease in Pisang Mas plantations near Melaka was reported. Since Pisang Mas is supposedly resistant to *F. oxysporum* f. sp. *cubense* (race 1), a new strain of the pathogen is thought to be the cause of the outbreak. However, culture samples sent to Dr. S. C. Hwang in Taiwan revealed that the pathogen is not race 4 but closer to race 1.

Recognized as the most serious disease in Thailand, Panama disease affects Kluai Namwa, one of the three most important cultivars. Losses are believed to be high.

In the Philippines, Panama disease is a major limiting factor in the commercial production of Latundan, Pitogo, and Lakatan. The pathogen is believed to be race 1, but race 2 has also been identified to

attack Latundan. Cavendish varieties are usually resistant to the disease, but some plants in poorly drained areas have become affected.

Moko is a serious problem only in the Philippines, specifically in Mindanao, where commercial plantations have been established. Affected cultivars are Cavendish types, Latundan, Lakatan, Morado, Amas, and Saba. Strict sanitation measures reduce the incidence of the disease.

Indonesia reports a major disease caused by the bacterium *Pseudomonas celebensis*. It is called blood disease because of red exudates from cut pseudostems and is considered as the most serious threat to banana production in Indonesia, particularly in Sulawesi. Recently, reports indicate that the disease is now present in West Java. The bacterium responsible for the disease is persistent in the soil and is believed to invade the roots of susceptible cultivars. Another bacterial disease caused by a *Pseudomonas* sp. which is different from the Moko and blood disease pathogens is also present in Java.

Viral diseases. Banana bunchy-top virus (BBTV) is considered a major disease in Indonesia and the Philippines. Its presence in Malaysia and Thailand has not been substantiated. In Indonesia, BBTV was first recorded near Bandung in West Java in 1978 and is now believed to be present in the Bogor area. It has also been reported in Bali, Irian Jaya, and West Kalimantan. The spread of the disease is considered a problem and, if uncontrolled, the virus could devastate banana cultivation in Indonesia.

Bunchy-top and mosaic diseases are widely spread among the existing banana cultivars and plantains in the Philippines. BBTV is present in Mindanao and Luzon, both in backyard and commercial plantations. There is an ambitious program to rogue all diseased plants and replant with virus-free materials produced through tissue culture.

Infections of cucumber mosaic virus (CMV) are also commonly observed. Recently, a disease caused by bract mosaic virus (BMV) has been identified. Saba and Cardaba cooking bananas are commonly affected, but most cultivars including wild *Musa balbisiana* seem susceptible. The disease can reduce yields by 40%.

BBTV, CMV, and BMV have been observed in the Southeast Asian Banana Germplasm Resource Center at Davao and in other collections at Los Baños. The favorable conditions for their transmission and spread are the cause of a growing concern for the survival of the regional banana gene pool in the Philippines.

Insect pests. All commercial banana varieties are prone to insect infestation. In the Philippines, the most important insect pests of banana are the thrips (*Thrips florum* Schmutz), mealybug (*Dysmicoccus* sp.), aphid (*Pentalonia nigronervosa* Coquerel), corm weevil or borer (*Cosmopolites sordidus* Germar), and scarring weevil (*Philicoptus iliganus* Heller). Other insect pests such as banana leaf roller

(*Pilopidas thrax* L.), scale insects (*Aspidiotus destructor* Sig., *Abralaspis palmae* Cock), and bagworm (*Eumeta fuscescens* Snell) are considered minor pests. Control measures for the major pests have been formulated.

In Indonesia, Malaysia, and Thailand, the banana weevil (*Cosmopolites sordidus*) and pseudostem borer (*Odoiporus longicollis*) are identified as the most destructive pests. *C. sordidus* is a major problem in the humid areas of Indonesia, such as in West Java and the highlands. Insecticides are not used to control insect pests but corm sections infested with borers may be destroyed.

In Malaysia, borers are controlled by insecticides. There is little information regarding losses caused by the borers in Thailand but damage was high in one small commercial plantation visited. For control, the use of clean planting materials and soil treatment are followed.

Banana leaf roller (*P. thrax* L.) and scab moth (*Nacoleia octosema*) are also considered serious pests in Indonesia and Malaysia. Some research on the biological control of leaf rollers are being undertaken in Indonesia.

Nematodes. The burrowing nematode (*Radopholus similis*) is most destructive in Giant Cavendish plantations in Mindanao, Philippines. It is mostly controlled by using clean planting materials and nematicides. Several cultivars such as Amas, Galamay Señora, Katsila, Manang, Tanggung, Tiparot, Saba, Cardaba, Katali, Inabaniko, Binaliw, and Siusok are reportedly resistant.

The use of biological control agents such as the fungus *Paecilomyces lilacinus* is promising. This measure can also be used to control the root-knot nematodes (*Meloidogyne incognita*, and *M. arenaria*) which are widely distributed and affect Cavendish cultivar, Saba, Cardaba, Latundan, and Lakatan. Resistant varieties are Alaswe, Dakdakan, Pastilan, Pogpogon, Paa Dalaga, and Viente Cohol. Spiral nematode (*Helicotylenchus* spp.), lesion nematode (*Pratylenchus* spp.), and reniform nematode (*Rotylenchulus reniformis*) are also observed in some banana plantations.

In Indonesia, damage caused by the burrowing nematode is considered serious because it predisposes the plants to disease infection.

Nematodes are controlled in Malaysian plantations by treating all propagating materials with formalin and applying Furadan to planting holes.

Growing Bananas under Adverse Environments

Most banana cultivars are known to perform best in areas with uniform rainfall distribution, with good soil drainage, and without the onslaughts of typhoons. Conversely, banana sustains a great deal of losses whenever typhoons, drought, and flooding occur.

Among the Southeast Asian countries, the Philippines is the most typhoon-prone area, particularly the central and northern parts of the country. Backyard and small-scale growers are most affected. The big commercial plantations are located in the island of Mindanao in southern Philippines. This region is outside the typhoon belt.

Of the other three countries, only Indonesia is similarly affected by typhoons but in a limited scale. Only the easternmost islands are subjected to storms. To cope with this situation, banana growers plant windbreaks. These are nonetheless ineffective once a typhoon unleashes its full force. There is now a trend to grow dwarf cultivars to minimize damage due to strong winds.

Thailand does not experience the ill effects of typhoons, but the country experiences flooding, particularly in the flood plains of central Thailand. Low elevation coupled with substantial rainfall brought about by the monsoon rains aggravate the problem. Growers have learned to solve this problem by growing bananas on ridges or beds between drainage canals.

On the broad plains around Bangkok where the water table is normally close to the ground surface, beds 2 to 3 m wide and several meters long are constructed by depositing the soil dug from canals alongside the raised beds. Rows of bananas are planted once the beds are 1 m above the canal water level.

Drought is a common problem of banana production in Southeast Asia. The eastern part of Indonesia is usually subjected to drought. Local varieties, like Pisang Saba and Pisang Kepok, show certain levels of tolerance to this adverse condition. Malaysia shares this problem with Indonesia. Fortunately, only a limited area is prone to drought in Malaysia. Farmers irrigate when they can, but there is no organized system being used.

In the Philippines, the effects of drought are less of a problem than those of typhoons, but the entire western part of Luzon and Visayas have long dry seasons limiting the choice of cultivars to either pure Balbisiana or hybrids with Balbisiana genomes. Saba and Cardaba (BBB), Matavia (ABB), and Latundan (AAB) are popular cultivars.

Other natural calamities peculiar to Southeast Asia are volcanic eruptions and earthquakes. The former causes serious destruction to crops, including bananas, but occurrence is rare and area affected is limited compared to devastations caused by typhoons and droughts. Damage caused by earthquakes is negligible.

Institutions Undertaking Research on Banana and Their Areas of Specialization

The national research programs of Indonesia, Malaysia, and the Philippines are highly centralized. The Agency for Agricultural Research and Development (AARD) and MARDI coordinate the research

activities of all agencies under the Ministries of Agriculture in Indonesia and Malaysia, respectively.

The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) in the Philippines has a more comprehensive mandate; as it coordinates not only the research programs of the various bureaus of the Department of Agriculture but also all the research agencies of the Department of Environment and Natural Resources, the research and development (R & D) institutes of the Department of Science and Technology, as well as all state colleges and universities undertaking research in agriculture and natural resources.

Research leadership in Thailand is more dispersed, but the heads of various national agencies involved in agricultural research are constantly in touch with each other to avoid duplication and promote complementation.

In Indonesia, the Central Research Institute for Horticulture is the lead agency for banana R & D. Seven of its branch stations located in different regions of Java, Sumatra, and Sulawesi undertake research projects on varietal selection, production management, crop protection, tissue culture, postharvest handling and processing, as well as marketing. Priorities are applied research with crop protection as the agency's area of specialization.

Other agencies involved in banana research are the Center for Research and Development on Biotechnology in Bogor and the famous Bogor Botanical Garden. Both institutions are interested in banana germplasm resources, taxonomy, and tissue culture with the latter specializing in wild species. Occasional researches are undertaken by agricultural universities, particularly by graduate students and professors interested in bananas. Details of agencies undertaking banana R & D and their areas of specialization are presented in Appendix E.

MARDI is the hub of banana R & D in Malaysia. Considerable expertise in the field of postharvest operations including preharvest and postharvest disease control are found at MARDI. The Institute's researchers are also active in applied research areas such as germplasm characterization, varietal evaluation, production management, processing and utilization, and tissue culture. There is interest in the nonconventional approaches to banana breeding.

Researchers at Malaysian universities are more inclined to basic research, such as seed physiology and biotechnology of ripening. Appendix E also presents the list of research institutions presently undertaking banana R & D in Malaysia.

Many government institutions undertake research on banana in Thailand where they address similar areas of concern as in Malaysia and Indonesia in the fields of production management, crop protection, postharvest operations, varietal classification and evaluation, tissue culture, and food technology.

A unique area of research that the Task Force members observed only in Thailand is the work of the Thai Packaging Center. This agency is testing packaging materials and structural designs of containers to improve the shelf life of fruits, including bananas. Appendix E again lists the agencies participating in banana R & D in Thailand.

The national research system in the Philippines includes both government and private research institutions; and the banana research network is strengthened by the active participation of the Twin Rivers Research Center (TRRC) in Davao, a private research institution devoted to banana R & D. While the research programs of TRRC is primarily geared towards the solution of problems in plantation agriculture, a considerable effort is devoted to the constraints of small growers who raise local cultivars for the Manila and export markets. TRRC's strength lies in the field of crop protection, production management, and tissue culture.

The University of the Philippines at Los Baños (UPLB) has long been associated with banana R & D. Its early taxonomists, Teodoro and Quisumbing, contributed significantly to banana classification in 1915 and 1919, respectively. Banana classification remains an area of great interest to UPLB's researchers who now apply chemotaxonomy in identifying bananas. Expertise in the field of crop protection (nematology, virology), biotechnology (monoclonal antibodies), postharvest technology, tissue culture, and marketing are recognized.

The Department of Agriculture, through its Bureau of Plant Industry in Davao, is sponsoring research projects in crop protection, farming systems, production agronomy, and classification of bananas. These and other institutions undertaking research on bananas in the Philippines are presented in Appendix E.

Salient Observations

1. The general belief that banana R & D do not enjoy priority ranking by national agricultural research systems (NARS) in Southeast Asia is no longer true. Discussions by members of the Task Force with heads of NARS in the region revealed that while banana is not ranked among Southeast Asia's important staple food crops, such as rice, and major export crops like rubber, oil palm, coconut, and sugarcane, it enjoys a higher priority than many other commercial crop and livestock commodities of the region. Proof is shown in Appendix E which presents a long list of agencies undertaking R & D projects on banana in the four countries visited and their various areas of specialization.
2. National governments are financing banana R & D projects within the limits of their capabilities. Some national agencies have succeeded in generating foreign funding to support banana R & D projects. Major donors include IDRC, IBPGR, and ACIAR/AIDAB.

3. Many problems exist in the field of banana classification, production management, pests and diseases, postharvest technology including processing, socioeconomics and marketing. There is also a dearth of trained manpower and research facilities. Amidst this undesirable situation of mounting problems and inadequate resources, wasteful duplication exists.
4. The Task Force strongly believes that a regional network on banana R & D in Southeast Asian is direly needed to coordinate the individual efforts of national programs on banana R & D and ensure complementation of projects for efficient use of meager resources.
5. The countries of Southeast Asia have a good performance record in regional cooperative projects. The establishment of the Regional Banana Germplasm Resource Center in Davao, Philippines could not have materialized if the countries in the region did not share their valuable germplasm materials. Cooperative research projects in postharvest technology of banana through the ASEAN Postharvest Handling Bureau based in Kuala Lumpur have yielded excellent and relevant information.
6. The research leaders of NARS in Southeast Asia realize that most of the problems affecting banana agriculture in the region are common among the proposed member countries of the network, and since the agroclimatic conditions are similar throughout the region, technologies generated by one member country can easily be transferred to the other members of the network.
7. The Directors General/Executive Directors of NARS in Southeast Asia have all pledged their support and cooperation in the establishment of a Regional Network for the Improvement of Banana and Plantain.

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Banana Germplasm Collections in the Philippines

Southeast Asian Banana Germplasm Resource Center,
Bureau of Plant Industry, Department of Agriculture,
Bago-Oshiro, Davao City

Philippine Banana Cultivars : 80

- A. Acuminata cultivars (AA Genome) : 18
- | | | |
|--------------|---------------------|-------------------|
| 1. Amas | 7. Inarnibal | 13. Señorita |
| 2. Bata-bata | 8. Kinamay Dalaga | 14. Suyak |
| 3. Binaktong | 9. Lakatan | 15. Talip |
| 4. Eda-an | 10. Morong Princesa | 16. Talipan |
| 5. Golimpang | 11. Pamoti-on | 17. Tudlo Tumbaga |
| 6. Guyod | 12. Pogpogan | 18. Viente Cohol |
- B. Acuminata cultivars (AAA Genome): 25
- | | | |
|----------------|-------------------|------------------|
| 19. Alaswe | 27. Dakdakan | 36. Oma |
| 20. Ambon | 28. Duhoy | 37. Pastilan |
| 21. Bangan | 29. Gao | 38. Pulutan |
| 22. Baukas | 30. Gros Michel | 39. Sarocsoc |
| 23. Binawe | 31. Inabaca | 40. Sulay Baguio |
| 24. Binalatong | 32. Inambak | 41. Tudlo Datu |
| 25. Bungulan | 33. Manang | 42. Tuldok |
| 26. Canara | 34. Morado | 43. Tumuk |
| | 35. Moradong Puti | |
- C. Acuminata x Balbisiana hybrids (AAB Genome) : 16
- | | | |
|-------------------|--------------------|-------------|
| 44. Bungaoisan | 49. Galamay Señora | 55. Popolo |
| 45. Daliri Dalaga | 50. Laknau | 56. Radja |
| 46. Daluyao | 51. Latundan | 57. Reynis |
| 47. Hilao-Hinog | 52. Maia Maole | 58. Ternate |
| 48. Inangel | 53. Muracho | 59. Tindok |
| | 54. Patag | |
- D. Acuminata x Balbisiana hybrids (ABB Genome) : 9
- | | | |
|----------------|-------------|------------|
| 60. Katali | 63. Matavia | 66. Pitogo |
| 61. Katsila | 64. Moko | 67. Pondol |
| 62. Madurangga | 65. Pelipia | 68. Siusok |
- E. Acuminata x Balbisiana hybrid (ABBB Genome) : 1
69. Tiparot
- F. Balbisiana cultivars (BB Genome) : 1
70. Abuhon
- G. Balbisiana cultivars (BBB Genome) : 9
- | | | |
|---------------|-----------------|-------------------|
| 71. Biguihan | 74. Mundo | 77. Saba Sa Hapon |
| 72. Gubao | 75. Pa-a Dalaga | 78. Sabang Puti |
| 73. Inabaniko | 76. Saba | 79. Turangkog |

APPENDIX A
(Continued)

H. Unclassified : 1

80. Katil

II. Banana Cultivars and Species Introduced to the Southeast Asian
Banana Germplasm Resource Center in Davao, Philippines

A. Malaysian Accessions: 29

- | | | |
|-----------------------|------------------------|--------------------|
| 1. Pisang Awak Betul | 11. Pisang Masam | 21. Pisang Segun |
| 2. Pisang Ekor Kuda | 12. Pisang Mundam | 22. Pisang Seribu |
| 3. Pisang Flava* | 13. Pisang Nangka | 23. Pisang Sintok* |
| 4. Pisang Go Nin Chio | 14. Pisang Pelimbing | 24. Pisang Surong* |
| 5. Pisang Jarum | 15. Pisang Pinang | 25. Pisang Susu |
| 6. Pisang Kapas | 16. Pisang Pulot | 26. Pisang Talas |
| 7. Pisang Keling | 17. Pisang Raja Talong | 27. Pisang Tandok |
| 8. Pisang Kra* | 18. Pisang Raja Udang | 28. Pisang Tioman |
| 9. Pisang Lemak Manis | 19. Pisang Raksa | 29. Pisang Tok |
| 10. Pisang Lilin | 20. Pisang Rasa | |

B. Thai Accessions: 35

- | | | |
|-------------------------|-----------------------|----------------------------|
| 1. Kluai Khai | 13. Kluai Khai Bong | 25. Kluai Tip Khum |
| 2. Kluai Lep Mu Nang | 14. Kluai Nak | 26. Kluai Namwa Luang |
| 3. Kluai Nam Phat | 15. Kluai Hom Kra | 27. Kluai Namwa Daeng |
| 4. Kluai Hom Thong | 16. Kluai Thong Daeng | 28. Kluai Namwa Khom |
| 5. Kluai Thong Ruang | 17. Kluai Khai Boran | 29. Kluai Som |
| 6. Kluai Nom Sao | 18. Kluai Thong Det | 30. Kluai Thom Khaek |
| 7. Kluai Hom | 19. Kluai Ngoen | 31. Kluai Khai Mai On |
| 8. Kluai Sa | 20. Kluai Pluak Na | 32. Kluai Nang Nuan |
| 9. Kluai Sa** | 21. Kluai Nam Tia | 33. <i>Musa acuminata</i> |
| 10. Kluai Lai | 22. Kluai Phaya | 34. <i>M. itinerans</i> |
| 11. Kluai Thong Kap Dam | 23. Kluai Tip | 35. <i>Ensete superbum</i> |
| 12. Kluai Hom Pochaman | 24. Kluai Tip Khum | |

C. Indonesian Accessions: 16

- | | | |
|-------------------|-------------------|-----------------------|
| 1. Pisang Agung | 7. Pisang Kates | 11. Pisang Lidi |
| 2. Pisang Ampyang | 8. Pisang Kepok | 12. Pisang Lingi |
| 3. Pisang Angleng | 9. Pisang Kepok | 13. Pisang Oli |
| 4. Pisang Candi | Malacacina | 14. Pisang Papan |
| 5. Pisang Emasari | 10. Pisang Klutuk | 15. Pisang Rojo Molo |
| 6. Pisang Kapas | Wulung*** | 16. Pisang Rojo Potho |

D. *Musa* Species and Related Genera from Various Sources: 10

- | | |
|--------------------------|---------------------------|
| 1. <i>Musa acuminata</i> | 6. <i>M. velutina</i> |
| 2. <i>M. balbisiana</i> | 7. <i>M. chiliocarpa</i> |
| 3. <i>M. textilis</i> | 8. <i>M. itinerans</i> |
| 4. <i>M. ornata</i> | 9. <i>M. violascence</i> |
| 5. <i>M. coccinea</i> | 10. <i>Ensete glaucum</i> |

*Wild *Acuminata*. **Synonym but distinct accession. ***Wild *Balbisiana*.

APPENDIX A
(Continued)

Southeast Asian Banana Germplasm Resource Center,
U.P. at Los Baños Banana Gene Bank,
University of the Philippines at Los Baños, Laguna

Papua New Guinea Accessions: 148

Accessions unclassified and presented alphabetically

- | | |
|-------------------|------------------------|
| 1. Abinakenau | 38. Kalapua |
| 2. Adimoo | 39. Karmumpo |
| 3. Agit | 40. Karoona |
| 4. Akee | 41. Katimor |
| 5. Ambowga | 42. Keemerey |
| 6. Amoliene | 43. Keemoro |
| 7. Armayey | 44. Kekenga |
| 8. Atakana | 45. Kendoar |
| 9. Babwey | 46. Kendoar Guramongo |
| 10. Bagatow | 47. Kenmnambo |
| 11. Bagul | 48. Kenmnambo Gareemey |
| 12. Barkol | 49. Koomeeango |
| 13. Brown River | 50. Komtar |
| 14. Budituana | 51. Kotnor |
| 15. Bunten | 52. Kumburgh |
| 16. Cullet | 53. Kunambo |
| 17. Dengree | 54. Kune |
| 18. Doctor | 55. Kurkh |
| 19. Dwonka | 56. Kuru Peck |
| 20. Fako Fako | 57. Kwaldalor |
| 21. Fytopi | 58. Lakem Connetnet |
| 22. Sagova | 59. Leewarp |
| 23. Galeo | 60. Leuwa |
| 24. Gana Auf | 61. Lum |
| 25. Gana Sumpu | 62. Malatawaya |
| 26. Garoto | 63. Mambee Thu |
| 27. Gusagidasee | 64. Mambeoolangre |
| 28. Henderweyargh | 65. Manam |
| 29. Heva | 66. Mandop |
| 30. Hoodoomadare | 67. Marama |
| 31. Hoodopataten | 68. Mardona |
| 32. Hooepa | 69. Markatooa |
| 33. Ileaya | 70. Mark Markila |
| 34. Jimmy | 71. Master |
| 35. Kabai | 72. Matringme |
| 36. Kakator | 73. Maywarvey |
| 37. Kala Kala | 74. Mbei |

APPENDIX A
(Continued)

75. Medey Yey	112. Taramba Gandia
76. Miamas	113. Taramba Tomarey
77. Migea Arizi	114. Teepea
78. Modok Gier	115. Teral
79. Mootaroo	116. Togam
80. Morga Marvee	117. Tomnam
81. Morong	118. Toowoolie
82. Morpa	119. Torp
83. Muga (Lae)	120. Torp
84. Muga (Waritsian)	121. Tukuroo
85. Munkantee	122. Twoberne
86. Noegwey	123. Umpako
87. Nombum	124. Unamunka
88. Nuisalamo	125. Wagiee
89. Nukin	126. Walebo
90. One Ark	127. Warik
91. Oonoonoo	128. Wm-o-gu
92. Oonoonoo Kengoa	129. Woo Woo
93. Oroua	130. Wudimissima
94. Pagatow	131. Yourh
95. Pasa	132. Yowa
96. Podoga	133. 49
97. Pok Pok	134. 50
98. Poreemokaqueey	135. 51
99. Por Wet	136. 61
100. Porp	137. 106
101. Puka	138. 107
102. Ragus Burung	139. 109
103. Roombum	140. 110
104. Rorar	141. 167
105. Setkowie Wein	142. 166
106. Somohagidasee	143. 200
107. Somwuk	144. 223
108. Swowmo	145. 224
109. TA	146. 232
110. Takumba Gandia	147. 233
111. Tamadawa	148. 234

APPENDIX B

Banana Germplasm Collection in Thailand

Kasetsart University Banana Germplasm Collection,
Pak Chong Student Training Farm,
Nakhon Rachasima

I. Thai Banana Cultivars: 39

A. Acuminata cultivars (AA Genome) : 9

1. Klwai Khai	4. Klwai Thong Kap Dam	7. Klwai Sa
2. Klwai Lep Mu Nang	5. Klwai Nom Sao	8. Klwai Hom
3. Klwai Thong Ruang	6. Klwai Lal	9. Klwai Hom Thong Son

B. Acuminata cultivars (AAA Genome) : 8

10. Klwai Nak	13. Klwai Hom Thong	16. Klwai Khlong Chang
11. Klwai Kung Kheio	14. Klwai Hom Khom	17. Klwai Khai Bong
12. Klwai Hom Kheio	15. Klwai Dok Mai	

C. Acuminata x Balbisiana hybrids (AAB Genome) : 10

18. Klwai Nam Phat	22. Klwai Khai Boran	25. Klwai Nam
19. Klwai Lanka	23. Klwai Thong Det	26. Klwai Khom
20. Klwai Roi Wi	24. Klwai Nang Nuan	27. Klwai Khom Nak
21. Klwai Ngoen		

D. Acuminata x Balbisiana hybrids (ABB Genome) : 10

28. Klwai Pluak Na	32. Klwai Som	35. Klwai Namwa Khao
29. Klwai Nom Mi	33. Klwai Tip	36. Klwai Namwa Daeng
30. Klwai Phaya	34. Klwai Namwa	37. Klwai Namwa Khom
31. Klwai Hakmuk		

E. Acuminata x Balbisiana hybrids (ABBB Genome) : 1

38. Klwai Theparrot

F. Balbisiana Cultivar (BBB Genome) : 1

39. Klwai Lep Chang Kut

II. *Musa* Species and Related Genera

A. *Musa acuminata* subsp. *banksii*
burmanica
malaccensis
microcarpa

B. *M. balbisiana*

C. *M. ornata*

D. *Ensete glaucum*

E. *E. ventricosum*

Banana Germplasm Collection in Malaysia

Malaysian Agricultural Research and Development Institute (MARDI),
Serdang, Malaysia

I. Malaysian Banana Cultivars : 54

A. Acuminata cultivars (AA Genome) : 15

- | | | |
|----------------------|------------------------|-----------------------|
| 1. Pisang Mas | 6. Pisang Boyan | 11. Pisang Jari Buaya |
| 2. Pisang Mas Sagura | 7. Pisang Keladi | 12. Pisang Ekor Kuda |
| 3. Pisang Kapas | 8. Pisang Raksa | 13. Pisang Jarum |
| 4. Pisang Lilin | 9. Pisang Serindek | 14. Pisang Masam |
| 5. Pisang Minyak | 10. Pisang Lemak Manis | 15. Pisang Nur |

B. Acuminata cultivars (AAA Genome) : 15

- | | | |
|------------------------|------------------------|----------------------|
| 16. Pisang Embun | 21. Pisang Bakar | 26. Pisang Susu |
| 17. Pisang Masak Hijau | 22. Pisang Tualang | 27. Pisang Thai |
| 18. Pisang Buai | 23. Pisang Mundam | 28. Pisang Ayam Man |
| 19. Pisang Berangan | 24. Pisang Raja Udang | 29. Pisang Pelimbing |
| 20. Pisang Serendah | 25. Pisang Minyak Laut | 30. Pisang Amping |

C. Acuminata x Balbisiana hybrids (AAB Genome): 12

- | | | |
|----------------------|------------------------|------------------------|
| 31. Pisang Rastali | 35. Pisang Raja | 39. Pisang Indian |
| 32. Pisang Pulot | 36. Pisang Nangka | 40. Pisang Tandok |
| 33. Pisang Kelat Air | 37. Pisang Keling | 41. Pisang Seribu |
| 34. Pisang Kapor | 38. Pisang Kelat Jambi | 42. Pisang Raja Talong |

D. Acuminata x Balbisiana hybrids (ABB Genome): 6

- | | | |
|-----------------------|-----------------------|-------------------|
| 43. Pisang Awak Betul | 45. Pisang Abu Perak | 47. Pisang Sematu |
| 44. Pisang Besar | 46. Pisang Abu Keling | 48. Pisang Kari |

E. Acuminata x Balbisiana hybrids (ABBB) : 2

- | | |
|---------------------|---------------------------|
| 49. Pisang Abu Siam | 50. Pisang Bengkulu Barat |
|---------------------|---------------------------|

F. Balbisiana cultivars (BBB) or Acuminata x Balbisiana hybrids (ABB): 4

- | | |
|-------------------------|------------------|
| 51. Pisang Batu Temalan | 53. Sabang Puti* |
| 52. Pisang Nipah | 54. Binendito* |

II. Musa Species and Related Genera

- A. *Musa acuminata* : Pisang Kra: 6 accessions
 B. *M. balbisiana* : Pisang Gala: 1 accession
 C. *M. ornata*
 D. *M. occinea*

- E. *M. velutina*
 F. *M. gracilis*
 G. *M. violascence*
 H. *Ensete glaucum*

*Introduced from the Philippines.

Banana Germplasm Collections in Indonesia

Indonesian Banana Cultivars at Cibinong: 35

Varietal names presented alphabetically, classification still ongoing

- | | |
|------------------------|-------------------------|
| 1. Pisang Ambon Hijau | 19. Pisang Lilin |
| 2. Pisang Ambon Lumut | 20. Pisang Longong |
| 3. Pisang Ambon Putih | 21. Pisang Nangka |
| 4. Pisang Angleng | 22. Pisang Oli |
| 5. Pisang Badak | 23. Pisang Papan |
| 6. Pisang Bedong | 24. Pisang Perecet |
| 7. Pisang Emas | 25. Pisang Ramo |
| 8. Pisang Jari Buaya | 26. Pisang Raja Bulu |
| 9. Pisang Kapas | 27. Pisang Raja Sereh |
| 10. Pisang Kastrol | 28. Pisang Raja Ampyang |
| 11. Pisang Kates | 29. Pisang Saba |
| 12. Pisang Keladi | 30. Pisang Saiman |
| 13. Pisang Kepok | 31. Pisang Seribu |
| 14. Pisang Kosta Hijau | 32. Pisang Siem Paris |
| 15. Pisang Kosta Putih | 33. Pisang Susu |
| 16. Pisang Lampeneng | 34. Pisang Tanduk |
| 17. Pisang Lampung | 35. Pisang Udang |
| 18. Pisang Lidi | |

Musa species: 1. *M. acuminata*
 2. *M. balbisiana*

Indonesian Banana Cultivars at Purwodadi
 Botanical Garden: 59

Varietal names presented alphabetically

- | | |
|-------------------|-------------------|
| 1. Pisang Ambon | 6. Pisang Berlin |
| 2. Pisang Ampyang | 7. Pisang Byar |
| 3. Pisang Awak | 8. Pisang Cebol |
| 4. Pisang Bakar | 9. Pisang Cici |
| 5. Pisang Bandung | 10. Pisang Dulang |

APPENDIX D
(Continued)

- | | |
|-------------------------|-------------------------|
| 11. Pisang Ebung | 36. Pisang Rojoketan |
| 12. Pisang Gajih Merah | 37. Pisang Rojokul |
| 13. Pisang Gajih Putih | 38. Pisang Rojolali |
| 14. Pisang Glinting | 39. Pisang Rojolingi |
| 15. Pisang Ijo | 40. Pisang Rojomolo |
| 16. Pisang Jaran | 41. Pisang Rojopendek |
| 17. Pisang Kates | 42. Pisang Rojosiem |
| 18. Pisang Kayu | 43. Pisang Rojotalun |
| 19. Pisang Kele | 44. Pisang Rojouter |
| 20. Pisang Kidang | 45. Pisang Rojowarangan |
| 21. Pisang Kisto | 46. Pisang Saleh Rosos |
| 22. Pisang Klutuk | 47. Pisang Santen |
| 23. Pisang Klutuk Sukun | 48. Pisang Sapon |
| 24. Pisang Kongkong | 49. Pisang Sasi |
| 25. Pisang Kreas | 50. Pisang Selendang |
| 26. Pisang Krepek | 51. Pisang Sembot |
| 27. Pisang Longok | 52. Pisang Sewu |
| 28. Pisang Mas | 53. Pisang Soboawu |
| 29. Pisang Medan | 54. Pisang Sobolondo |
| 30. Pisang Morosebo | 55. Pisang Songroito |
| 31. Pisang Nongko | 56. Pisang Sukun |
| 32. Pisang Prentel | 57. Pisang Susu |
| 33. Pisang Pulut | 58. Pisang Sri |
| 34. Pisang Rayab | 59. Pisang Umbuk |
| 35. Pisang Rojokenongo | |

APPENDIX E

**AGENCIES ENGAGED IN BANANA R & D AND THEIR
AREAS OF RESPONSIBILITY/SPECIALIZATION**

Country	Agency	Responsibility/Specialization
Indonesia	Agency for Agricultural Research and Development (AARD), Jakarta	Central research planning and coordinating agency of the Ministry of Agriculture
	Central Research Institute for Horticulture, Jakarta	Research and development projects on horticultural crops, with emphasis on fruits and vegetables
	Branches of the Central Research Institute for Horticulture undertaking banana R & D	Since the organization of the Central Research Institute for Horticulture under the direction of Dr. Subjianto, banana has been given high priority. R & D projects on banana are now being undertaken in a number of research stations of the Institute located in various regions of Indonesia. The field of activity in the various stations are as follows:
	Solok	Production management, marketing studies, germ-plasm collection and evaluation

APPENDIX E
(Continued)

Pasar Minggu	Postharvest technology and processing, tissue culture
Malang	Postharvest technology, marketing studies
Tlekung	Germplasm collection and evaluation
Segunung	Crop protection
Subang	Germplasm collection and evaluation
Jeneponto	Crop protection
Center for Research and Development on Biotechnology, Bogor	Tissue culture, germplasm collection and classification
Bogor Botanical Garden	Collection, maintenance, and classification of wild <i>Musa</i>
Purwodadi Botanical Garden (a branch of Bogor Botanical Garden)	Collection and maintenance of banana and plantain cultivars of East Java

APPENDIX E
(Continued)

Malaysia	Malaysian Agricultural Research and Development Institute (MARDI), Serdang	Central research planning and coordinating agency of the Ministry of Agriculture
		Research on important crops and livestock of Malaysia
		Research on 16 fruit commodities with banana as top priority
		Development of Pisang Mas as an export fruit to Europe and perhaps Japan and Hongkong (primary objective)
Research thrusts of MARDI on bananas		Production management; postharvest technology including preharvest and postharvest diseases; processing and utilization; germplasm collection, evaluation, and characterization; tissue culture; and crop improvement through selection and somaclonal variation

APPENDIX E
(Continued)

Universiti Pertanian Malaysia (UPM), Serdang	Seed physiology (wild bananas) Industrial uses of banana (fiber, pulp, and paper manufacture)
Universiti Kebangsaan Malaysia (UKM), Kuala Lumpur	Banana postharvest physiology and biochemistry
University of Malaya (UM), Kuala Lumpur	Processing of banana into fruit mixes and baby food
ASEAN Postharvest Handling Bureau, Kuala Lumpur (Regional agency)	Coordinating and financing research and develop- ment projects on postharvest technology with priority on cereals and perishable horticultural crops, including bananas
Horticultural Research Institute, Department of Agriculture, Bangkok	Research and development projects on horticultural crops, including bananas
	Germplasm collection and evaluation

Thailand

APPENDIX E
(Continued)

Kasetsart University (KU), Bangkok	Crop protection (pests and diseases)
Horticulture Department	Postharvest technology
	Germplasm collection and classification
	Tissue culture
Institute of Food Research and Product Development (IFRPD)	Research and development projects on food science and technology: presently active in processing studies, including the uses of banana in baby food manufacture, banana puree, chips, powder, dried fruit, and wine
Thailand Institute of Scientific and Technological Research (TISTR), Thai Packaging Center (TPC), Bangkok	Research and development projects on structural designs of containers to improve shelf life of fruits and vegetables, presently testing pack- aging designs and materials for banana

APPENDIX E
(Continued)

Philippines	Food and Agriculture Organization (FAO) of the United Nations, Bangkok	Project development, implementing and financing of food and agriculture programs
	Department of Science and Technology (DOST), Manila	
	Industrial Technology Development Institute (ITDI), Manila	Processing and utilization (banana ketchup, banana chips, and flour).
	Forest Products Research and Development Institute (FPRDI), Los Baños, Laguna	Industrial uses of banana (fiber, pulp and paper manufacture)
	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Laguna	Central research planning, coordinating, and monitoring agency of the Department of Science and Technology. Coordinates all researches undertaken by the different Bureaus of the Department of Agriculture, Department of Environment and Natural Resources, all state colleges and universities in agriculture and forestry, all commodity research institutes on coconut, sugar, rice, root crops, tobacco, cotton, forestry, etc.

APPENDIX E
(Continued)

Department of Agriculture (DA), Manila	Research and development projects on crops, livestock and fisheries important to Philippine agriculture; regulatory functions related to quarantine, grades, and standards, national programs on food and nutrition, marketing studies, etc.
Bureau of Agricultural Research (BAR), Manila	Central research planning and coordinating Bureau of the Department of Agriculture
Bureau of Plant Industry (BPI), Davao Experiment Station	Germplasm collection, evaluation and characterization, tissue culture
	Crop protection (pests and diseases with emphasis on viral problems)
	Production management including role of bananas in cropping systems
BPI, Manila	Production, utilization of banana (wine)

APPENDIX E
(Continued)

<p>University of the Philippines at Los Baños (UPLB), Los Baños, Laguna</p>	<p>Germplasm characterization (chemotaxonomy), germplasm conservation through tissue culture</p>
<p></p>	<p>Crop protection (pest management with emphasis on nematology, diseases with priority on early detection of virus diseases through monoclonal antibodies)</p>
<p></p>	<p>Postharvest technology (packaging, transport, storage, and control of postharvest diseases), processing and utilization for human consumption and livestock feed</p>
<p></p>	<p>Marketing studies</p>
<p>Visayas State College of Agriculture (VISCA) Baybay, Leyte</p>	<p>Role of bananas in farming systems (banana under coconut, banana-livestock production)</p>
<p>Twin Rivers Research Center (TRRC), Tagum, Davao del Norte</p>	<p>All aspects of banana production for the export trade, crop protection and propagation through tissue culture (major emphasis)</p>

APPENDIX F

Agencies and Projects Visited by the Banana Task Force Members

Indonesia	Thailand	Philippines
<p>Agency for Agricultural Research and Development (AARD), Jakarta</p>	<p>Food and Agriculture Organization (FAO) of the United Nations, Regional Office for Asia and the Pacific (RAPA)</p>	<p>University of the Philippines at Los Baños (UPLB), Institute of Plant Breeding</p>
<p>Center for Research and Development on Biotechnology (CRI), Bogor</p>	<p>Kasetsart University (KU)</p>	<p>UPLB, National Institutes of Biotechnology and Applied Microbiology (BIOTECH)</p>
<p>Cibinong Banana Collection</p>	<p>Kasetsart University (KU), Institute of Food Research and Product Development</p>	<p>UPLB Postharvest Horticulture Training and Research Center (PHTRC)</p>
<p>Central Research Institute for Horticulture, Pasar Minggu, Jakarta</p>	<p>Thailand Institute of Scientific and Technological Research (TISTR), Thai Packaging Center (TPC)</p>	<p>UPLB, Department of Horticulture, UPLB Banana Gene Bank</p>
<p>Malaysia Malaysian Agricultural Research and Development Institute, (MARDI), Serdang</p>		<p>Department of Agriculture - Bureau of Plant Industry, Davao Experiment Station, Bago-Oshiro Southeast Asian Banana Germplasm Resource Center</p>

APPENDIX F
(continued)

Malaysia

MARDI Banana Germplasm Collection

Universiti Pertanian Malaysia
(UPM), Serdang

Universiti Kebangsaan Malaysia
(UKM), Kuala Lumpur

Thailand

Thailand Department of
Agriculture Fruit Pathology
Division

Prathum Tani, Commercial
Small-Holder Banana
Plantation

Pak Chong Student
Training Farm,
Nakhon Rachasima,
Thailand Banana
Variety Collection

Philippines

Twin Rivers Research Center (TRRC),
Tagum, Davao del Norte, a private
research center specializing in
banana production

Hijo Plantation, Tagum, Davao del
Norte, a large commercial banana
plantation exporting bananas to
Japan and the Middle East