

Horticultural Research and Education Opportunities in Indonesia

Tim D. Davis^{1,3}

Borlaug Institute for International Agriculture and Department of Horticultural Sciences, Room 202 HFSB,
2133 Texas A&M University, College Station, TX 77843-2133

Purwiyatno Hariyadi²

Southeast Asian Food and Agricultural Science and Technology (SEAFAST) Center,
Bogor Agricultural University, Bogor, Indonesia

Additional index words. biodiversity, tropical horticulture, human health, teaching, research, extension, rooftop gardens, university partnerships

Abstract. Indonesia is one of the most populated countries in the world and is rich in plant biodiversity. The country's hot humid climate is conducive to the production of many tropical horticultural crops. There are many plant species indigenous to Indonesia that have potential as horticultural crops but which have not been fully evaluated and therefore remain underused. Many of these plants have market potential and may have value for human health and nutrition. Furthermore, horticulture has been identified as one of the priority areas for collaboration between U.S. and Indonesian universities and for Indonesian agricultural development. Accordingly, we are presently working with three Indonesian universities to facilitate agricultural development related to horticulture by: 1) strengthening their curriculum related to plant biodiversity; 2) conducting research aimed at identifying bioactive compounds in underused plants that may have benefit to human health; 3) establishing university-led outreach education programs that lead to a better understanding of plant biodiversity and use; and 4) fostering enterprise based on underused Indonesian plant species. Other untapped agricultural research and development opportunities exist in the postharvest handling of tropical fruits and vegetables. Overall, the climate for collaboration between U.S. and Indonesian academic institutions is quite favorable from both a political and a scientific perspective.

Indonesia is a large, rapidly growing developing country in southeastern Asia with a population approaching 250 million. Composed of over 17,000 islands, the country is one of the most populated in the world. Indonesia is characterized by a hot, humid tropical climate with abundant rainfall with some areas receiving almost daily precipitation. The climate includes a wet season running from roughly November to June. In most areas, the relatively short dry season is not characterized by true drought conditions because rainfall still occurs, just not as abundantly as in the wet season. As an example, rainfall during the statistically driest month of the year (August) in Manado is 132 mm (5.2 inches) compared with 415 mm (16.3 inches) in the statistically wettest month of January (Weatherhobo, 2012). Indonesia is mountainous with many volcanic peaks and temperatures vary with elevation. Because of a climate conducive to tropical plant growth, the country

is rich in plant biodiversity. According to Conservation International, two of the world's "Biodiversity Hotspots," Sundaland and Wallacea, are located in Indonesia (Conservation International, 2012).

Presently, the main vegetable crops in Indonesia are: cabbage (*Brassica oleracea*), potatoes (*Solanum tuberosum*), onion (*Allium cepa*), chili (*Capsicum annuum*), tomatoes (*Lycopersicon esculentum*), Chinese cabbage/mustard (*Brassica rapa*), spring onion (*Allium cepa*), cucumber (*Cucumis sativus*), long beans (*Vigna unguiculata*), and cayenne pepper (*Capsicum annuum*). These crops comprised 73% of the total vegetable production in Indonesia, which amounted to 6,964,036 tons in 2007 (Adam, 2011). Primary fruit crops in Indonesia are: banana (*Musa acuminata*), Siamese orange (*Citrus sinensis*), pineapple (*Ananas cosmosus*), mango (*Mangifera indica*), salacca (*Salacca zalacca*), papaya (*Carica papaya*), jackfruit (*Artocarpus heterophyllus*), durian (*Durio zibethinus*), and watermelon (*Citrullus lanatus*). These crops comprised 92% of the total fruit production of 17,116,622 tons in Indonesia in 2007 (Adam, 2011).

The scope of diversity of plants native to Indonesia is emerging with new species still being discovered and with more discoveries anticipated in the future. Some indigenous Indonesian plant species have potential for development into horticultural crops. However, many of these species remain understudied and thus underused. The development of new horticultural crops in Indonesia is attractive for several reasons: 1) regarding human health and nutrition, there is a general need to diversify Indonesian diets, which are based largely on rice, to include more fruits and vegetables (FAO, 2003); 2) horticultural

crops generally require less land area than other crops and, in some cases, can be grown on marginal lands, thus offering the potential for slowing forest destruction and conserving biodiversity; and 3) horticultural crops generally yield more economic value per unit land area than traditionally grown agronomic crops and thus offer potential for economic development in villages.

The purposes of this article are to enhance understanding of Indonesia from a horticultural perspective, briefly review some of our collaborative horticultural work in Indonesia, and to stimulate thought regarding potential future university collaboration. The article is based on a workshop presentation made at the 2011 ASHS annual meeting in Hawaii (Davis and Hariyadi, 2011).

GENERAL HORTICULTURAL RESEARCH AND EDUCATION NEEDS/ OPPORTUNITIES IN INDONESIA

In 2010, thanks to financial support from the Borlaug Institute of International Agriculture, several Texas A&M University faculty members (including the senior author) made a trip to Indonesia to explore needs and opportunities for potential horticultural collaboration with universities and other organizations. The Borlaug Institute, named after Nobel Laureate Dr. Norman E. Borlaug, has a long history of working in Indonesia on agricultural development projects (Table 1). This experience provided a strong foundation for developing and strengthening collaboration on horticultural research and education. During the exploratory trip to Indonesia, we visited with faculty at several universities and with various personnel at the U.S. Embassy in Jakarta, including the U.S. Ambassador to

Received for publication 14 Nov. 2012. Accepted for publication 18 Dec. 2012.

This paper was part of the workshop "Exchange of Information on International Collaborations and Activities" held 25 Sept. 2011 at the ASHS Conference, Waikoloa, HI, and sponsored by the Working Group of Asian Horticulture (WGAH). This project is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of Texas A&M AgriLife and The USAID Tropical Plant Curriculum Project partners and do not necessarily reflect the views of USAID or the United States Government.

¹Regional Director for Asia and Professor.

²Professor and Director.

³To whom reprint requests should be addressed; e-mail t-davis5@tamu.edu.

Table 1. Norman E. Borlaug Institute of International Agriculture engagement in Indonesia from 1995 to the present.

Project name	Yr(s)	Project description	Funding source
Higher Education Development training of Indonesian university administrators	1995	Through this program, Texas A&M provided administrative training for ≈60 Indonesians from over 10 Indonesian universities	Asian Development Bank
ASEAN Agriculture Committee Mission to Indonesia	1996–97	The purpose of this Mission was to explore agricultural development opportunities as well as new ventures for the private sector in Indonesia	ASEAN Secretariat
Directorate General of Higher Education Delegation to TAMU	1997	Professor Harsono Taroepatjeka and colleagues visited TAMU to discuss collaborative efforts	Government of Indonesia
Ph.D. Training in Poultry Science, follow-on to ASEAN Agriculture Committee Mission	1996–99	With logistical support from USDA/FAS, TAMU provided Ph.D. degree training for Indonesian student in poultry science	USDA/FAS
Feasibility Study of Storage and Distribution of Frozen and Chilled Poultry in Indonesia	1998	1) Focus on distribution and storage of frozen or chilled poultry; 2) assess the nutritional impact of poultry in the diet; 3) assess the economic impact of an expanded poultry industry; and 4) food safety through processing/storage procedure	Small Ruminants CRSP (USAID)
Food Safety & HACCP Training	2002	Provided technical assistance in food safety and HACCP to several Indonesian delegations from universities and the government	USDA
Education for Community Food Enterprise Development	2000–03	1) Develop food products and improve existing products through partnerships between universities and private industries; 2) develop improved curriculum driven by private industry; 3) technical and management training; 4) create trust between the private sector and universities; and 5) tours for partners to U.S. universities and industries	USDA/FAS (Food for Progress)
Indonesia Cold Chain Project	2003–05	Establish linkages in the refrigerated food chain from the point of production (farmer, fisherman, etc.) to the point of consumption (consumer, processor) in eastern Indonesia	USDA/FAS (Food for Progress)
Southeast Asia Food and Agriculture Science and Technology Center	2005–09	The SEAFAS Project is a joint project of TAMU System and Bogor Agric. Univ.; SEAFAS is designed to bring together academic, governmental, NGO's and business sectors to focus on the improvement of food science and technology issues in the region	USDA/FAS
Sustainable Agriculture and Natural Resources Management	2006–09	SANREM CRSP cooperatively with SEAFAS, TAMU System has been engaged in program review and with the indigenous crops collection at SEAFAS	SANREM CRSP
Food Security, Higher Education	2010	Planning for agricultural education with Putera Sampoerna Foundation and food security needs assessment and planning with SEAFAS Center, USDA/FAS, and USAID	Borlaug Institute, USDA
Food Security, Higher Education	5–7 Oct. 2010	Conference on food security planning for Indonesia with USDA/FAS, Indonesian universities and agencies, led by Borlaug Institute/SEAFAS	USDA/FAS
Food Security, Higher Education	Nov. 2010	Indonesian university and agency representatives hosted by Borlaug Institute	USDA/FAS

Information courtesy of Dr. Ed. Price, former Associate Vice Chancellor and Borlaug Institute Director.

ASEAN = Association of Southeast Asia Nations; CRSP = Collaborative Research Support Program; HACCP = Hazard Analysis and Critical Control Point; SEAFAS = Southeast Asian Food and Agricultural Science and Technology Center; TAMU = Texas A&M University; USAID = U.S. Agency for International Development; USDA/FAS = U.S. Department of Agriculture, Foreign Agriculture Service.

Indonesia and his staff. Based on these discussions, we identified several areas of mutual interest.

From a political perspective, the U.S. government is interested in strengthening academic relations with Indonesia. This goes well beyond the connection of current U.S. President Obama with the country. Indonesia's strategic location within southeast Asia, its democratic system of government, and its rapidly growing middle class are of interest to the United States. One area targeted by the U.S. government for improved relations is university partnerships with \$165 million being targeted for strengthening academic ties with Indonesia (Wilhelm, 2011) Within the general category of university partnerships,

horticulture is one discipline specifically identified by the U.S. Embassy in Jakarta for potential collaboration.

Because of the general need to diversify diets of Indonesians (FAO, 2003), we determined that there was significant interest in beginning to characterize phytochemicals in Indonesian fruits and vegetables that might have properties related to human health. In addition, we found considerable interest in studying new fruit and vegetable crops indigenous to Indonesia with purported human health-promoting properties. A critical need exists to examine these properties using a solid scientific approach. As it stands now, putative human health benefits are based on rather limited anecdotal evidence.

For Indonesian fruits and vegetables to be produced and consumed more widely, there is a critical need to have a better understanding of postharvest handling and processing. Access to refrigeration is limited in many areas and the potential for postharvest losses is great. Rolle (2006) reported that postharvest losses in Indonesia were estimated to be between 20% and 50%. Postharvest losses of potato (*Solanum tuberosum* L.) at Hikmah Farm, Pangalengan, West Java, Indonesia, was reported to be 10% (Rismawati and Rahayu, 2009) and postharvest losses of red chili pepper (*Capsicum annum* L.) at the farm level were ≈40% (Piay et al., 2010). Research and education in this area would greatly help in identifying ways to counter

such losses. A good start on this occurred with the USDA-funded Indonesia Cold Chain Project mentioned in Table 1, but much more work is needed regarding fruits and vegetables, especially with crops that are less well known and currently underused.

We also identified interests and needs for outreach activities related to horticulture. Land grant-type extension programs have had limited documented effectiveness in some parts of Indonesia and the connections between academic institutions and industry are limited. Until this situation is improved, it will be difficult to effectively translate research results into benefits for local Indonesian communities and home industries.

Although not a focus of our exploratory trip and not directly related to the aforementioned needs or our current project, it was also noted that there are numerous impressive examples of incorporating vegetation into architectural designs of skyscrapers in Jakarta. This includes various types of rooftop gardens and creative use of plants in architecture (Fig. 1). Such plantings might provide interesting research and education opportunities for those interested in rooftop horticulture. With abundant and relatively consistent rainfall, these types of plantings have a comparative advantage over other parts of the world with less predictable precipitation and climate patterns.

ONGOING HORTICULTURAL RESEARCH AND EDUCATION COLLABORATION

Our ongoing collaborative efforts are centered on an USAID university partnership grant related to underused Indonesian tropical plants. The four partner institutions for this project are: Bogor Agricultural University (located in West Java near the capital of Jakarta), Udayana University (located in Denpasar on the island of Bali), Sam Ratulangi University (located in Manado on the island of Sulawesi in the province of North Sulawesi), and Texas A&M University (College Station, TX). The three Indonesian partner universities represent a wide geographical and cultural range. Two of the three universities (Bogor and Udayana) are located below the equator, whereas the other (Sam Ratulangi) lies above the equator (Fig. 2). Bogor is located in a predominantly Muslim region, whereas the areas surrounding Udayana and Sam Ratulangi have large Hindu and Christian populations, respectively.

The first overall objective for our collaboration is to strengthen university curricula in tropical plant science at the Indonesian universities. In particular, this includes the areas of tropical plant biodiversity and use. To accomplish this objective, each Indonesian partner is developing four course modules that can be shared among institutions for a total of 12 modules (Table 2). This sharing will help achieve efficiency by using subject matter experts at each institution and will help improve consistency of curricula across institutions. Texas A&M University faculty members review course content and make suggestions



Fig. 1. Photographs illustrating creative use of horticultural plants in architectural design of buildings in Jakarta, Indonesia (upper photo: Intiland Building; lower photo: Grand Indonesia Shopping Town; all plants visible in both foreground and background are growing on rooftops).



Fig. 2. Map showing locations of these partner universities in Indonesia participating in the USAID-funded Tropical Plant Curriculum project. Bogor = Bogor Agricultural University; Udayana = Udayana University; UNSRAT = Sam Ratulangi University.

for improvement. Although these course modules are primarily targeted for undergraduate students, they are also being used as a basis for developing less advanced curricula that can be used for the community education activities mentioned later in this section.

Characterization of bioactive compounds in selected underused Indonesian tropical plants is the second overall objective of our collaboration. Although there is much folklore and anecdotal evidence of human health-promoting properties of tropical plants in Indonesia, there is a need to provide a scientific underpinning to these claims. Without this, there will be hesitation by entrepreneurs in establishing plant production systems and

in investing in value chain activities. Accordingly, each Indonesian partner university will begin to characterize bioactive compounds in three plants with purported health benefits (Table 3). The plants were selected after considerable discussion among the partner institutions and based on perceived opportunities for achieving success within a two- to three-year timeframe. These plants have occasionally been used by local communities for a variety of food and medicinal purposes. At present, the selected plants are only growing sporadically in local communities and there is no concerted effort for more widespread cultivation. Most analyses are currently being conducted in Indonesia but, if

Table 2. Tropical plant science-related course modules being developed at Indonesian partner universities as part of USAID-funded Tropical Plant Curriculum Project.

	Indonesian institution		
	Bogor Agricultural Univ.	Udayana Univ.	Sam Ratulangi Univ.
Phenolic Compounds of Tropical Plants	Aromatic and Flavor Compounds	Tropical Plant Products: Business Model and Project Management	Tropical-Based Biopesticides
Processing of Tropical Roots and Tubers as Source of Carbohydrates	Preserving Biodiversity Using Local Wisdom		Tropical Plants Conservation
Evaluation of Bioactivity of Plant Compounds for Health			
Natural Food Additives	Postharvest of Tropical Plant Products		Wallace Line Plant Geography ^z

^zThe Wallace Line denotes the ecological transition zone between Asia and Australia.

Table 3. Plants for which phytochemical characterization is being conducted at Indonesian partner universities as part of the USAID-funded Tropical Plant Curriculum project.

	Indonesian institution		
	Bogor Agricultural Univ.	Udayana Univ.	Sam Ratulangi Univ.
<i>Talinum triangulare</i> (Jacq.) Willd.	<i>Cymbopogon citratus</i> (DC. ex Nees) Stapf	<i>Canarium indicum</i> L.	
<i>Solanum torvum</i> Sw.	<i>Gigantachloa nigrociliata</i> (Bse) Kurz	<i>Musa acuminata</i> Colla	
<i>Sauropus androgynus</i> (L.) Merr.	<i>Catharanthus roseus</i> (L.) G. Don	<i>Arenga pinnata</i> (Wurmb) Merr.	

needed, will also be carried out at Texas A&M University. Faculty members from Texas A&M will review results of chemical analysis and provide technical expertise. Although this is a longer-term objective, we feel it is important to at least begin providing a scientific base of understanding related to bioactive compounds in these plants.

The third overall objective of the partnership is to provide community education related to tropical plant biodiversity and use. Several communities and vocational high schools near the Indonesia partner institutions have been targeted for training, which will include topics such as biodiversity, good agricultural practices, improvement of product quality and safety, product diversification, licensing of products, and business model development. Specific targets regarding the number of groups and people to be trained have been set for each partner institution. Initial training sessions have been well received by participants. Texas A&M faculty members have visited several targeted communities and serve as an additional training resource. The ultimate outcome of such training will be a better understanding of tropical plant resources in Indonesia and how they might be used for economic development in local communities.

The final objective for our collaboration is to promote the commercialization of under-used tropical plants and their products. One of the key obstacles to commercialization is related to food quality and safety. Accordingly, a major goal is to work with small- to medium-sized enterprises to improve safety and quality so that licensing can be obtained from the Indonesian National Agency for Drug and Food Control. Faculty and staff at the SEAFast Center in Bogor have considerable experience in working with entrepreneurs to carry out the required process to obtain licensing. Without such licensing, enterprises are only able to sell their products

within their local villages and prospects for economic development are severely limited.

LESSONS LEARNED THUS FAR

Although our projects are still ongoing, several lessons have already been learned. We offer these with the caveat that they are opinions, although we believe informed opinions. First and foremost, we have confirmed that significant opportunities exist for research and education related to the improvement, production, postharvest handling, and marketing of tropical fruits and vegetables. The political climate for collaborating with Indonesian academic institutions is quite favorable, which improves prospects for obtaining funding. Although horticulture is a priority area for collaboration, it is important to tie research and education activities to broader issues of importance to Indonesia such as conservation of biodiversity, improvement of human health, and providing opportunities for economic development in villages.

Funding organizations such as USAID are much more interested in documenting clear impacts of research and education activities on the people of Indonesia rather than in traditional academic metrics such as refereed publications. So, although not easy, it is important to plan research and education activities that will have clear and documentable impacts within a reasonable timeframe.

Literature Cited

Adam, L. 2011. Horticulture marketing product development prospects in Indonesia. Paper presented at 21st Annual World Forum and Symposium. The Road to 2050: Sustainability as a Business Opportunity. Frankfurt, Germany. 29 Oct. 2012. <https://www.ifama.org/events/conferences/2011/cmsdocs/2011SymposiumDocs/262_Symposium%20Paper.pdf>.

Conservation International. 2012. Biodiversity hotspots. 17 Oct. 2012. <http://www.conservation.org/where/priority_areas/hotspots/asia-pacific/Pages/asia-pacific.aspx>.

Davis, T.D. and P. Hariyadi. 2011. Horticultural research and education opportunities in Indonesia. *HortScience* 46:S64.

FAO. 2003. WTO Agreement on agriculture: The implementation experience - developing country case studies. Commodity policy and projections service commodities and trade division. Rome, 2003. 31 Oct. 2012. <<http://www.fao.org/docrep/005/Y4632E/y4632e00.htm>>.

Piay, S.S., A. Tyasdjaja, Y. Ermawati, and F.R.P. Hantoro. 2010. Farming and postharvest of chilli pepper (*Capsicum annum* L.) [Budidaya dan Pasca Panen Cabai, in Indonesian language]. Research Report, Agency of Agricultural Research and Development, Ministry of Agriculture, Republic of Indonesia.

Rismawati, L. and M.S. Rahayu. 2009. Postharvest handling of potato (*Solanum tuberosum* L.) at Hikmah Farm, Pangalengan, Bandung, West Java. Research Report, Department of Agronomy and Horticulture, Faculty of Agriculture, Institut Pertanian Bogor, Bogor, Indonesia.

Rolle, R.S. 2006. Improving postharvest management and marketing in the Asia-Pacific region: Issues and challenges. In: Rolle, R.S. (ed.). Postharvest management of fruit and vegetables in the Asia-Pacific region. Reports of the APO seminar on Reduction of Postharvest Losses of Fruit and Vegetables (held in India, 5–11 Oct. 2004) and Marketing and Food Safety: Challenges in Postharvest Management of Agricultural/Horticultural Products in Islamic Republic of Iran, 23–28 July 2005. Asian Productivity Organization, Tokyo, Japan.

Weatherhobo. 2012. Manado, Indonesia. 17 Oct. 2012. <<http://weatherhobo.com/indonesia/manado/>>.

Wilhelm, I. 2011. Building on presidential bonds, U.S. and Indonesia seek ways to increase academic partnerships. *Chronicle of Higher Education*, 31 Oct. 2011 issue. 17 Oct. 2012. <http://chronicle.com/article/USIndonesia-Seek-Ways/129591/?sid=at&utm_source=at&utm_medium=en>.