PAPER 2:
BREEDING AND BIOTECHNOLOGY RESEARCH PROGRAM OF INDONESIAN TROPICAL FRUIT RESEARCH INSTITUTE

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ABSTRACT

Indonesian Tropical Fruit Research Institute (ITFRI) is a part of Indonesian Agency of Agricultural Research and Development (IAARD), Department of Agriculture. The reponsibility of ITFRI is to produce technologies for increasing competitiveness of tropical fruit agribusiness in the global market. The priority commodities are divided into main and potential commodities. The main commodities are banana, mango, mangosteen, and salacca, while the potential commodities are papaya, durian, avocado, watermelon, melon, pineapple, and breadfruit. Research activities of ITFRI are divided into three groups, namely fruit breeding, ecophysiology, and pests and deseases research. This paper explains about the activities in breeding and biotechnology research, concerning management of genetic resources, conventional breeding, molecular breeding, conservation and use of tropical fruits, and seed production and distribution. Management of genetic resources is important in mantaining tropical fruit germplasms. Cultivar improvement is directed to produce superior cultivars for meeting rising consumer demands, high productivity, and resistant to biotic and abiotic stress. Seed propagation, distribution and dissemination are the key factors in developing new cultivars and to increase technology adoption.

Keywords: genetic resources, conventional breeding, molecular breeding, tropical fruits

INTRODUCTION

Fruits are important sources of vitamins, minerals and supplemental food, and play a role in maintaining the body's nutritional balance. Fruit commodities have high economic value and potential to increase family income (Soemarwoto and Soemarwoto, 1984). The need for fruit crops in Indonesia increases from year to year as the population increases and increase of public awareness on nutrition. The efforts to increase production and quality of fruit crops in Indonesia are aimed to fulfill domestic and export demands. Approximately 392 fruit species are found in Indonesia, but only a few have been cultivated. Most of these are still growing wild in the forests (Soedjito and Uji, 1987). Conservation of cultivated and wild tropical fruit species is an urgent need since it provides direct benefit to livelihoods through the development of new products as well as their role in maintaining natural ecosystems (Stolton et al., 2006). On-farm conservation is an effective farming strategy which also provides the answer for improving the quality of life through sustainable local genetic resource management on the basis of traditional farming systems (Maxted et al., 1997).

Indonesian Tropical Fruit Research Institute (ITFRI) is a part of Indonesian Agency of Agricultural Research and Development (IAARD), Department of Agriculture. The reponsibility of ITFRI is to produce technologies for increasing competitiveness of tropical fruit agribusiness for the global market. Research activities of ITFRI are divided into three groups, namely fruit breeding, ecophysiology, and pests and deseases research. This paper explains about the activities in breeding and biotechnology research, concerning management of genetic resources,

conventional breeding, molecular breeding, conservation and use of tropical fruits, and seed production and distribution. The contents of this paper are divided into five sections under the following headings: management of genetic resources, conventional breeding, molecular breeding, conservation and use of tropical fruit, and seed production and distribution.

MANAGEMENT OF FRUIT GENETIC RESOURCES

Previous studies have reported that there are 266 species of indigenous fruits encountered in Indonesia and 62 species of them are cultivated. Four genera of indigenous fruits are recommended to be developed in Indonesia such as *Durio*, *Mangifera*, *Garcinia* and *Nephelium*. This study also reported that duku (*Lansium domesticum*), salak (*Salacca zalacca*), matoa (*Pometia pinnata*) have good prospects for being developed in Indonesia (Uji, 2007). Management of genetic resources program in ITFRI consists of exploration, characterization, collection, selection, conservation and use of wild and cultivated tropical fruits.

Exploration, characterization, and collection genetic resources

ITFRI has conducted exploration, characterization, collection and evaluation of tropical fruits. The exploration data includes passport data and plant description can be accessed through http://sdghorti.puslithorti.net which was documented through the Institution Intranet Genetic Resources Information System (SIPPin). In managing fruit genetic resources ITFRI is supported by six experimental stations, i.e. Aripan and Sumani (West Sumatera), Subang (West Java), Cukurgondang, Kraton, and Pandean (East Java). The largest number of tropical fruit collection is found in the Aripan experimental farm. ITFRI has collected 200 accessions of banana (*Musaceae*) from Sumatera, Java, Maluku Islands and Papua. The collections are maintained *ex situ* in the field, *in vitro* in the laboratory and *in vivo* in the screenhouse. Other collections are 3 mango species, 5 durian species, 6 salacca species, 9 *Garcinia* species, and 6 *Ananas* species (Table 1).

Table 1. Collection of fruit genetic resources at ITFRI

Fruit Commodity	Species	Variety/Accessions	Location (Experimental farm)
Mango	3	208 varieties and progenies	Cukurgondang
Mangosteen	1	2 varieties and 73 accessions	Aripan
Banana	2	190 varieties and accessions	Sumani
Durian	5	78 varieties	Aripan and Sumani
Salacca	6	600 progenies from crossing	Aripan, Sumani, and Subang
Ananas	6	150 hybrid progenies	Aripan
Papaya	1	12 varieties and 20 hybrid progenies	Aripan and Sumani
Avocado	1	28 varieties	Aripan, Sumani
Matoa		3 varieties	Aripan
Star fruit		11 accessions	Aripan, Sumani
Dragon fruit		7 varieties	Aripan
Buni		1 variety	Subang
Cempedak		1 variety	Subang
Dewandaru		2 varieties	Subang
Duku		4 varieties	Aripan
Duwet		1 variety	Aripan, Subang
Genitu		1 variety	Subang
Jambu Air		27 accessions	Aripan

Table 1. Collection of fruit genetic resources at ITFRI (continued)

Fruit Commodity	Species	Variety/Accessions	Location (Experimental farm)
Guava		21 accessions	Sumani
Jambu bol		3 accessions	Aripan, Sumani
Citrus		15 accessions	Aripan, Sumani
Kecapi		2 varieties	Subang
Kedondong		2 varieties	Sumani, Subang
Kepel		1 variety	Subang
Kerendang		1 variety	Subang
Kesemek		2 varieties	Subang
Langsat		2 varieties	Aripan, Subang
Leci		2 varieties	Sumani
Lengkeng		9 varieties	Aripan, Sumani
Markisa		2 varieties	Sumani, Subang
Garcinia species	9		Aripan, Subang
Namnam		2 varieties	Subang
Nangka		10 varieties	Aripan, Subang
Rambutan		37 varieties	Aripan, Subang
Sarikaya		3 varieties	Cukur Gondang, Aripan
Sawo		7 varieties	Aripan, Sumnai, Subang
Sour Sop		14 varieties and accessions	Aripan, Sumani, Subang
Bread Fruit		3 varieties	Aripan, Sumani, Subang
Water melon		4 varieties	Aripan, Sumani

CONVENTIONAL BREEDING

Crossing and selection from indigenous population

Almost all Indonesian tropical fruit varieties were obtained from conventional breeding through selection of indigenous population and hybridization. ITFRI's genetic resource collection has been utilized as a parental source in breeding programs of new varieties of pineapple, salacca, durian, banana, mango, papaya, watermelon and melon (Table 2.)

Conventional hybridization of banana has started with the identification of resistant genotypes of male parents. For this, five accessions, namely, Kole (AA), Klutuk (BB), Jaran (*M. acuminata* spp. burmanica), BKT-11 (AAw) and Calcutta-4 (AAw) were obtained. These male parents were crossed with commercial varieties (female parents). The hybrid seeds were obtained when Calcutta-4 crossed with Kepok Kuning (ABB), Raja Siem (ABB) and Ketan (AAB). The hybrid plants are now being evaluated in the field. Selection of mango germplasm at Cukurgondang experimental farm has been released, totalling 14 varieties with some of these having red skin, namely Marifta-01 and Ken Layung, Red Garifta, Garifta Kuning, Garifta Gading, and Garifta Orange (Rebin and Karsinah, 2010)

Table 2. List of ITFRI varieties from conventional breeding

Fruit Commodity	Variety	Main characteristics	Breeding Method
Salacca	Sari Intan 295	Thick pulp, very sweet (19-21 ° Brix), good aroma, well adapted at low to medium altitude	Hybridisation
Salacca	Sari Kampar	Thick pulp, very sweet without astringent (20 – 22°Brix), good aroma, crispy, well adapted at low to medium altitudes	Hybridisation
Papaya	Merah Delima	Fruit weight: 0,8-1,9 kg, cylindris with star hole, thick (2,5 to 4,5 cm) and orange pulp, chewy, sweet taste (11-14,50°Brix), 43,40 to 98,25 mg Vit. C/100g, Fruiting 2 to 3 months after planting and first harvesting at 7 to 8 months after planting, 45 to 60 cm in height. Productivity 70 to 90 ton/ha/six months.	Hybridisation
Papaya	Dapina Agrihorti	Fruit weight (150 to 2500 g), thick pulp and red-orange in colour, sweet taste (11 to 13°Brix), productivity 60-100 ton/ha/year, shelf live: 8-10 days	Hybridisation
Papaya	Agrisolinda	Medium fruit (500-1000 g), thick and yellow bright pulp, sweet taste (12-13 ° Brix), slightly chewy texture, edible portion 75-85%, good aroma, high productivity 80 ton / ha / year, well adapted to drought stress, hard soil texture and high rain fall.	Hybridisation
Papaya	Carvita Agrihorti	Fruit weight 400-1100 g, yellow-green skin, red-orange pulp and 2-4 cm in thickness, sweet taste (10-14 ºBrix), high productivity, high vitamin C, and first harvesting at 220-230 days after planting	Hybridisation
Guava	Piraweh Ampalu	High productivity (250-280 kg/ton/year, 1,45 - 1,74 cm in thickness, yellow-green skin colour, red pulp, sweet taste (7,67-10,07 Brix), sugar and acid ratio 9,61-20,74, and edible portion 72,16-86,09%	Hybridisation
Watermelon	Serif Saga Agrihorti	Oblong fruit, light green, skin thickness 1,10-1,25 cm, fruit weight 4,33-5,55 kg, sugar content 10-12 ºBrix, sweet taste, red flesh colour, adapt well on lowland in the dry season.	Hybridisation
Mango	Agri Gardina 45	Oblong fruit, pointy fruit tip, red at the base and yellow tip, harvesting at 90 to100 days after flowering, adapting at dry and low to medium altitude, flowering to harvesting period 90-100, high productivity (136-273 fruits / tree / year at 3 years to 4 years), attractive fruit peel (red base, yellow tip), sweet flavor (TSS 15-18 ºBrix), medium aroma	Hybridisation
Mango	Mangga Gadung 21	Large fruit (350-650 g/fruit), thick flesh (7.26-8.8 cm), low fiber content, high starch content (10.27%). low water content (75-77%) and sweet taste (TSS 15-21 ºBrix).	Hybridisation
Mango	Garifta Orange	Sweet- sour flesh (16,8,0 ° Brix), Vitamin C 58.1 mg / 100 g, fruit length 8.5-11.5 cm; width 6.5-8.5 cm; thick pulp 2.4-3.2 cm; first flowering at 5 years old, flowering until harvest period 105-110 days. Productivity 135.4 kg /tree/ year; fruit weight 235-365 g, resistant to antrhracnose and fruit flies	Hybridisation
Mango	Garifta Merah	Sweet flesh (15.5° Brix), vitamin C 45.0 mg / 100 g; fruit length 14.0-16,5 cm; width 6.8-8.3 cm, thick pulp 2.8-13.6 cm; first flowering 5 years after planting, productivity 62.28 kg/tree/year; fruit weight 220-320 g; strong aroma, resistant to anthracnose and fruit flies.	Hybridisation
Mango	Garifta Kuning	Fruit weight 190-230 g/fruit, sweet (17,5 ° Brix), vitamin C 61,10 mg/100 g; fruit length 10.5 cm; width 8.8-10.3 cm, thick flesh (3.0-3.8 cm); first flowering 5 years after planting, productivity 76.76 kg/tree/year; fruit weight 320-400g; good aroma, and resistant to anthracnose and fruit flies	Hybridisation

Table 2. List of ITFRI varieties from conventional breeding (continued)

Fruit Commodity	Variety	Main characteristics	Breeding Method
Mango	Garifta Gading	Sweet taste (18.0 ° Brix), Vitamin C 45,1 m/ 100 g; thick flesh (2.8-3.4 cm); first fruiting 5 years after planting, productivity on 64,42 kg / tree/year; good aroma, and resistant to anthrachnose and fruit flies.	Hybridisation
Mangosteen	Ratu Kamang	Long pedicel (more than 2.5 cm). Round and pointed base (height/diameter ratio 0.93-0.94), number of fruit segments 5-8, round stigma lobe, water content 81.54-84.73%, fruits with gamboge disorder less than 8%, edible portion 32.67%, smooth skin.	Selection from indigenous populatiom
Mangosteen	Ratu Tembilahan	Short pedicel (< 1.5 cm), elliptic fruit (heigt/ diameter ratio 0.78–0.80), ellip stigma lobe, number of fruit segment (4-11), moisture content 78-82%, crunchy, slightly sour taste, edible portion 27.5%, firmly flesh, suitable for processing and for swamp land.	Selection from indigenous populatiom
Durian	Tambago Sungai Tarab	Ovoid flower buds, yellow Orange flesh, sweet taste, high productivity (820 -1220 kg/tree/ year).	Selection from indigenous populatiom
Durian	Sambeng	Fruit shape oval-obovoid, thick and yellow flesh, medium to thick, sweet taste, smooth and sligthly fiber.	Selection from indigenous populatiom
Durian	Kalumpang Sijunjung	Fruits shape globose, very sweet, thick pulp (1,18-1,98 cm), and high edible portion (35,33-43,18%).	Selection from indigenous populatiom
Banana	Raja Kinalun	Plant height 2,25 – 2,55 m, 4-5 suckers/plant, 8–9 hands / bunch, 12–14 finger/hand,100–105 fruits/bunch, 95–120 g/fruits, 32,6 mg vitamin C/100g, sweet taste (TSS 23,5–24,0o Brix), edible portion 80-85%. dessert banana, shelf live 15-24 days, productivity 15–20 ton/ha/year.	Selection from indigenous populatiom
Banana	Kepok Tanjung	Plant height 3,5-4 m, 3–5 suckers/plant, 15 - 25 kg/bunch, 9–17 hands/bunch, 13–18 fingers/hand, 150–250 fruits/bunch, yellow-orange pulp, 125–170 g/fruit, 23,0 mg vitamin C/100g, sweet taste (29–30 0Brix), dessert banana, shelf live 15-21 days, productivity 20-30 ton/ha/year resistant to blood deseases. Origin: Seram Island (Maluku Province)	Selection from indigenous populatiom

BREEDING FOR WILT RESISTANCE

Selection of seedling populations of four Indonesian wild *Musa* to *Fusarium* wilt resistance

The experiment was conducted by using the seeds of four wild *musa* species *M. Balbisiana* from Nusa Tenggara Timur, *M. acuminata* ssp. Sumatrana, *M. acuminata* ssp. Halabanensis, *M. acuminata* ssp. Microcarpa. The seedlings was then transfered to small pots prior to fusarium inoculation with VCG 01213/16 [TR4] and VCG 0124-5 [TR1]. Resistant plantlets will be transferred to the soil for further evaluation.

Evaluation candidate of superior banana cultivar resistant to *Foc*

The research was conducted at the Aripan Experimental Farm to test the resistance of two new varieties INA-03 and INA-02 to *Fusarium oxysporum* f. sp *cubense* (*Foc*). The variety was observed for vegetative and generative growth, and registered as a resistant variety to *Foc*. In the year of 2017, INA03 is being processed for release as a new variety resistant to *Foc*.

MOLECULAR BREEDING

Conventional breeding has been shown to improve quality of fruit crops. However, this method has many weaknesses, such as the long breeding time and the morphological character evaluation that is strongly influenced by the environment. Molecular breeding can serve to accelerate the breeding program, shorten the selection process, and eliminate the effect of environmental factors and plant growth.

Application of molecular markers for genetic variability study

Identification of genetic diversity of fruit crops has been done on mangosteen, mango, salacca, papaya, durian through the Random Amplified Polymorphic DNA (RAPD), Intersimple Sequence Repeat (ISSR), and Simple Sequence Repeat (SSR) techniques. Population genetic structure of mangosteen (*Garcinia mangostana* L.) was studied using 8 RAPD and 5 ISSR primers. A total of 106 samples from seven mangosteen populations in Purwakarta (West Java), Kerinci (Jambi), Tembilahan (Riau) and Bulukumba (South Sulawesi) were used in this study. Genetic diversity was analyzed using the GenAlex 6.2 program. The results showed the highest level of genetic diversity within populations found in Purwakarta population (Na=1.32 ,Ne=1.32, and I=0.28) and the lowest in Kerinci ((Na=1.00, Ne=1.17, and I=0.15). Pairwise populations of Kerinci and Bulukumba showed the closest genetic distance (D=0.08) with the highest uniformity (Nei I = 0.92). In contrast, the couple of Bulukumba and Tembilahan populations shows the furthest genetic distance (D= 0.164) with the lowest genetic uniformity (Nei I = 0.85). Analysis of Molecular Variance (AMOVA) showed that genetic diversity within population equal to among populations, i.e., 50%. Each of Purwakarta and Tembilahan populations were divided into two distinct genetic groups (Mansyah et al., 2012).

Application of microsatellite markers on mango was conducted to identify varieties, and genetic similarity of Gadung and Arumanis which are known as commercial mango cultivars. Past mango experts have claimed the Gadung cultivar to be synonymous with the Arumanis. Thirty microsatellite markers were used to discriminate the cultivars. The results showed that Gadung-21 was similar to Arumanis-135 (Tasliah, 2016). Molecular research on banana is used to determine somaclonal variation in tissue culture propagation. The observation showed the variation of DNA banding patterns occuring on the sixth and tenth sub culture plantlets (Sutanto, 2015). Molecular analysis of salacca was used to support the release of a new variety, Sari Intan 48. The results indicate that Salaca var. Sari intan 48 is genetically different with its comparable variety (Hadiati, 2015). Molecular analysis of pineapple obtained the specific bands of Cayenne and Queen groups. It can also provide information on the presence of somaclonal variation in ananas tissue cultured plants (Hadiati, 2015).

Application of molecular genetics for specific traits

The utilization of molecular markers for specific traits at ITFRI was for selecting banana varieties resistant to the fusarium wilt, selecting mango varieties based on fruit size and resistance to fruit drop, selecting mangosteen non gamboge disorder genotypes, and identification of SSR markers specific for yellow pulp color, and small seeds for durian.

Isolation and characterization of Resistance Gene to Fusarium Wilt on Indonesian Wild *Musa* Species

Genomic DNA was isolation from two banana cultivars (one suceptible cultivar: Barangan and one resistant cultivar: Rejang), and four wild species (*M. balbisiana, M. acuminata* ssp. sumatrana, *M. acuminata* ssp. halabanensis, *M. acuminata* ssp. microcarpa). Degenerate primers were used to isolate RGA fragments, and then the PCR product was cloned, sequenced

and analyzed using BLASTN, BLASTP, multiple alignment and phylogenetic analysis. Isolation and characterization of resistance genes from local banana cultivars were important in order to support the development of *Foc* resistant banana cultivars. Resistance gene analogues (RGAs) were isolated and characterized form three fusarium resistant banana cultivars using degenerate primers based on NBS domains. From 91 fragments sequenced, 17 fragments were positively NBS-type sequences and encoded as MNBS1-MNBS17. Phylogenetic analysis of MNBS deduced amino acid classified into three groups. The first group consisted of 14 members (MNBS1-MNBS14) with 97.4% identity, and the other three groups consisted of one member (MNBS15, MNBS16 and MNBS17, respectively) with 28.5% identity. All MNBS sequences were categorized as non-TIR-NBS-LRR. Comparison and phylogenetic analysis of MNBS with other known RGA and R genes showed that deduced amino acid MNBSs shared 91.7-98.8% identity with *Musa* NBS-LRR and 19.9-35.5% identity with known R genes. Among them, MNBS17 shared 50.5% identity with RGC2 (ABY75802) that was assosiated to *Foc* race 4 resistant *Musa* species (Sutanto et al., 2014)

Identification of molecular marker for selecting mango variety based on fruit size and resistancy to fruit drop

The research comprised of two subactivities : 1) Evaluation of SCAR markers for selection mango varieties based on fruit size, 2) Development of SNAP markers for fruit size and resistancy to fruit drop on mango. The research steps including design degenerate primers for polygalacturonase gene class II (PG2) and JOINTLESS and specific primers for geneFas (Yabby - like TF), sequencing of PCR products, sequence analysis and identification of SNP sites, and development and evaluation of SNAP markers. The research is still in progress.

Development of molecular markers for selecting non gamboge disorder mangosteen genotypes

The research consists of two activities namely sequencing specific PCR products from RAPD analysis and microsatellite analysis of gamboge disorder and non gamboge disorder genotypes. The results obtained 69 sequences of polymorphic and monomorphic DNA fragments on mangosteen. Among the sequences found was a DNA fragment similar to the enzyme suspected to be associated with the calcium/calmodulin-dependent protein kinase II delta (CAMK2D). This enzyme works for regulation of calcium ions and xyloglucan galactosyltransferase for cell wall physiology mechanisms allegedly related to mangosteen damage by yellow latex. Other sequences obtained indicated that the mangosteen individuals were different in molecular characters of microsatellite DNA fragment or transposon which is known as non coding region (Mansyah et al., 2015). Microsatellite analysis showed variation of IGMP 012 SSR locus of non gamboge disorder and gamboge disorder genotype of mangosteen (Mansyah et al., 2016).

Identification and characterization of SNP markers for selecting non-astrigent genotypes on salacca

The activities including DNA extraction, DNA amplification with specific primers for gene*LAR* and *ANR*, and sequencing PCR product. The observations including analysis and identification of *non-synonymous* SNP situs, design specific primers for SNAP marker, and evaluation of SNAP primers efectivity. The research is still in progress.

Identification of SSR markers for yellow pulp and small seeds on durian

The research was conducted by a bulked pseudo-segregant analysis (BpSA). The results obtained showed 3 loci suspected as potential marker for identification of yellow flesh of durian, mDz3G731, mDz2E9, and mDz6F06; 2 loci as a marker for the identification of large seed

characters, mDz1G3 and mDz03A31; as well as 2 locus for small seed character, mDz1G102 and mDz1C41. The three loci of mDz3G731, mDz2E9, and mDz6F06 should be tested for use as a specific identification for yellow flesh, large seeds and small seeds (Santoso, 2015).

CONSERVATION AND USE OF TROPICAL AND WILD TROPICAL FRUIT

Conservation of five Indonesian bana local cultivars on farmers orchard

Planting of five Indonesian banana local cultivars Ambon Hijau (AAA), Kepok Tanjung (ABB), Barangan (AAA), Bile (AB), Libod (AA) were conducted at Kecamatan Situjuh Kabupaten Lima Puluh Kota, West Sumatera. It is necessary to introduce local cultivars to farmers, as well study the acceptance of farmers and the market to the cultivars in addition to know the adaptability of the local cultivars to be developed by farmers. Activities that have been implemented are coordination with farmer groups, banana seed production, training of banana cultivation and pest and deseases control. The next activity is the distribution banana seedlings.

Planting banana var "Kepok Tanjung" at Nagari Salayo, Kabupaten Solok

The activity started in 2017 by the planting of banana var Kepok Tanjung at Selayo, the main production area of bananas. Kepok Tanjung is a banana variety which has no heart and naturally avoids the incursion of the banana blood desease.In this location, banana was wiped off by the banana blood disease. The objective of this program is to rejuvenate the banana production in this location. The local goverment of Solok district strongly supports the program and will develop Selayo as a Banana village.

Conservation and use of *Garcinia* species based on Community Based-Biodiversity Management (CBM)

This activity has been developed on the basis of Bioversity International's activities from the "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services", project's priority on *Garcinia* species. This underutilized species grows on buffer zonse in the forest of Sijunjung district-West Sumatra, is not well maintained and in danger of extinction by rapid genetic erosion due to habitat destruction, agricultural expansion, conversion of land for settlement, and uncontrolled exploitation. These can be addressed by managing *Garcinia* genetic resources through conservation and utilisation by implementation of the 'Community Based-Biodiversity Management' (CBM) strategy which includes: 1) Documenting the agreed procedures for managing community-based knowledge among key stakeholders; 2) Identification of local community-based organizations (CBOs) for implementing farmers information database; 3) Nursery community development; 4) Recognizing and promoting diversity through diversity fairs; and 5) Supervising planting material multiplication and added value to support conservation. In the third year of activities, the local community has successfully produced 'Garci-tea', a unique product of *Garcinia atroviridis*. These activities are successful in creating new income generation opportunities in rural areas and bringing the local genetic resources, *Garcinia* atroviridis, from the forest to the international market. Further activities are needed for ensuring the sustainability of the CBM in collaboration with the local goverment. In the long run, the conservation activities will contribute to ecosystem services and in reduce negative impacts of climate change. Before this activity the community was not aware of the diversity of genetic resources they possessed and did not utilize the local genetic resources to improve economy. Instead they were cutting down the rare fruit trees, the plants grown in the forest, and had lack of local government participation. In the third year of the activity, several benefits arose such as the community recognizing their genetic resources, they begun utilizing the asam gelugur (*Garcinia atroviridis*) in bioindustry (dry leave and fruits), availability

of plant materials for planting in conservation locations increasef, and the local governments started to participate in conservation. These conservation activities need to be mantained and facilitated by infrastructure to initiate the development of bioindustry products. Another important activity is the promotion of processed products and linking farmers to the market. Collaboration of governments, communities and the private sector is required through the management and utilization of local genetic resources for ecological, economic and social benefits.

SEED PRODUCTION AND DISTRIBUTION

One of the problems in fruit crop development in Indonesia is the limitation of plant materials (seedlings) to be distributed, due to: 1) Limited number of parent trees as a source of seeds; Most of the new varieties are released as single trees; 2) Slow seedling growth; 3) Limited propagation techniques; 4) The seed availlability is dependant on fruit season; and 5) Plant tissue culture technology is still limited.

The availability of good quality seedlings is required to increase fruit production. The Indonesian Agency for Agricultural Research has developed a Tropical Fruit Seed Production Unit to produce and distribute tropical fruit seeds. The seed production program consists of: 1) Increasing the number of parent trees through determination of duplicate trees, DNA analysis, registration of parent trees, and developing Foundation Blocks of scion; 2) Accelerate the growth of seedlings; and 3) Provision of seed production facilities and infrastructure. These activities complement and support the Indonesian Ministry of Agriculture's program, the 'Year of Horticulture 2018'. For the year 2017, a total of 971,000 tropical fruit plant seedlings consisting of mango, mangosteen, durian, banana, salacca, papaya, and breadfruit will be produced for distribution to farmers and growers.

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