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Conservation and utilization of *Melaleuca cajuputi* sub sp *cajuputi*, an indigenous species in Moluccas Island, Indonesia

A Rimbawanto*¹, N K Kartikawati¹ and F Latumahina²

¹ Centre of Forest Biotechnology and Tree Improvement, Jl. Palagan Tentara Pelajar Km 15, Purwobinangun, Pakem, Sleman 55582

² Faculty of Forestry, Pattimura University. Jl. Ir. M. Putuhena Poka Ambon Maluku 97233

*E-mail: rimba@indo.net.id

Abstract *Melaleuca cajuput* (cajuput) subsp. *cajuputi* is an endemic species of Indonesia, found naturally in the island of Buru, Seram and Ambon and cultivated in Java. The cajuputi tree is harvested for the leaves which contain important essential oil of 1,8 cineole. Because of intensive utilization and inappropriate management of the resources, the genetic diversity in the natural distribution is under threat. Collection of genetic materials across its natural distribution conducted in 1995 and 1998 had captured more than 160 genotypes for screening of high oil yield and 1,8 cineole content. The selected genotypes had been planted as seed orchards in Java for production of genetically improved seeds. Breeding program is continuing to produce elite clones. The use of superior seeds/clones for plantation is the best solution to increase cajuput oil production and to achieve self-sufficiency in oil supply. Both industrial scale and smallholder plantations are being established to increase the national production which currently stood at around 650 ton/year whilst domestic demand is already over 3500 ton/year. The species is a good example of successful domestication. The native stands are still utilized for oil production and plantations outside the natural range are developing. The paper also discusses importance of breeding program to increase cajuputi oil production in Indonesia.

1. Introduction

Cajuput is one of the plants in the family Myrtaceae of the genus *Melaleuca*. In the old literature Cajuput scientific name was *Melaleuca leucadendra* or *M. leucadendron* [1] The name has been revised to *Melaleuca cajuputi* subsp. *cajuputi*. *M. cajuputi*, that consists of 3 subspecies: 1). subsp. *cajuputi* Powell, 2). subsp. *cumingiana* (Turcz.) Barlow, and 3) subsp. *platyphylla* Barlow [1]

Natural distribution of *M. cajuputi* subsp. *cajuputi* covers Western Australia, Northern Australia (Northern Territory) and Indonesia, namely in Ambon, Buru, Seram, and eastern Timor, for subsp. *cumingiana* (Turcz.) Barlow, covering the western part of Indonesia (Sumatra, West Java and Southern Kalimantan), Malaysia, Myanmar, Thailand and Vietnam, while subsp. *platyphylla* Barlow covers the northern part of Queensland / Australia, the northwestern part of Papua New Guinea, the southern part of Papua, Aru and and Tanimbar [2], see Figure 1.

In its natural distribution, the tree has become scarce because of inappropriate management. The cajuputi tree is harvested for the leaves which contain important essential oil of 1,8 cineole. As leaves is the main biomass product, the local has applied burning practice in cajuputi stands to stimulate the growth of new shoots and their leaves. Consequently, the main stem is dead because of repeated burning (figure 2). Since cajuputi tree is a good root sucker, new shoots grow profusedly from the disturbed root forming a blanket of shoots (figure 3). These dense shoots are a good source of leaves for the local to collect. Up till these days, local people in Buru, Seram and Ambon are still dependant



on cajuput genetic resources for their livelihood, particularly as source of cajuput oil. There is more than 100 household cajuput industrial in Mollucas [4].

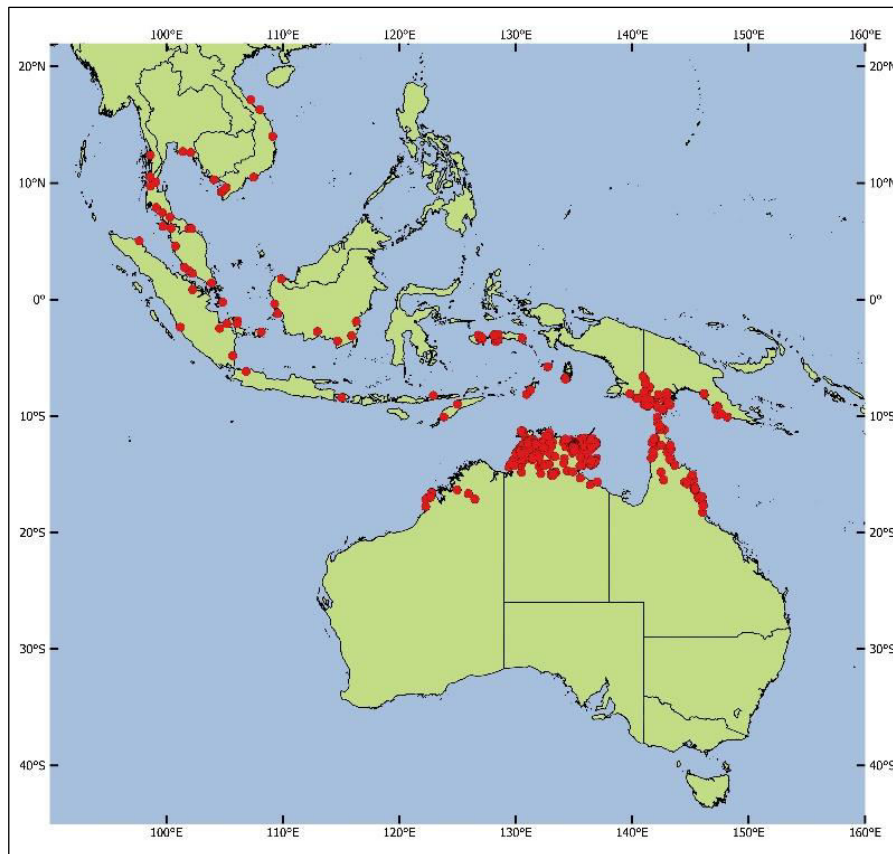


Figure 1. Natural distribution *Melaleuca cajuputi* [3].

Cajuput plantation in Moluccas spread over 4 districts, namely in Buru 125000 Ha, West Seram 60000 ha, Southeast Moluccas 25000 Ha and Central Moluccas 70000 Ha. Moluccas Province has annual production cajuput oil from natural plantation reaches 21.98 tons in 2016 and increase to 32.65 tons in 2017 [5].

The leaves of *M. cajuputi* possess antibacterial, anti-inflammatory and anodyne properties and are used traditionally against pain, burns, colds, influenza and dyspepsia. Cajuputi oil is produced from the leaves by steam distillation. Cajuputi oil is classified as traditional medicine for treating illnesses such as colic, headache, toothache, earache, leg cramps, various types of pains, skin disease, fresh wounds, and burns; internally, a small dose serves as a diaphoretic, an antispasmodic, a stimulant, as well as being used as antibacterial. As such demand for cajuputi oil has been on a steady increase. In fact, Indonesia is the world biggest producer and consumer of cajuputi oil. Published figures put the production figure at around 650 ton/year, whilst demand has exceeded 3500 ton/year [6] The gap of demand against supply is filled by imported eucalypt oil, which also contains 1,8 cineole

In Indonesia it is used externally to treat colic, headache, toothache, earache, leg cramps, various types of pains, skin disease, fresh wounds, and burns; internally, a small dose serves as a diaphoretic, an antispasmodic, and a stimulant. Cajuputi oil is also known to have other health benefit. Recent study examined the suitability of cajuputi oil for flavour ingredient in cajuput candy [7]



Figure 2. Landscape view of cajuputi after fire in Namlea, Buru Island.



Figure 3. Regrowth from root sucker after fire in Namlea, Buru Isl.

2. Domestication

Cajuputi tree was domesticated in Java in the early 1900 being established as plantation for oil production. Seeds were taken from trees in Buru and planted in central Java [8]. These original stands may had been the source of genetic materials for plantation in other parts of Java, which in 2015 has covered an area of around 31,000 ha. For more than 70 years, no attention was given to improve the genetic base of the cajuputi populations. Plantation manager in Java were simply collecting seeds from the existing trees for seedling production.

The narrow genetic base of the original cajuputi seeds brought in from Buru is destined to affect the productivity of the plantation. High level of inbreeding is likely to occur over successive generations. In fact, oil yield as one important parameter of productivity in plantation in Java has declined, with an average yield of around 0.6 – 0.8%.

A program to improve the genetic quality of cajuputi genetic resources was started in 1995, aiming at increasing the genetic diversity of Forest Genetic Resource in Java by introducing new genetic materials from the natural distribution as well improving the oil yield and cineole content [9]. Seeds were collected across its natural distribution in Buru, Seram and Ambon Islands as well as from northern Australia. Since the population of mature trees in Buru, Seram and Ambon is dwindling, collection of genetic materials is also considered as saving the diversity of the species. Some 272 trees were sampled for their seeds and leaves, and upon arrival in the lab they were screened for high cineole and oil yield. Details of seeds collected is presented in the table 1.

Table 1. Number of trees sampled in Maluku and Australia.

Seedlot	Species	Site	Latitude °S	Longitude ^o E	Number of trees
<u>Maluku</u>					
19532	<i>M. leucadendra</i>	Hukurila, Ambon	03°44'09"	128°14'57"	10
19533	<i>M. leucadendra</i>	Halong, Ambon	03°39'54"	128°13'10"	6
19534	<i>M. cajuputisubsp.cajuputi</i>	Ratagelombeng, Buru	03°08'33"	126°54'36"	8
19535	<i>M. cajuputisubsp.cajuputi</i>	Samalagi, Buru	03°03'59"	126°48'13"	4
19536	<i>M. cajuputisubsp.cajuputi</i>	Gogoria, Buru	03°19'12"	127°00'04"	16
19537	<i>M. cajuputisubsp.cajuputi</i>	Ykasar, Buru	03°20'34"	126°57'41"	13
19538	<i>M. cajuputisubsp.cajuputi</i>	WaiGeren, Buru	03°23'57"	126°55'28"	33
19539	<i>M. cajuputisubsp.cajuputi</i>	Masarete, Buru	03°22'38"	127°08'12"	12
19540	<i>M. cajuputisubsp.cajuputi</i>	Cotonea, Seram	03°04'22"	128°06'30"	18
19541	<i>M. cajuputisubsp.cajuputi</i>	Pelita Jaya, Seram	03°03'00"	128°08'00"	17
19542	<i>M. cajuputisubsp.cajuputi</i>	Waipirit, Seram	03°19'43"	128°20'20"	6
19543	<i>M. cajuputisubsp.cajuputi</i>	Suli, Ambon	03°37'02"	128°18'40"	6
19544	<i>M. cajuputisubsp.platyphylla</i>	Agtubul, Tanimbar	07°50'00"	131°21'00"	7
19545	<i>M. viridiflora</i>	Kantar, Tanimbar	08°12'24"	130°59'48"	5
19600	<i>M. cajuputisubsp.platyphylla</i>	Maror, Aru	06°48'48"	134°20'21"	1
19601	<i>M. leucadendra</i>	Maror, Aru	06°48'48"	134°22'00"	1
19602	<i>M. viridiflora</i>	Maror, Aru	06°48'48"	134°21'00"	1
<u>Australia</u>					
18897	<i>M. cajuputisubsp.cajuputi</i>	Mataranka, NT	14°56'00"	133°08'00"	5
18898	<i>M. cajuputisubsp.cajuputi</i>	Wangi, NT	13°09'00"	130°35'00"	5
18921	<i>M. cajuputisubsp.cajuputi</i>	Kapalga, NT	12°40'00"	132°19'00"	6
19567	<i>M. cajuputisubsp.cajuputi</i>	Coomalie Creek, NT	13°00'31"	131°06'53"	5
19568	<i>M. cajuputisubsp.cajuputi</i>	Port Keats, NT	14°14'02"	129°31'11"	11
19570	<i>M. cajuputisubsp.cajuputi</i>	Elizabeth Downs, NT	13°44'41"	130°27'19"	10
19571	<i>M. cajuputisubsp.cajuputi</i>	LaBelle, NT	13°08'04"	130°20'13"	15
19572	<i>M. cajuputisubsp.cajuputi</i>	Wangi, NT	13°09'51"	130°35'20"	20
19576	<i>M. cajuputisubsp.cajuputi</i>	Beagle Bay, WA	16°58'33"	122°40'04"	15
19577	<i>M. cajuputisubsp.cajuputi</i>	Carnot Bay Spring, WA	17°09'00"	122°18'00"	1
19578	<i>M. cajuputisubsp.cajuputi</i>	Waterbank Station, WA	17°46'00"	122°16'00"	5
19579	<i>M. cajuputisubsp.cajuputi</i>	Elizabeth River, WA	12°36'20"	131°04'21"	5
19580	<i>M. cajuputisubsp.cajuputi</i>	Berry Springs, NT	12°42'33"	131°00'02"	5

Sampling of cajuputi oil from local distillery in Buru in 1996 found that the oil quality is variable indicating the variability of the trees where the leaves were harvested from (J. Doran pers.comm.) as described in Table 2 and Table 3. Cajuputi oil is purchased and sold by traders in three grades in the Moluccas. Grading depends on where the trees are grown, which appears to affect the proportion of 1,8-cineole in the oil. Grade 1 oil of 55-65% cineole content comes from hillside trees. Grade 2 oil of 20-55% cineole content comes from trees on lower sites. Grade 3 oil presumably comes from locations that produce oils of very low cineole content, such as Gogoria and WaiGeren on Buru Island.

Table 2. Different quality of cajuputi oil from different distillery.

Provenance	Distillery	Quality	% 1,8-cineole
Buru	DesaNamlea	Grade 1	66.2
Buru	DesaNamlea	Grade 2	46.5
Buru	DesaNamlea	Grade 4	38.1
Buru	DesaWaiPuti	Grade 1	69.4
Buru	DesaJikuBesar	Grade 2	24.2
Ambon	DesaSuli	Grade 2	63.1
Seram	Komersil	Grade 1	36.9
Seram	DesaPelita Jaya	Grade 2	54.5

Details examination of the oil quality of the leaf samples reveal the diversity of genetic quality of the trees in different populations.

Table 3. Percentage of trees in a natural population that fulfilled the selection criteria of cineole content.

Provenance	No. of trees sampled	Trees with 1,8 cineole >39%	% population with 1,8 cineole >39%
Ratagelombeng, P.Buru	8	2	25%
Samalgi, P. Buru	4	1	25%
Ykasar, P. Buru	14	2	14%
WaiGeren, P. Buru	34	1	3%
Masarete, P. Buru	12	7	58%
Waipirit, P. Seram barat	6	2	33%
Pelita Jaya, P. Seram	17	5	29%
Cotonea, P. Seram barat	18	7	39%
Suli, P. Ambon	6	5	83%

First generation progeny trial, which later was converted into seed orchard, was established in 1998 in Gunungkidul Yogyakarta. Improved seeds of 1,2 % oil yield and 1,8 cineole of 67% were produced from this seed orchard. Series of breeding works were carried out to further improve the genetic quality, including progeny trial using broader genetic base, 2nd generation progeny trial, full sib progeny trial, clonal test and genetic gain trial. Outline of the breeding strategy is presented in the following diagram (Figure 4)

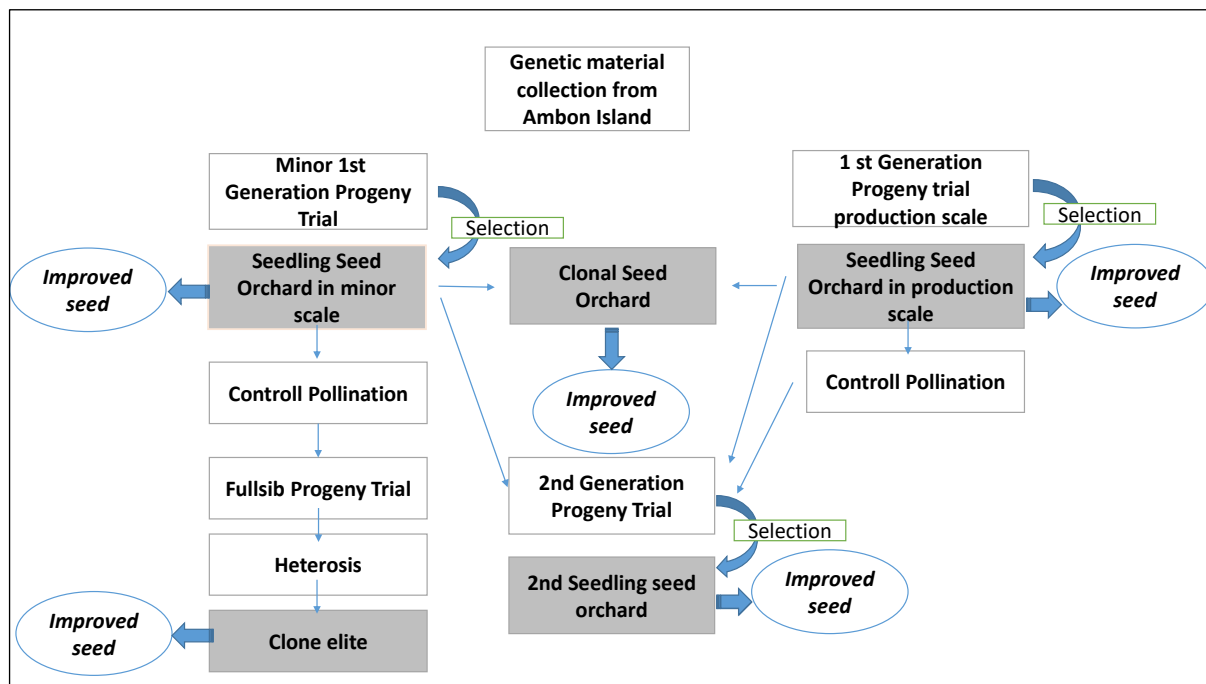


Figure 4. Breeding strategy of *Melaleuca cajuputi* sub sp cajuputi.

3. Utilization

Cajuputi tree is a good example of successful domestication of a species that leads to utilization for economic benefit. Since it was introduced to Java in 1926, cajuputi has been managed as commercial plantation to produce essential oil. A state company that manage public forest land in Java selected the species to be planted in areas where teak would not grow. The opportunity to develop the cajuputi oil industry is still very promising, given the large gap in supply and demand. Indonesia as the largest producer of cajuputi oil in the world has all the necessary factors (superior germplasm, land, climate, humans, financing) to take advantage of this opportunity.

In the last 5 years new plantations have been established in an attempt to increase oil production. Most notably, is the 4,000 ha plantation being established since 2015 in Bima West Nusa Tenggara (NTB). This large-scale cajuputi plantation is expected to drive the cajuputi oil industry in Indonesia, so that it can reduce imports of substitute oil. Smaller plantations were also planted in different areas in Sumatera, Jawa, Kalimantan and Papua by community group using genetically improved seeds.

Cajuputi plantation and its distillery is suitable for economic empowerment of villages. Small scale plantation of between 5-20 ha has been established in different areas in Indonesia. An example of successful small-scale plantation was established in 2015 in Kampung Rimbajaya Kabupaten Biak Numfor Papua initiated by Centre for Forest Biotechnology and Tree Improvement in Yogyakarta. A 5 ha cajuputi plantation was established using genetically improved seeds of high oil yield (>1.2%) and high 1,8 cineole content (>65%). Within 18 months after planting, leaves had been harvested and giving a good yield of oil as well as high in cineole content. Similar small-scale plantation of between 5-10 ha using high oil yield seeds are being established in 4 locations with grant from Ministry of Science and Technology. These smallholder plantations are part of a new partnership program known as Inti-Plasma or partnership between industry and smallholder farm, in which industry will take up the cajuputi oil produced by the smallholder farms. This arrangement will ensure farmers that their cajuputi oil sale is secure, so they can focus on producing oil.

4. Conservation status

As cajuput is still relatively common throughout its wide geographical range, there are no current conservation concerns. Study on genetic diversity in seed orchard showed that seed orchard in Paliyan Gunungkidul has a high genetic diversity (0.98) [10]. It means that base population for breeding strategy of cajuput is broad and during domestication process in establishing seed orchard the loss of genetic diversity very small. However, in order to increase the genetic base of the breeding population, it is necessary to explore and collect seeds from existing natural stands in Buru and Seram. These genetic materials would be useful for genetic infusion in the advance breeding populations.

Melaleuca cajuput sub sp *cajuputis* a good a root sucker and also sexual reproduction. In Ambon, cajuput propagation is done with root sucker; it is very rare to use seeds and seedlings like those managed in Java so the risk of clonality in cajuput in Ambon is very high. The same phenomena also occurs in *Melaleuca deanei* which grows in Sydney region extensive regenerate with root sucker and has a problem in clonality [11]. Clonal propagation in relation to biomass production and cajuput oil is not affected as long as the productivity of the cajuput plant is high. But from the genetic conservation point of view, this clonal plantation poses concerned over genetic diversity and the risk of being attacked by pests and diseases if the genetic diversity is low. Efforts to introduce superior seeds that have been produced by CFBTI to the Moluccas Islands is necessary to increase genetic diversity and plant productivity.

The conversion of cajuput stands into an illegal gold mine on Mount Botak in Buru Island has threatened the genetic diversity of cajuput, and highlighted the importance of in situ genetic conservation of the species (Figure 5). Although the illegal gold mining operation had been stopped, the cajuput stands had disappeared. The loss of cajuput on Mount Botak has implications for the loss of genetic diversity of cajuput in Ambon.



Figure 5. Mount Botak after illegal gold mining.

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