Introducing genetically improved *Melaleuca cajuputi* subsp cajuputi to increase farmers`s welfare: a success story in Papua

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**Abstract.** Cajuput tree is native to Maluku and produce 1,8 cineole based essential oil. Since 1995, the Centre of Biotechnology and Tree Improvement has implemented a genetic improvement program of cajuput aiming to increase oil yield and oil content. The program has successfully produced superior seeds with the yield of 2%. In early 2016, a small scale pilot plantation of cajuput was established in 5 ha community land di Kampung Rimbajaya Distrik Biak Timur Kabupaten Biak, Papua. Leaf distillation started at the end of 2017 using a simple distillation unit. Previously, the local farmers were woodcutters and shifting cultivators. After the establishment of cajuput plantation, they became permanent farmers and cajuput oil refiners. Leaf distillation of genetically improved trees produced oil yield of 1.3%, a significant improvement from the average of 0.6 – 0.8% yield of unimproved trees. This 5 ha plantation of 2500 trees/ha potentially produce 400 kg/year. Some of the cajuput oil is sold in a local market in 8ml bottle. This cajuput oil production scheme has increased the farmers welfare. Furthermore, the success story of Kovarwis farmers inspired other farmers surrounding Rimbajaya to develop similar plantation. When this small-scale plantation is replicated in other parts of Indonesia, cajuput oil production will increase and Indonesia may one day become self-sufficient in cajuput oil. An agreement with cajuput packaging company is being establish to ensure that the oil produce by farmers will be purchased by the company and thus ensuring steady supply of good quality oil.

**Keywords:** cajuput oil, Papua, improved seed, sosial forestry

1. **Introduction**

Agroforestry is based on the premise that land-use systems that are structurally and functionally more complex than either crop or tree result in greater efficiency of resources (nutrients, light, and water) capture and utilization, and greater structural diversity that entails tighter nutrient cycles [1]. Agroforestry practices have been implemented in many places with diverse of systems depending on the available of resources, crops and trees characteristics. Most of them are being taken place to improve the land-uses productivity and local people welfare.

Non-timber forest products (NTFPs) are a very abundant natural resource in Indonesia. They have excellent prospects for development that provide an economic value for improving people welfare. One of the NTFP commodities that has an excellent potential and good economic value is *Melaleuca cajuput sub sp cajuput* (cajuput). Cajuput is a plant producing essential oil that contains medicinal properties. In Indonesia, the natural stands of cajuput are distributed in the islands of Maluku, Buru, and Seram. In other countries, it is also found in the northern and western of Australia, Thailand, and Vietnam [2].
National demand for cajuput oil reaches 3500 tons/year. On the other hand, the national average capacity of cajuput oil production is only 600 tons/year that is mostly supplied from Perhutani (400 tons/year), KPH Yogyakarta (40-50 tons/year) and some home industries in the Maluku Islands [3]. This deficiency is then supplied through substitute oil of eucalyptus imported from China.

Some efforts for increasing the national capacity of cajuput oil production are being continuously taken place either through breeding or improving cultivation techniques. Since 1995, the Centre of Biotechnology and Tree Improvement (CFBTI) has implemented a genetic improvement program of cajuput aiming to increase oil yield and oil content [4]. Along the 20 years of breeding program, genetically improved seed had been produced in terms of improving oil yield and cineole content. Following the achievement in producing high quality of seed, demonstration plot of high productive cajuput plantations were then established in some locations. Other potential of cultivation techniques such as adopting agroforestry practices are also challenged to improve the cajuput productivity and socio-economical impact, particularly for local people.

This paper presents a success story in introducing genetically improved cajuput (Melaleuca cajuputi subsp cajuputi) to increase farmer’s welfare. The pilot project was established in 2016 in Biak, Papua which was set up under an integrated process from plantation, oil distillation and marketing of the oil product. After three years from the planting, the pilot project had some success in realising the economic impact of planting the improved cajuput for increasing farmer’s welfare. The project also implies for adopting potential agroforestry practices to obtain economic added value from the cajuput plantation.

2. Materials and Methods

2.1. Framework agroforestry for NTFP

![Diagram of framework cajuput plantation](image)

**Figure 1. Scheme of framework cajuput plantation**

In this study, the framework of project was set up under three considerations with a basis of the uses of genetically improved seed, that is 1) planting cajuput plantation under potential agroforestry system, 2) sustainable of cajuput oil production and market, 3) sustainable economic income for farmer. Breeding process of cajuput followed by the small scale/demonstration plot plantation and cajuput oil home
industry will be the first main target in this framework. In future, it will be scaled up and linked into ‘CORE- PLASMA’ schemes in which the sustainability of market for oil production could be more ensured and offer in competitive price. In addition, potential agroforestry system will be challenged in this cajuput plantation to increase the added value.

2.2. Study site
Cajuputi plantation is establish in Kampung Rimbajaya, East Biak District, Biak Numfor Regency, in collaboration with Biak Numfor Forest Management Unit (FMU) in Papua Province. The site is at 1°08'21.7"S - 136°12'56.8"E with the altitude about 60 m above sea level (Figure 2).

![Figure 2. Location Biak Numfor District. Papua](image)

Based on data from First Class Station of Meteorology Frans Kaisiepo Biak, the average temperature in Biak Numfor during 2018 was 27.2°C. Minimum temperature average of Biak Numfor in 2018 was 23.2°C while the maximum temperature average was 32.0°C. The average of relative humidity during 2018 in Biak Numfor was 87.0%. The proportion of rainfall was 171.7 mm with the highest rainfall was in March (297.2 mm), and the lowest was in November (97.7 mm). Total rainfall in 2018 is 2008.9 mm. Meanwhile, the average of rain days in a month was 19.4 rain days. [5].

2.3. Local people / farmer selection
Biak regency population is approximately 148,404 people (data 2018) with an average population density of 57 people / km² [5]. The daily livelihood of the community is as fishermen, farmers, traders, and government employees. In the East Biak district, there is a village that was once a transmigrant village, called Rimba Jaya. Some communities have livelihoods as farmers, and land tenants in the forest. Many years ago, the land in Rimba Jaya were planted with agathis, bamboo and fruit plants.

2.4. Introducing planting material of improved cajuput
The results of cajuputi breeding program with local genetic sources have been able to increase the productivity of cajuputi oil yield from 0.8% (an average) to 1.25% -1.5%. Superior cajuputi seed have been produced and are available to the public. This pilot project in Rimbajaya is considered as a testing ground for the actual genetic gain of improved seed, as well as an attempt to introduce cajuput industry to improve farmer’s welfare.

The establishment of a demonstration plot for the development of cajuputi in Rimba Jaya was initiated by CFBTI collaborate with the Biak Numfor FMU. Nurseries activities, plant maintaining and leaf harvesting are carried out by CFBTI researchers collaborate with farmer and technical staff at the Biak Numfor FMU. The area of the plantation was 5 hectares community land managed by Kovarwis farmer group, using superior seeds of cajuput with spacing 4 x 1 m. Installation of a distillation unit
produced by Balai Riset dan Standarisasi Industri Ambon with a capacity of 100 kg was carried out in 2017. Given the good growth the trees, the leaves were first harvested within 18 months since planting.

3. Results and Discussions

3.1. Project initiation
Introducing an initiative project for planting new species in local people’s land requires careful approachment. To address a good understanding of local people of Biak, Papua for the project of cajuput planting, before the implementation CFBTI in collaboration with Fprest Managemen Unit (FMU) and regional office of Biak Numfor regency held periodical meeting of socialization to local people and other relevant stakeholders (Figure 3). It provides a basic introduction to the cajuput plants including the information of genetically improved seed, cultivation, benefit, profitability and economic analysis. There was support from the local government and good enthusiasm of the farmer groups to develop cajuputi in Biak Numfor.

![Figure 3. Coordination and Socialisation Pilot project developing cajuput plantation](image)

3.2. Project implementation
The project was implemented through four main steps: 1) improved seed and seedling preparation, 2) site selection and planting, 3) leaf harvesting and distilling, 4) packaging and marketing of the cajuput oil product.

3.2.1. Improved seed and seedling preparation. Improved seed for this project was supplied by CFBTI as a product of breeding. Amount of 10 gram cajuput seed was prepared that could produce around 30,000 seedlings. In the case of cajuput, seedling preparation is one of critical steps due to appearing some difficulties, such as in the process of germination and pricking out. Moreover, cajuputi is a new species developed in Biak Numfor region and the local people was not familiar in the cultivation of this species. The facilities for nursery is also limited. Therefore it is necessary to conduct a transfer technology in nursery from CFBTI staff to the farmer and technical staff at the Biak Numfor FMU. Regardless the existing of constraints, the number of seedlings available for the target of area is around 15,000.

3.2.2. Site selection and planting. The selected area for planting cajuputi is around 5 hectares located in Rimba Jaya Village, Biak Timur District, Biak Numfor Regency or around 20 km from the nursery. The site is at 1°08'21.7"S - 136°12'56.8" E with the altitude is ± 60 meters above sea level. Previous vegetation of the area was occupied by agathis which is surrounded by other species such as Gmelina, coconut, rambutan, durian, matoa. The site topography is flat, and the soil type is mediterranean, brownish-yellow that indicates a relatively infertile soil. This site conditions is suitable for growing cajuput because this species can grow in marginal lands and in soil with poor drainage [2]; [4]
Land preparation is carried out by manual land clearing with no plowing. The three months old of cajuput seedling (around 30 cm height) were planted in spacing of 4 × 1 meters to set the tree density of 2500 tree per hectare. The size of planting holes is 40 × 40 × 40 cm which was then added by 5 grams of fertilizer and termiticide prior to the planting of seedling (Figure.4). As the targeted of tree density, 12500 cajuput seedling were planted in all the total area of 5 hectares. Tree growth were monitored periodically at every six months to assess the tree productivity and anticipating any potential threats of pest and diseases. The planted cajuput tree in Biak Numfor showed very good growth indicating the suited site and climate in Biak for growing of cajuput. The average growth at 18 months old was 6 meters in height with the amount of leaf biomass ranging from 9 to 12 kg per tree. The leaf of cajuput tree in this project could be further continuously harvested at every 9 months up to 25 years age.

![Figure 4. Land preparing, distributing and planting cajuput trees](image_url)

### 3.2.3. Leaf harvesting and distilling

The first harvesting of cajuput leaves is commonly practiced at two years of age considering the stability of essential oil produced and also performance of trees for pruning. But in this site of project, considering superior growth of the planted cajuput tree, the first harvesting time could be started 6 months earlier at 18 months of age. The amount of leaves biomass at the first harvesting reached around 12 kg per tree. The same as ordinary technique, coppice system was practiced during the first harvesting by cutting the main stem of cajuput tree at around 1 meter above the ground (Figure.5). With 80% of survival rates, the first harvesting capacity of the leaves biomass
production from the 5 ha cajuput plantation in Biak is around 120 tonnes. However, due to the limitation of labour for leaves collection, at the moment the harvesting was practiced only from 5000 trees during the first harvesting.

Collected leaves was transferred by small vehicle to the distillation site located at around 1 km from the plantation. The distillation unit was set under a capacity of 100 kg leaves for each time of distilling. The results of the distilling show that the oil yield is 1.3%. The oil yield of cajuput at the pilot project is better as compared to the yield of cajuput trees planted using ordinary seeds that is only ranging 0.7% - 0.9% [6]

Figure 5. Leaf Harvesting and distilling (above). Performance cajuput stand after pruning (bottom).

3.2.4. Packaging and marketing of the cajuput oil product. Cajuput oil production is rarely found in Papua region. The Farmers under Kovarvis Farmer Group in Biak for this project seemed to be the first cajuput oil producer in Papua. This condition provided a good chance for the Farmers in this project to attract the consumers through selling the original 100% cajuput oil, particularly for Papua region. There are two types of packaging in the cajuput oil selling practiced by the Farmers that is as a crude oil and a small-packages. The crude cajuput oil was distributed in litre unit, while the small-packages was in roll and spray of 10 ml - 30 ml mini bottle (Figure 6).
3.3. Social Economic Impact

Before there was cajuputi planting, the community worked as loggers and shifting cultivators. Over time, the number of trees felled has declined in addition to the illegal logging restrictions. Besides the cost of cutting down trees is also not comparable with the benefits. Shifting cultivation is also increasingly less attractive because the cultivated land is getting further away from where they live. The existence of cajuputi plantations has had an impact on changes in the socio-economic conditions of the community. The mainstream that living by timber harvesting in the forest is no longer.

The Kovarwis farmer group has felt the economic impact of cajuputi planting in the village of Rimbajaya. According to [6] stated that the potential of cajuputi oil production from the first harvesting (age 18-20 months) with an area of 5 ha is 1.125 tons of oil. It further stated that taking into account the cost of planting per hectare of Rp. 23,000,000 and operational costs per hectare per year for Rp. 14,000,000, as well as the purchase of a 100 kg capacity distillation unit for Rp. 14,000,000, in the second year (one year after planting) a profit of Rp. 37,800,000; while in the 3rd year onwards the profit potential can reach Rp. 60,850,000; assuming oil prices have not changed. If the cost components of plant maintenance, harvesting and leaf distilling are excluded from production costs because the activity carried out by the farmer groups themselves, then the profit in the second year can reach Rp. 188,000,000, while in the third year and so the potential to get a net profit of 122,000,000.

At present cajuputi oil production in the village of Rimbajaya has only reached approximately 400 liters. The low production is partly due to the limited number of harvested leaf and the fact that there is only 1 distillation unit. Ideally, for a 5 ha, it needs 2 distillation units. Nevertheless, the economic impact of this 5 ha cajuput plantation has been felt by the farmers (Kovarwis farmers group). [7] conducted a financial analysis of the cajuputi farm in Rimbajaya village stating that the NPV for 25 years at a 9.2% discount rate was Rp. 757,171,972.00 (Rp. 151,434,394.32 per hectare), IRR of 72.74%, BCR of 1.77 and payback period after 2 years and 3 months.

3.4. Future direction

One of the many challenges in improving farmer’s livelihood is lack of legal and institutional framework at the village level. Generally, farmers understand well the economics of producing and selling, but their understanding of the rules and regulations are often lacking.

Along with the increasing production of cajuputi oil from Rimbajaya, institutional efforts are needed to regulate the marketing of the oil produced. It is anticipated that in the future more farmers would be involved in cajuput oil production. In Rimbajaya, a Village-Owned Enterprise (BUMDES) has been established to manage the economically important produce, including cajuputi oil. BUMDES can play a role in facilitating farmers to obtain licensing from the district government to sell the cajuput in the market. Such licensing will ensure customers of the legality of the products.
3.5. Core-plasm concept
For small scale cajuput plantation to be sustainable, the sale of cajuputi oil must be secured. They cannot rely on retail sale as the volume will be very small. Crude cajuput oil is a ready to use product. In fact, there are many small oil distillers in places like Buru. Seram or Ambon that package the oil and sell them in local market. The bulk of the oil, however normally go to local trader who supply bigger industry in large volume.

Motivated by the successful operation in Kampung Rimba Jaya, a scheme of collaboration between industry and cajuput grower was initiated. With grant from government, small scale plantation of between 5 -10 ha will be established in several locations. When the leaves are ready for harvesting, within 24 months since planting, they will be distilled, and the oil produced will be taken up by a cajuput oil packaging industry. When this scheme is operational, farmers will have secure income and oil packaging industry will get constant supply of raw material. The long term goal of this collaborative scheme is that Indonesia can produce sufficient amount of cajuput oil to meet the domestic demand. Eventually, the need to import eucalypt oil as substitute will no longer exist.

4. Conclusion
Cajuput plantation and leaf distillation in Biak, Papua gave sosio economic impact for the farmer. The succes story establishment household cajuput industri has inspiring other farmer to follow the same activity. In the national scale the development of the cajuput in small scale industrial model involving the community needs to be developed in other locations to improve the welfare of the community and be able to increase national cajuput oil production and reduce the import of substitute oil.

References
[1] Nair, “Encyclopedia of Ecology,” Rosa Mosquera-Losada. 2008.
[2] J. C. Brophy, J., Craven, L.A., & Doran, Melaleucas. Their Botany, essential oils and users. Canberra: ACIAR Monograph N0 156. Australian Centre for International Agricultural Research, 2013.
[3] A. Rimbawanto, N. K. Kartikawati, and Prastyono, Minyak Kayuputih dari Tanaman Asli Indonesia untuk Masyarakat Indonesia. Yogyakarta, Indonesia: Penerbit Kaliwangi, 2017.
[4] J. Doran, A. Rimbawanto, V. Gunn, B, and A. Nirsatmanto, Breeding Plan for Melaleuca cajuputi subsp. cajuputi in Indonesia. Yogyakarta, Indonesia: CSIRO Forestry and Forest Product, Australia Tree Seed Centre and Forest Tree Improvement Research and Development Institute, 1998.
[5] Badan Pusat Statistik Kabupaten Biak-Numfor, Biak Numfor dalam Angka 2019. 2019.
[6] Rimbawanto A, Prastyono, Kartikawati NK, Sumardi, “Kebun Kayuputih Skala Kecil Untuk Memenuhi Kebutuhan Minyak Kayuputih Dalam Negeri dan Mengurangi Impor Minyak Substitusi,” in Prosiding Seminar Nasional Silvikultur IV. Penerapan Silvikultur untuk Pengelolaan Hutan dan Pengentasan Kemiskinan, 2019.
[7] Prastyono, Rimbawanto, Kartikawati NK, Sumardi, “Analisis Finansial Perkebunan Kayuputih Skala Kecil: Studi Kasus Pilot Project Pengembangan Kayuputih untuk Kelompok Tani di Kampung Rimbajaya, Distrik Biak Timur.”

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