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Propagation of *Bajakah* and *Akar Kuning* to Support Bioprospecting of Traditional Medicine from Peat Swamp Forests: Prospect and Challenges

Hesti Lestari Tata[1*], Septiana Asih Widuri[2], Noorcahyati[2], Antun Puspanti[*], Bina Swasta Sitepu[3], Mawazin[3]

[1]Research Center for Ecology and Ethnobiology, The National Research and Innovation Agency (BRIN), Jalan Raya Cibinong Km. 46, Bogor, Indonesia 16911
[2]Balai Pengujian Standar Instrumen Lingkungan Hidup dan Kehutanan Samboja, Jalan Raya Soekarno-Hatta Km. 38, Balikpapan, Indonesia 76136
[3]Research Center for Plant Conservation, Botanic Garden and Forestry, The National Research and Innovation Agency (BRIN), Jalan Raya Cibinong Km. 46, Bogor, Indonesia 16911

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Abstract

Bajakah and akar kuning are known as traditional medicine from peatlands, which are usually extracted from their natural habitats. Over extraction and illegal cutting have become a threat to the extinction of both species. Therefore, propagation and cultivation of those medicinal plants are necessary to be conducted outside forest areas to meet the demand of raw materials of traditional medicine and minimize the risk of species extinction. The experiment of stem cutting propagation of two bajakah species (*Uncaria acida and Salacia sp.*) *and akar kuning* (*Fibraurea tinctoria*) *were conducted separately in two different nurseries. The results showed that stem cuttings of woody liana could produce more than one new shoot. The new shoots of U. acida and Salacia sp. grew after eight weeks, with a survival rate of 96% and 50%, respectively. The survival rate of F. tinctoria stem cutting after six weeks was 83.3%. These indicate that bajakah and akar kuning can be propagated and cultivated to support the bioprospecting of traditional medicinal plants. Despite some challenges, such as limitation of akar kuning and bajakah population at the pole stage in their habitats, it is an initial step of a long process of bajakah and akar kuning bioprospecting.*

Keywords: Fibraurea tinctoria, Uncaria acida, Salacia sp., stem cutting, Kalimantan

**Correspondence author, email: made.hesti.lestari.tata@brin.go.id*

Introduction

Akar kuning and *bajakah* are traditional medicines from Kalimantan that have been used by traditional communities of Dayaks and Banjarese. Akar kuning is a group of species, consisted of *Coscinum fenestratum*, *Fibraurea tinctoria*, and *Arcangelisia flava* (Noorcahyati, 2012; 2017); while *bajakah* is a group of species of *Uncaria* spp. and *Salacia* sp. (Tata & Sopha, 2020). *Akar kuning* is used to remedy hepatitis, malaria, diabetic, and immune booster (Noorcahyati, 2012). It contains secondary metabolite, as antioxidant, anti-microbes, hepatoprotector, anti-diabetic. Berberin is known as an active metabolit compound of *F. tinctoria* and *A. flava* (Noorcahyati, 2017; Kolina et al., 2018). Some traditional communities believe that boiled stem of *bajakah* may be cured cancer, tumor, and cysts (Maulina et al., 2019; Tata & Sofa, 2020). The phytochemical compounds of three species of *bajakah* (*Salacia* sp., *U. acida*, and *U. gambir*) has been identified using GCMS-pyrolysis. *Bajakah* contained 30−40 types of phytochemical compounds, and the largest component is phenol, such as eugenol and piperidine (Paramita & Tata, 2021).

Among various plant diversity in Indonesia, *akar kuning* and *bajakah* have been recognized in bioprospecting. Bioprospecting is defined as systematic exploration and investigation of the commercialization of new phytochemical compounds, genes, proteins, and other products that have economic values (Dwiartama et al., 2020). To achieve the main goal of traditional medicine commercialization, cultivation of the traditional medicine, in this case, *akar kuning* and *bajakah*, shall be established. Sustainable cultivation and harvesting will provide raw materials of the traditional medicine industry (WHO, 2003; National Medicinal Plants Board, 2009).

Both *akar kuning* and *bajakah* are woody lianas, which grow naturally in the primary and secondary forest, in the peat swamp and lowland forests (Noorcahyati 2017; Tushar et al. 2008; Turner, 2018; Paarakh et al., 2008). Until recently, the specimens of *akar kuning* dan *bajakah* were collected from their natural habitat (Noorcahyati et al., 2016; Rinaldi et al., 2017; Kalima et al., 2021). Over cutting from their natural habitat may reduce their population drastically, because of low regeneration. *Akar kuning* (*Coscinum fenestratum*) has very low regeneration. The trees will produce seeds after 15 years. The dormant seeds need special treatment before germination (Tushar et al., 2008). Another report showed that many seeds of *F. tinctoria* appeared on the forest floor, and it has the potential to be used as a seed source (Kalima, 2021). Fruits of *akar kuning* are also known as the food of *orang utan* (*Pongo pygmeus*) (Morrogh-Bernard, 2009), which may affect the dormancy of the seeds. The seedling population of *F. tinctoria* in the peat swamp forest of Tabati in Mentangai, Central Kalimantan was reported abundantly in the amount of 375 and 675 stems ha^{-1} (Kalima, 2021).

On the contrary, very limited information about seeds and regeneration of *bajakah* (*Salacia* sp. and *U. acida*) in their natural habitat. A red *bajakah* (*U. gambir*) needs 53 days (almost 2 months) in fruiting development. Time accumulation from initiation to fruit ripening is about 112 days (almost 4 months). The ripe capsule fruits will break and the seeds are spread by the wind (Jamsari et al., 2007). Therefore, *bajakah*'s seeds and seedlings cannot be easily found in the field.

Vegetative propagation allows us to get planting stocks in large amounts and similar genetic properties with the plant sources (Libby, 1973; Hartmann et al., 2002; Siregar et al., 2008). Stem cutting is the commonest vegetative propagation technique for horticulture and woody species (Hartmann et al., 2002; Beyl & Trigiano, 2008). Shoot cutting is also a common vegetative propagation technique for woody species, such as *Gyrinops verstegii* (Setyayudi, 2018), *Shorea uliginosa* (Azwin & Sadjati, 2018), and *Elaeocarpus ganitrus* (Rachman & Rohandi, 2012). Woody lianas, such as *Uncaria* spp. and *Salacia* sp., have monopodial trunk (Keller, 1996); hence we assumed stem cutting method is suitable for those species.

A limited report on the cultivation technique of *akar kuning* (*F. tinctoria*) and *bajakah* (*U. acida* and *Salacia* sp.) are available, whereas cultivation is an important part of good agricultural practices (GAP) in the development of traditional medicine (WHO, 2003; National Medicinal Plants Board, 2009; Kementerian Pertanian, 2012a). Good cultivation techniques of *akar kuning* and *bajakah* will support the development of those species, not only as traditional medicine ("*jamu*") but also can be improved as standardized herbal medicine, and phytopharmaca.

The research reported here is based on two studies that were conducted in two locations. The research questions of these studies were as follow: 1) what is survival rate of stem cutting on *U. acida*, *Salacia* sp., and *F. tinctoria*? 2) what did effect of site condition on survival and growth of *F. tinctoria*? 3) what did influence of seedlings source on survival and growth of *F. tinctoria*?

Base on those research questions, there were two objectives of the research: 1) to study stem cutting technique of *akar kuning* (*F. tinctoria*) and *bajakah* (*U. acida* and *Salacia* sp.) and to report their early growth in the nursery study; 2) to describe the survival and growth of *akar kuning* (*F. tinctoria*) from field planting trial in two different site conditions, e.g. in wet- and dry-land, using two different sources of wildlings as planting stock.

Methods

Research site The study reported here consists of two separate activities, that have been conducted in two locations, namely in Samboja, East Kalimantan for *akar kuning*, and Bogor, West Java for *bajakah*. The plant propagation materials of *akar kuning* (*F. tinctoria*) were collected from the Samboja area of East Kalimantan. The stem cutting experiment was carried out in the nursery of the Research Institute of Natural Conservation of Samboja. The experiment was then continued with a planting trial in two different site conditions, e.g. flooded (wet) area and dry area in the same landscape of Forest with Specific Purpose (FWSP) of Samboja.

The vegetative propagation experiment of bajakah used two species of *bajakah*, e.g. *Salacia* sp. and *Uncaria acida*, that were collected from the peatland ecosystem of Sebangau area in Central Kalimantan. The *bajakah*'s experiment has not continued to the planting experiment.

Stem propagation of *akar kuning* and *bajakah* The experiment of *F. tinctoria* consisted of two experiments, namely vegetative propagation in the greenhouse and planting experiment in the field. Whilst, *bajakah* experiment consisted of vegetative propagation in a greenhouse only. The vegetative propagation experiment of *akar kuning* and *bajakah* was not designed as a comparative study.

The stem of *akar kuning* in diameter of 0.5−1.0 cm was cut into some pieces of 15 cm in length. Sterilized fine sand was used as rooting media. Rootone-F was used as root inducer, while control treatment was without root inducer. Each treatment was replicated 30 times. The variables which were observed consisted of survival rate.

The experiment in Bogor used two species of *bajakah*, those were *Salacia* sp. and *U. acida*. The stem diameter of *Salacia* sp. was ranging from 3.2−3.5 cm. The stem diameter of *U. acida* was ranging from 2.0−2.2 cm. The stem was cut into pieces of 15 cm in length. The mixture of rice husk and cocopeat (1:1) was used as rooting media. The numbers of stem cutting were very limited, which were 6 and 10 cuttings for *Salacia* sp. and *U. acida*, respectively. The variables observed in the propagation experiment consisted of survival rate, shoot ability, and growth of the stem cutting. The new shoots were then transplanted into a polybag using media of soil and rice husk mixture (1:1). The growth was observed for up to 14 months in the greenhouse.

Planting experiment of *akar kuning* Wildings of *akar kuning* for planting experiment were assembled from two sources, e.g. from peatland ecosystem of Sebangau area in Central Kalimantan and lowland ecosystem of Samboja area. The planting experiment was designed as a randomized block design, with site condition as block and source of wildings as treatment. The site conditions were consisted of flooded land (or wet-land) and dry-land.

The planting space was 3 m × 3 m. The variables observed in the planting experiment consisted of survival rate, the absolute growth rate of height and stem diameter, and leaf number at 7, 18, and 22 months after planting.

Data analysis The vegetative propagation experiments of *akar kuning* and *bajakah*, and planting experiments of *akar kuning* were analyzed using analysis of variance. Variables analyzed with analysis of variance consisted of absolute growth of height (AGH), absolute growth of stem diameter (AGD), and the number of leaves.

The formula of absolute growth of height (AGH) and growth of diameter (AGD) are as shown in Equation *[1]* and Equation *[2]*, respectively (Hunt, 1990).

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$$AGH = \frac{H2 - H1}{t2 - t1} \quad [1]$$

$$AGD = \frac{D2 - D1}{t2 - t1} \quad [2]$$

note: H1 = height in time (t) one; H2 = height in time (t) two; D1 = stem diameter in time (t) one; D2 = stem diameter in time (t) two.

General linear model (GLM) with repeated measurement was functioned in the analysis using SPSS version 21.0 for IBM. When the p-value is < 0.05, Least significant difference (LSD) was applied as a Post hoc test.

Results

Experiment in the nursery The survival rate of *F. tinctoria* stem cutting is shown in Figure 1a; while the survival rate of *Salacia* sp. and *U. acida* is shown in Figure 1b. Root inducer application to *F. tinctoria* resulted in a higher survival rate compared to control (Figure 1a). In the experiment of *bajakah*, Rootone-F was applied for stem cuttings, but it was not considered as treatment. Stem cutting *U. acida* has a higher survival rate compared to *Salacia* sp. (Figure 1b).

Stem cutting of *bajakah* produced more than one new shoot. *U. acida* produced new shoots was ranging from 1–4, while *Salacia* sp. produced 1–2 new shoots. The figures of stem cutting experiment of *bajakah* and akar kuning in the greenhouse are shown in Figure 2. The new shoots were then transplanted in the polybag using a mixture of soil and rice husk (1:1) as media. Different species of *bajakah* significantly affected the height increment of the stem cuttings. The growth and leave number of *Salacia* sp. and *U. acida* at 14 months after transplanting is shown in Table 1.

Planting trial The survival rate of planted *F. tinctoria* wildlings in the field experiment is shown in Figure 3. *F. tinctoria* wildlings from Sebangau that were planted in dry-land conditions have the highest survival rate, while *akar kuning* from Sebangau that were planted in the wet-land conditions has the lowest survival rate.

Variance analysis of growth variables from planting trials of *F. tinctoria* showed that interaction of wildlings' source and age significantly affected AGH and number of leaves. AGD is influenced by the interaction of site condition, source of wildling, and age. At the age of 18 MAP, *F. tinctoria* wildlings from Sebangau and Samboja had the

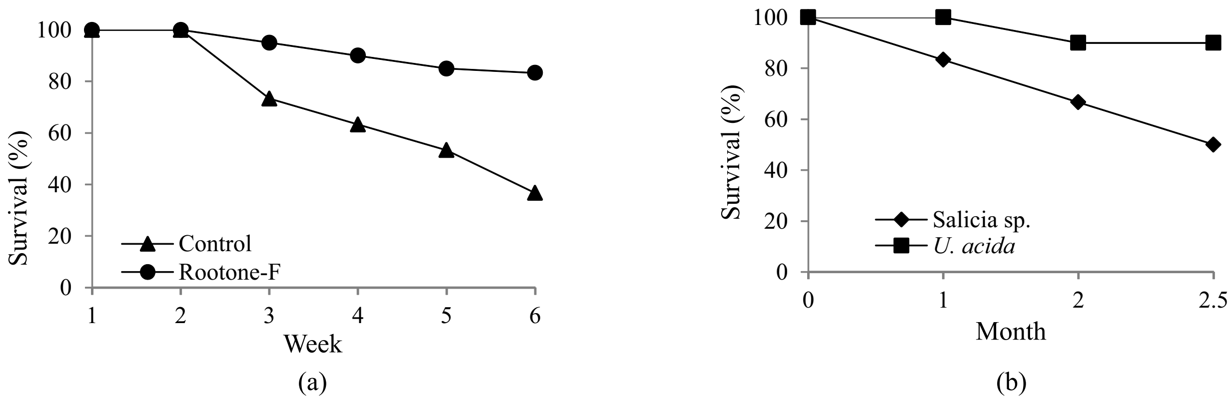

Figure 1 Stem cutting survival. (a) *Fibraurea tinctoria* for 6 weeks; (b) *Salacia* sp. and *Uncaria acida* for 2.5 months.

(a) (b) (b)

Figure 2 Stem cutting experiment in the greenhouse. (a) *Fibraurea tinctoria*; (b) *Uncaria acida*; (c) *Salacia* sp.

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lowest AGH and AGD compared to the age of 7 and 22 MAP. In general, the wet-site conditions resulted in a lower growth rate than dry-site conditions. Wildling source from Samboja has better performance (general means of AGH and AGD are 5.84 cm and 0.044 cm, respectively) than that from Sebangau (general means of AGH and AGD are 4.82 and 0.006 cm, respectively). The growth of *F. tinctoria* planting trial is shown in Table 2.

Discussion

Growth performance of cutting as woody lianas, *akar kuning* and *bajakah* have good viability in vegetative propagation of stem cutting technique. The root inducer, such as Rootone-F, resulted in a higher survival rate compared to control. The stem size of *akar kuning* (0.5−1 cm) was suitable to be used as cutting materials. Roots and new shoots have been developed and grown within 1.5 months.

The stem size of *bajakah* used for cutting was larger than that of *akar kuning*. Stem diameter of *U. acida* (red *bajakah*) was 2.02 cm, while *Salacia* sp. (white *bajakah*) was 3.52 cm. The survival rate of *Salacia* sp. is lower than that of *U. acida*. The roots and new shoots have been developed and grown within 2−2.5 months. Both *U. acida* and *Salacia* sp. developed multi shoots in one stem cutting. Cutting growth of *Salacia* sp. at the age of 14 months after transplanting is lower than that of *U. acida* (Table 1).

***Akar kuning* performance in the field** In the natural habitat, akar kuning grows in a humid condition, under canopy and light in-tolerant. Field planting experiment of *F. tinctoria* in two different site conditions showed akar kuning planted in dry-land condition has higher survival rate than that in wet-land condition (Figure 3). *Akar kuning* and *bajakah* can be planted in both dry-land and wet-land conditions, no matter where the source of planting stock is. However, the condition of the planting site may affect the concentration of secondary metabolite contents in the plant, as reported by other studies (Yang et al., 2018; Jan et al., 2021). Further study in the effect of planting sites on secondary metabolite content of the cultivated *akar kuning* and *bajakah* is necessary to be examined.

Prospect and challenges Until recently, the raw material of *akar kuning* and *bajakah* as traditional medicine are collected from the natural habitat. There is a national regulation on the guideline for GAP of crops medicine launched by the Minister of Agriculture in 2012 (Kementerian Pertanian, 2012a). GAP is defined as specific methods in agriculture to provide healthy and safe food and/or process food (including medicine) (WHO, 2003; Hidayat & Supartoko, 2017). According to the Ministry of Agriculture (Kementerian Pertanian, 2012a), raw materials of traditional medicine should be derived from sustainable cultivation. Thus, *akar kuning* and *bajakah* should be cultivated and must apply GAP to develop a sustainable herbal medicine business.

This research was just an early step of several stages that are necessary to be conducted in bioprospecting. The bioprospecting process tends to go toward the commercial industry, particularly for traditional medicine (Dwiartama et al., 2020). In the traditional medicine industry, the guideline of GAP for medicinal crops shall be followed as mandatory. The guideline is consisted of eighteen stages, as follows: i) criteria, ii) registration and certification, iii) land management, iv) seed (and seedlings) utilization, v) planting or cultivation technique, vi) fertilizer application, vii) plant protection from pests and diseases, viii) irrigation, ix) harvesting (or collection), x) equipment and agricultural tools, xi) environmental conservation, xii) workers, xiii)

Table 1 Early growth of two species *bajakah* stem cuttings in the nursery at 14 months after transplanting

Species	Height increment (cm)*	Diameter (mm)*	Number of leaves*	Survival (%)
Salacia sp.	30.00 ± 28.99b	3.05 ± 2.01a	16 ± 8a	50
Uncaria acida	47.50 ± 13.62a	3.49 ± 0.69a	15 ± 4a	96

*Value followed by a different letter in the same column is significantly different at *p*-value = 0.05

Table 2 The absolute growth rate of height (AGH), the absolute growth rate of diameter (AGD), and number of leaves of *Fibraurea tinctoria* from planting trial in two site conditions and two sources of wildling

Site condition	Wildling source	Age (MAP)	AGH (cm week^{-1})*	AGD (cm week^{-1})*	Number of leaves*
Dry	Samboja	7	7.67 ± 9.32abc	0.013 ± 0.008b	12 ± 7a
	Sebangau	7	2.62 ± 3.60cd	0.009 ± 0.007bc	5 ± 3c
Wet	Samboja	7	9.47 ± 7.09ab	0.009 ± 0.005bc	7 ± 5bc
	Sebangau	7	1.67 ± 1.56d	0.012 ± 0.005b	6 ± 3c
Dry	Samboja	18	3.03 ± 3.05bc	0.228 ± 1.043a	10 ± 6ab
	Sebangau	18	3.84 ± 4.16bc	0.002 ± 0.004d	5 ± 3c
Wet	Samboja	18	1.75 ± 2.61cd	0.004 ± 0.007cd	9 ± 6ab
	Sebangau	18	2.97 ± 2.80cd	0.001 ± 0.003d	5 ± 3c
Dry	Samboja	22	7.83 ± 9.97abc	0.001 ± 0.004d	9 ± 7ab
	Sebangau	22	7.75 ± 7.60abc	0.005 ± 0.007cd	6 ± 4bc
Wet	Samboja	22	5.00 ± 6.04bc	0.008 ± 0.010bc	6 ± 4bc
	Sebangau	22	10.10 ± 6.45a	0.007 ± 0.010bc	7 ± 3bc

*Value followed by the different letter is significantly different at *p*-value 0.05; MAP is a month after planting

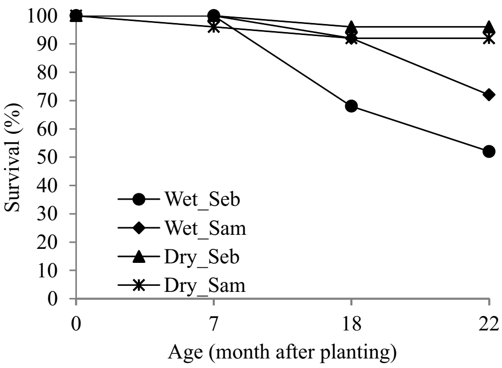

Figure 3 The survival rate of *Fibraurea tinctoria* planting experiment in two different site conditions and wildling sources. (Remarks: Wet_Seb: wet site, wildling source from Sebangau; Wet_Sam: wet site, wildling source from Samboja; Dry_Seb: dry site, wildling source from Sebangau; Dry_Sam; dry site, wildling source from Samboja).

cleaning facilities and worker health, xiv) waste management, xv) recording and tracing, xvi) complaint, xvii) internal evaluation, and xviii) coaching and guidance (Kementerian Pertanian, 2012a).

The big challenge to vegetative propagation of *akar kuning* and *bajakah* is limited material availability for stem cutting. Two studies reported that seedlings of *F. tinctoria* were abundant in the forest floor, however, sapling and pole stages were very limited (Noorcahyati et al., 2016; Kalima, 2021). This is owing to people usually cutting and collecting *akar kuning* stem poles in the natural habitat without considering sustainable harvesting (Kalima, 2021). The same case was also reported on *bajakah* (Tata & Sopha, 2020).

Until recently, there is no regulation on collecting and harvesting *akar kuning* (Kalima, 2021) and *bajakah* from the wild. Over extraction becomes a threat of species extinction. The life cycle of *F. tinctoria*, *Salacia* sp., and *U. acida* are not understood well. Further study in eco-physiology, phenology, and propagation techniques of *akar kuning* and *bajakah* are necessary to be carried out seriously before they can be developed into a traditional medicine business, like seasonal medicinal crop commodities, such as turmeric, ginger, and others. Another example is *U. gambir*, locally known as gambir, which has been established as one of the horticulture commodities since the Dutch colonial (Heyne, 1987). It became one of superior estate commodities of West Sumatera Province, because it has been cultivated widely (Kementerian Pertanian, 2012b; Yurstia, 2017). When *akar kuning* and *bajakah* are sustainably cultivated and managed, they can also be developed as potent herbal medicine business.

Conclusion

The results showed that stem cuttings of woody liana could produce more than one new shoot. The new shoots of U. acida and Salacia sp. grew after eight weeks, with a survival rate of 96% and 50%, respectively. The survival rate of *F. tinctoria* stem cutting after six weeks was 83.3%. These indicate that *bajakah* and *akar kuning* can be propagated and cultivated to support the bioprospecting of traditional medicinal plants.

Recommendation

An advance vegetative propagation technique, such as tissue culture, is recommended to produce mass planting stocks of *akar kuning* and *bajakah*. Further research activities should be strengthened to support bioprospecting of these two traditional medicines.

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