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Natural production potency of nipa (*Nypa fruticans*) sap as production commodity for bioethanol

Potensi produksi alami nira nipah (*Nypa fruticans*) sebagai komoditas penghasil bioetanol

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Abstrak. *Hidayat IW. 2015. Potensi produksi alami nira nipah (*Nypa fruticans*) sebagai komoditas penghasil bioetanol. Pros Sem Nas Masy Biodiv Indon 1 (1): 109-113.* Nira nipah (*Nypa fruticans* Wurmb.) memiliki manfaat unggul untuk diolah lebih lanjut menjadi bioetanol. Bioetanol yang dihasilkan nipah lebih banyak apabila dibandingkan dengan tanaman budidaya lainnya, seperti tebu, singkong, kelapa dan kentang. Potensi hasil ini sangat strategis, apabila dihubungkan dengan program nasional mengenai pengembangan energi baru dan terbarukan untuk mengatasi masalah kebutuhan energi yang semakin meningkat. Nipah mendominasi konfigurasi tumbuhan mangrove di sepanjang pantai utara pulau Sumatera, terutama di Sumatera Selatan. Sungsang, Sumatera Selatan, merupakan salah satu habitat dan ekosistem nipah yang penting. Penelitian ini dilakukan dengan tujuan menganalisis potensi produksi alami nira nipah yang mampu diolah lebih lanjut menjadi bioetanol. Hasil penelitian menunjukkan bahwa pada tahun 2013, potensi produksi alami nira nipah di Sungsang berkisar antara 109,45-437,86 L ha^{-1} $hari^{-1}$. Apabila dengan pengolahan lebih lanjut nira nipah menghasilkan 8,98%-14% etanol, maka bioetanol yang dihasilkan berkisar antara 9,83-61,3 L ha^{-1} $hari^{-1}$ atau 3.587,92-22.374,54 L ha^{-1} $tahun^{-1}$.

Kata kunci: bioetanol, nira nipah, produksi alami

Abstract. *Hidayat IW. 2015. Natural production potential of nipa (*Nypa fruticans*) sap as sources for bioethanol production. Pros Sem Nas Masy Biodiv Indon 1 (1): 109-113.* Nipa (*Nypa fruticans* Wurmb.) sap is a potential source for bioethanol production. Nipa bioethanol production generates higher yield in comparison with other crops, such as sugarcane, cassava, coconut, and potato. This potential is very relevant to the national program on the development of new and renewable energy to meet the growing energy demand. Nipa can be found growing dominantly in mangrove ecosystem along the northern coast of Sumatra, particularly in South Sumatra. Sungsang, South Sumatra, is one of the critical habitats for nipa. This research was aimed to analyze the potential of natural production of nipa sap which can be processed further into bioethanol. The results showed that the potential natural production of nipa sap ranged from 109.45 to 437.86 L ha^{-1} day^{-1} in 2013. For further processing, nipa sap generating 8.98% to 14% of ethanol would then result in bioethanol ranging from 9.83 to 61.3 L ha^{-1} day^{-1} or 3,587.92 to 22,374.54 L ha^{-1} $year^{-1}$.

Key words: bioethanol, natural production, nipa sap

INTRODUCTION

Global primary energy consumption increased by 2.3% in 2013, acceleration over 2012 (+1.8%) (British Petroleum 2014). Until July 2014, around 78.9% of the total primary energy share was produced from fossil fuel that precludes nuclear, hydro, biofuel and other energy sources (U.S. EIA 2014). For comparison, in 1973, fossil fuel percentage of the total primary energy share was 86.7%. On the other hand, globally, 57.7% of the energy is accounted for transportation system (Kumar et al. 2010).

It also occurs in Indonesia, in 2013, oil consumption reached 1.61 million barrels per day by "only" capable to produce as much crude oil 874.79 thousand barrels per day (U.S. EIA 2014). The dependence of the energy needs of Indonesia on fossil fuels is also seen in the proportion of the total fossil fuel consumption by 73% compared to other sources, such as biomass and other renewable sources, by 27% in 2012. This certainly implies a concern for the policy makers for exploring alternatives that would be viable and regenerative to attain sustainability. Renewable energy opened up prospects for appropriate resource conservation and an eco-friendly solution directed to energy security (Everett et al. 2012).

Indonesia as a rich country of biodiversity resources, have a high potential for developing new and renewable energy derived from plants. One that has been investigated is bioethanol derived from nipa (*Nypa fruticans* Wurmb.) sap. Ethanol which produced by nipa sap is better than sugarcane, even other sugar sources such as cassava, coconut and potato (Hamilton and Murphy 1988). Nipa sap is a potential material to be processed into bioethanol (Matsui et al. 2011; Tamunaidu and Saka 2011; Tsuji et al. 2011; Tamunaidu and Saka 2013; Tamunaidu et al. 2013).

Bioethanol is one source of renewable energy which can replace or as mix of fossil fuels, widely used in beverages, cosmetics, in the health field as an antiseptic substance, a solvent, as well as an industrial raw material. Total nipa sap chemical composition is 19.5 wt%, mainly consisting of sucrose, glucose and fructose (Tamunaidu and Saka 2013). The potential of nipa sap which can be generated ranged from 0.4 to 1.2 L d^{-1} per palm (Tamunaidu et al. 2013).

Nevertheless, the potential and utilization of *N. fruticans* currently faced with the problems of land use changes that threaten the existence and its sustainability. Mangrove ecosystem which becoming a major habitat of nipa gradually depleted or damaged, as occurred in most of the northern coast of Sumatra. According Ridho et al. (2006), mangrove areas in the Banyuasin (including Sungsang) was reduced by 20,546.5 ha since 1992 to 2003. The results of the interpretation of satellite data were also discovered that 55.4% (158,989.39 ha) mangrove area in Banyuasin II District (including Sungsang) categorized as moderate damaged and heavily damaged and only 44.6% (127,983.57 ha) categorized in good condition (Departemen Kehutanan 2006). Exploitation of mangrove areas in this region which continuously occurred will be potentially reducing the diversity of plant species. Therefore, it needs a habitat conservation strategy to be able for collaborating ecological interests and socio-economic benefits for the surrounding community.

The purpose of this study was to assess the natural sap production potential of nipa palms to be processed into bioethanol according to its abundance in the habitat. Abundance studies were carried out to evaluate its individual amount and the total of panicles as based for the quantity assessment of nipa sap production. Hopefully with this potential production, it will encourage conservation efforts for nipa from activities that cause depletion.

MATERIALS AND METHODS

Study site

The study was conducted in Sungsang which administratively located in Banyuasin II District, Banyuasin Regency, South Sumatra Province. The object of study is the abundance of *N. fruticans* which potentially be utilized as bioethanol production substance through its tapping sap. Area of study is located at 2º16'33"S to 2º30'31"S and 104º45'10"E to 104º55'4"E (Figure 1). Topographically, the site is a swampy area with a moderate tidal influence. Sungsang is a delta area formed between the confluence of the Musi River, Telang River and Banyuasin River. Sungsang is located at the mouth of three rivers, and faced directly with the Bangka Strait.

Sampling acquisition of nipa was conducted on eight plots with three sub-plots repetition in each plot. Each sampling sub-plot was measuring 10x10 square meters. Plots selection was based on the level of disturbance of land use changes around the community of nipa. Location of Plot I was adjacent to agricultural land and plantations, Plot II was adjacent to plantations. Plot III and VII were located contiguous with settlement; Plot IV, V and VI were as undisturbed sites type; and, Plot VIII was located adjacent to agricultural land, plantations and settlement (Figure 1). The site selection of plots was expected be able to describe the representation of the diversity of the areas surrounding nipa community.

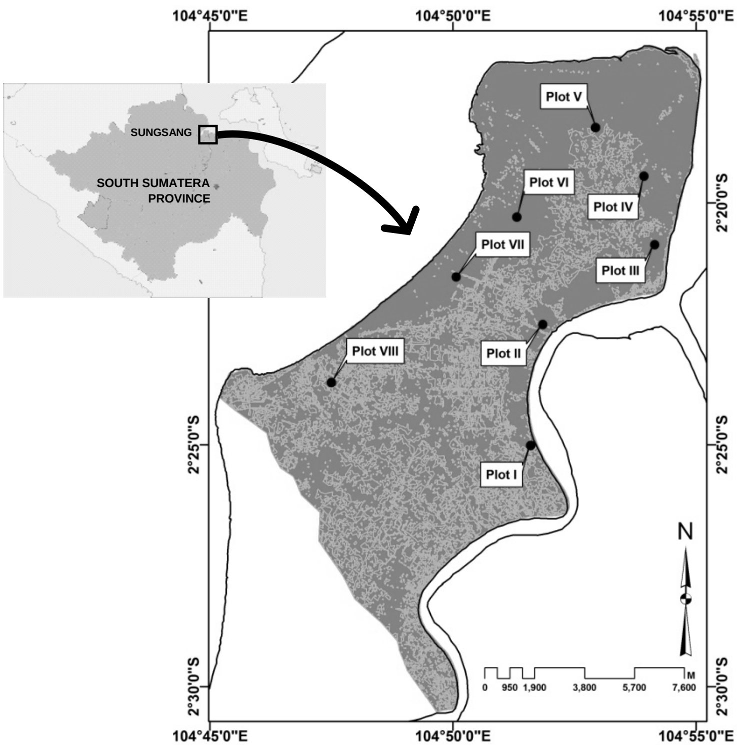

Figure 1. Study site in Sungsang, South Sumatera Province and location of sampling plots of *N. fruticans.*

Data collection and analysis

In each sub-plot was conducted data collection on individual abundance of nipa and the number of fruit stalks. Sub-plots were made at homogeneous nipa configuration, due to analyze the optimal potential of the natural production of nipa sap. Data were collected during February to March 2013. Abundance of individuals was calculated based on the number of individuals of nipa. The number of fruit stalks was calculated based on the number of fruit stalks which produced in each sub-plot. Fruit stalks which were calculated didn't consider the age factor (juvenile, mature or elder). This was conducted based on the assumption that each fruit stalk can grow into adulthood so ready to be harvested its sap.

Natural potency of nipa sap which produced by a single fruit stalk in a day with twice harvesting (morning and afternoon) about 0.5 L day^{-1} (Hamilton and Murphy 1988; Efendi 2012) and maximum about 2 L day^{-1} (Hamilton and Murphy 1988; Efendi 2012; Matsui et al. 2014), then nipa sap production ha^{-1} can be estimated as = [0.5 x ∑*number of fruit stalks* ≤ *nipa sap production* ≤ 2 x ∑*number of fruit stalks*] L ha^{-1} day^{-1}. If the further processing of nipa sap was capable to generating 8.98% (Trisasiwi et al. 2011) to 14% (Abdullah et al. 2013) per volume of bioethanol, then the potential bioethanol which can be produced is = [8.98% x *nipa sap production* ≤ *potential bioethanol* ≤ 14% x *nipa sap production*] L ha^{-1} day^{-1}.

RESULTS AND DISCUSSION

Results

Based on processing of field data collection, the highest average number of individuals is in Plot III (Figure 2). Afterward, Plot V, I and IV have a high number of individual. On the other hand, the lower number of individuals was in Plot II, VI, and VIII. Plot VII has the lowest average number of *N. fruticans*. On the other hand, the amount of fruit stalks was directly proportional (relatively) to the number of individuals of nipa (except at Plot V had a highest number of fruit stalks). More individuals of palm, then the more the fruit stalks can be found in the field at each sub plot.

Each fruit stalk that counted was expected to grow and produce nipa sap. Earlier studies were suggested that a single fruit stalk with twice a day harvesting of nipa sap, can produce about 0.5 L day^{-1} (Hamilton and Murphy 1988; Efendi 2012) and maximum about 2 L day^{-1} (Hamilton and Murphy 1988; Efendi 2012; Matsui et al. 2014) of nipa sap. Therefore, the amount of nipa sap can be produced was about 1.33-910.99 L ha^{-1} day^{-1} (Table 1). The highest production was at Plot V which produced 227.75-910.99 L ha^{-1} day^{-1} and the lowest was at Plot VIII which produced 1.33-5.33 L ha^{-1} day^{-1}. Therefore, the average of natural nipa sap production in Sungsang based on the average amount of fruit stalks was about 109.46-437.86 L ha^{-1} day^{-1}. In addition, the number of sap producing days and fruit stalk length were found to be highly correlated with sap yield (Rasco Jr et al. 2012).

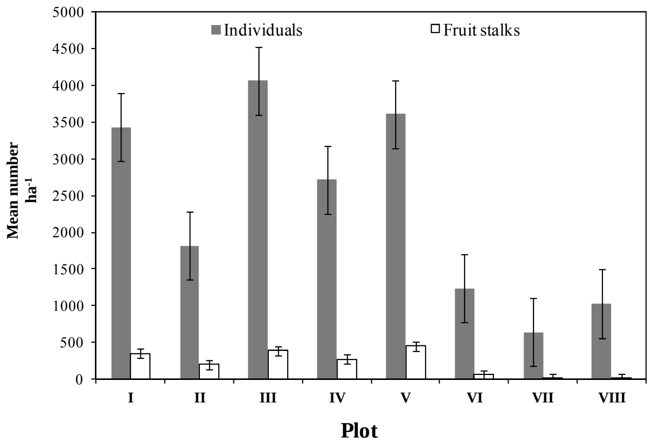

Figure 2. The average number of individual of *N. fruticans* and fruit stalk, in number ha^{-1}, at all eight plots sites with three sub-plots repetition in each plot.

Table 1. Natural production potency of *N. fruticans* sap.

No. Plot	Mean number of fruit stalks ha^{-1}	Mean number of *N. fruticans* sap*) L ha^{-1} day^{-1}		
		Min.	**Ave.**	**Max.**
I	354.22	177.11	442.77	708.43
II	198.05	99.02	247.56	396.09
III	392.32	196.16	490.40	784.64
IV	269.83	134.81	337.03	539.25
V	455.49	227.75	569.37	910.99
VI	63.73	31.87	79.66	127.46
VII	15.33	7.67	19.17	30.67
VIII	2.67	1.33	3.33	5.33

Note: Based on nipa sap production with twice a day harvesting (Hamilton and Murphy 1988; Efendi 2012; Matsui et al. 2014).

Table 2. Natural production potency of bioethanol from further processing of *N. fruticans* sap.

No. Plot	Mean number of potential bioethanol production*) L ha^{-1} day^{-1}		
	Min.	**Ave.**	**Max.**
I	15.90	57.54	99.18
II	8.89	32.17	55.45
III	17.62	63.73	109.85
IV	12.11	43.80	75.50
V	20.45	74.00	127.54
VI	2.86	10.35	17.84
VII	0.69	2.49	4.29
VIII	0.12	0.43	0.75

Note: Based on study of Trisasiwi et al. 2011; Abdullah et al. 2013.

Nipa is able to produce higher yields alcohol compared with other crops: nipa by traditional management 6,480-10,224 L ha^{-1} $year^{-1}$; sugarcane 3,350-6,700 L ha^{-1} $year^{-1}$; cassava 3,240-8,640 L ha^{-1} $year^{-1}$; coconut sap 5,000 L ha^{-1} $year^{-1}$; and, sweet potato 6,750-18,000 L ha^{-1} $year^{-1}$ (Hamilton and Murphy 1988). The estimated annual ethanol yield from nipa sap in east coast of Southern Thailand of 4,550-9,100 L ha^{-1} $year^{-1}$ (Tamunaidu et al.

2013) was as competitive as 5,300-6,500 L ha^{-1} $year^{-1}$ estimated in sugarcane and 3,100-3,900 L ha^{-1} $year^{-1}$ for corn as reported by Marris (2006). Based on earlier study, nipa sap was capable to generating 8.98% (Trisasiwi et al. 2011) to 14% (Abdullah et al. 2013) per volume of bioethanol. Therefore, the potential bioethanol which can be produced in Sungsang is shown in Table 2.

The data in Table 2 shown that the highest production of bioethanol was Plot V with 127.54 L ha^{-1} day^{-1}, and the lowest Plot VIII with 0.12 L ha^{-1} day^{-1}. Therefore, the average amount of bioethanol can be produced from *N. fruticans* sap in Sungsang was about 9.83-61.3 L ha^{-1} day^{-1}. Consequently, the potential of ethanol production from nipa sap was estimated to 3,587.92-22,374.54 L ha^{-1} $year^{-1}$ of ethanol from on-site. Even though the range between minimum and maximum values is quite large, these estimated values are practical and can be used for development of future nipa palm ethanol industry.

Discussion

The data shown at Figure 2 can be assumed that the proliferations of nipa, generally, were not affected by changes in the surrounding environment. It can be seen that Plot III (highest) and Plot I which had an average number of individual at high level, although at around community of nipa has turned into another land use, such as agricultural land, plantations and settlement. This demonstrates the wide ecological amplitude of the nipa palm (Giesen et al. 2006; Teo et al. 2010). Based on Jian et al. (2010), nipa palm populations collected from China, Thailand, Japan and Vietnam showed low genetic diversity. Most of the nipa palm populations were found in the more brackish mangrove forest strips, situated further inland and away from the direct exposure to pure seawater (Theerawitaya et al. 2014). Giesen et al. (2006) noted that the palm is found in mangrove areas with calm conditions and a high freshwater input. The rich natural nutrients in seawater and its soil were sufficient for the palm growth. Furthermore, external addition of organic and inorganic fertilizers did not show any significant response in terms of nipa palm growth and sap yield as reported by Bamroongrugsa and Purintavarakul (2006).

Furthermore, the potential estimated daily nipa sap in Sungsang of 109.46-437.86 L ha^{-1} day^{-1} (Table 1) was an abundant and prime raw material to be processed further into more valuable economic matter. Nipa sap has an advantage to be further processed into bioethanol. The potential estimated daily ethanol yield from nipa sap in Sungsang of 9.83-61.3 L ha^{-1} day^{-1} (Table 2), or to be conversed in a year production as 3,587.92-22,374.54 L ha^{-1} $year^{-1}$ of ethanol, is as competitive as 5,300-6,500 L ha^{-1} $year^{-1}$ estimated in sugarcane and 3,100-3,900 L ha^{-1} $year^{-1}$ for corn (Marris 2006).

In addition to growing nipa for its bioethanol, there are other advantages of growing nipa. Continuous productivity of nipa means no displaced labour, which is one of major problem in sugarcane ecosystem (Hamilton and Murphy 1988). Production of nipa is not interrupted by replanting and rotation (Hamilton and Murphy 1988). Other advantages are no bagasse disposal problem and nipa does not compete with other crops for agricultural land except where total reclamation is undertaken on mangrove land (Hamilton and Murphy 1988). On the other hand, the capability of nipa shoot biomass as a potential adsorbent for removing and recovering heavy metal ions from aqueous solution was also reported (Wankasi et al. 2006; Wan Ngah and Hanafiah 2008; Okugbo et al. 2012).

From the economic viewpoint, even though tapping of nipa saps could be labor-intensive, it will create a considerable number of jobs and help generate sustainable livelihood for coastal communities (Ame et al. 2011; Tamunaidu et al. 2013). Nipa has also contributed for carbon sequestration benefit in mangroves configuration (Kuenzer and Tuan 2013). Furthermore, these palms could initiate coastal rehabilitation and restore degraded lands (Bamroongrugsa et al. 2008; Hashim et al. 2010; Tamunaidu et al. 2013). Additionally, fossil energy inputs such as nitrogen, phosphate and potash fertilizers, herbicides and insecticides, machinery, irrigation, electricity, diesel fuel and gasoline used in sugarcane plantations has very limited use or not necessary in terms of nipa palm management (Tamunaidu et al. 2013).

Nipa palms were found to produce high yields of sugar saps similar with other sugar crops. It was further found to be fermented to ethanol in high yields. Furthermore, the annual potential of ethanol yields from nipa sap was also as competitive as sugarcane and corn. Based on the development of its natural potential, then it is expected that deforestation and land degradation that occurs in the mangrove forest, as habitat of *N. fruticans*, can be suppressed. Therefore, ethanol produced from nipa saps may be more sustainable than conventional sugar and starch feedstock that are currently available in the market.

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