EFFECTS OF TAPPING PATTERN AND WOOD VINEGAR, LIME AND GALANGAL STIMULANTS ON SAP PRODUCTION OF SWAMP JELUTONG (*DYERA LOWII*) IN INDONESIA

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SUKADARYATI, DULSALAM & YUNIAWATI. 2016. Effects of tapping pattern and wood vinegar, lime and galangal stimulants on sap production of swamp jelutong (*Dyera lowii*) in Indonesia. Jelutong trees are exploited to meet the high market demand for sap but this natural resource is still not sustainably managed. Techniques of sap harvest (tapping) that are both environmentally friendly and sustainable are needed. This study was aimed at providing information on tapping techniques and the use of organic stimulants in the tapping of jelutong sap. Two tapping techniques (half-spiral and V-shape tapping), and three types of organic stimulants (galangal, lime and wood vinegar) were employed. Results showed that wood vinegar, galangal and lime increased sap production to 20.9, 20.5 and 18.1 g compared with control (11.0 g). It was also observed that V-shape tapping produced more jelutong sap than half-spiral tapping. The impurity content in jelutong sap ranged between 0.45 and 0.75%. Our research results demonstrated the potential benefits of using organic stimulants in jelutong sap production.

Keywords: Tapping techniques, organic stimulants, environmentally friendly, tapping innovations

INTRODUCTION

Indonesia was once the largest exporter of jelutong sap in the world. Exports reached a record high of 6500 tonnes in 1990 but declined in the following years, falling to 1182 tonnes in 1993 (Coppen 1995). Jelutong sap is used in the manufacture of chewing gum, car tyres, adhesives and varnishes (Waluyo 2010). Jelutong sap is an exudate obtained from the tapping of jelutung trees (*Dyera* spp.). Proper implementation of tapping techniques is necessary to increase sap production. The two common tapping techniques used in extracting jelutong sap are V-shape and half-spiral tappings. The tapping community usually employs V-shape tapping with a 30º–45º angled cut and with bark injury inflicted every 2–3 days or once a week (Waluyo 2010). The V-shape method is able to produce more sap in hill jelutong than in swamp jelutong and, upper tapping (upward-direction injury) produces more sap than lower tapping (downward-direction injury (Coppen 1995). Half-spiral tapping, which produces a half-spiral pattern from upper left to lower right has also been reported to be highly productive (Waluyo 2010).

The sap that oozes out when a tree stem is tapped serves as self-defense mechanism to seal the tapping injury. As the sap is exposed to air, volatile compounds (either monoterpenes or sesquiterpenes) evaporate and the diterpenes polymerise thereby sealing the tapping injury (Martin et al. 2003). Tapping is better conducted in the morning when sap flow is higher and coagulation is slower, so more sap can be collected before coagulation and sealing of the tapping injury. Jelutong tapping is currently performed without the use of stimulants and maximum sap production from *Dyera costulata* and *Dyera laxiflora* is only 2.5 and 0.5 kg per year respectively (Handadhari 2004). As organic stimulants have been shown to increase latex production in other sap-producing tree species (Martin et al. 2003), the potential for using stimulants to improve the yield of jelutong sap should be explored.

In this study, we compared the effects of V-shape and half-spiral tappings and the use of three organic stimulants, namely, galangal (*Alpinia galangal*), lime (*Citrus aurantifolia*) and wood vinegar on the yield of jelutong sap.

MATERIALS AND METHODS

Study site and experiment design

The study was conducted from May till June 2014 on 10- and 11-year-old swamp jelutong (*Dyera lowii*). We chose 80 trees with circumferences at breast height between 40.5 and 88.0 cm (mean 48.1 cm) planted at the Forestry Area Reserved for Special Purposes (FARSP, 2° 17'– 2° 25' S and 114° 0'–114° 7' E), Tumbang Nusa village, Jabiren Raya subdistrict, Central Kalimantan. FARSP is managed by the Forestry Research Institute of Banjarbaru in Tumbang Nusa. The jelutong stands in FARSP were planted in 2004/2005 and consisted of swamp jelutong and mountain jelutong (*D. costulata*) which were evenly distributed.

A factorial design based on completely randomised design with two factors, i.e. tapping technique and stimulant, with 10 replicates was used for this study. A total of 80 jelutong trees within a 1-ha plot were randomly selected for the treatments and their circumferences at breast height and heights were recorded. Undergrowth and other vegetation were removed so that tapping sites got direct exposure to sunlight.

The altitude of the study area was up to 5 m above sea level with a slope of 0–18% and peat depth ≥ 6 m. Average temperature is 23 °C (range 23–33 °C). Average rainfall was 5852 mm year^{-1} while annual rainfall values in 2012 and 2013 were 6678 and 8775 mm respectively. In the rainy season, floodwaters reached 25 cm above the soil surface. The soil type is classified as histosol with pH of 3.5.

Preparation of organic stimulants

Galangal and lime base extracts were obtained by processing galangal tubers and lime fruit respectively following Sukadaryati and Dulsalam (2013). Unpurified juices squeezed from galangal and lime were used instead of purified extracts because of their bioactive components or other chemical compounds. Before being applied to the study trees, these base extracts were diluted with distilied water at a ratio of 1:1 for use as galangal and lime stimulants.

Wood vinegar base was obtained as distillate from the cooled condensate of the gas/vapour released during carbonisation of pine (*Pinus merkusii*, locally known as *tusam*) waste biomass (twigs, branches and residual stems). The carbonisation process took 25–30 hours during which the released gas/vapour was cooled down by passing through a condensing device to yield crude wood vinegar. Cooling took about 6 hours. Crude wood vinegar, which is dark brown in colour, comprises two main components, namely, pyroligneous liquor (less dense liquid) and tar deposit (more dense and settles into thickened mass below the liquor). The separation of those two components was carried out through distillation process where crude wood vinegar was heated to about 100–150 °C to obtain the distillate, leaving behind the denser tar (Pari & Nurhayati 2009). The wood vinegar distillate base was mixed with frying oil (as heat conductor) at a ratio of 1:1 (w/w) for use as wood vinegar stimulant (Wijana et al. 2005). Impurity content of the sap from each treatment was tested following SNI (2012).

Treatment applications

For three consecutive mornings between 7 and 8 a.m., trees were tapped following the V-shape or half-spiral pattern (Figures 1 and 2). Trees were tapped at about 1-m stem height at an angel of 30–40°, with the tapping injury directly facing sunlight. Total wound length and depth for the two tapping techniques were similar. Incisions crossed half the tree circumference. Stimulant treatments were immediately applied after tapping whereby approximately 1 mL of stimulant was sprayed onto the fresh incision. The length of the incision for V-shape tapping was a quarter of the circumference of the tree, either left or right section incision. A collection container was secured beneath the incision channel to collect the sap for 24 hours after which the sap was collected and weighed. A new incision was made daily about 2 cm above the previous incision, also followed by application of stimulant, with a total of three incisions made on each tree. The treatment was also carried out using half-spiral pattern (Figures 2a–c).

Data analysis

Data on the yields of jelutong sap obtained according to tapping techniques and kinds of stimulants were analysed using completely

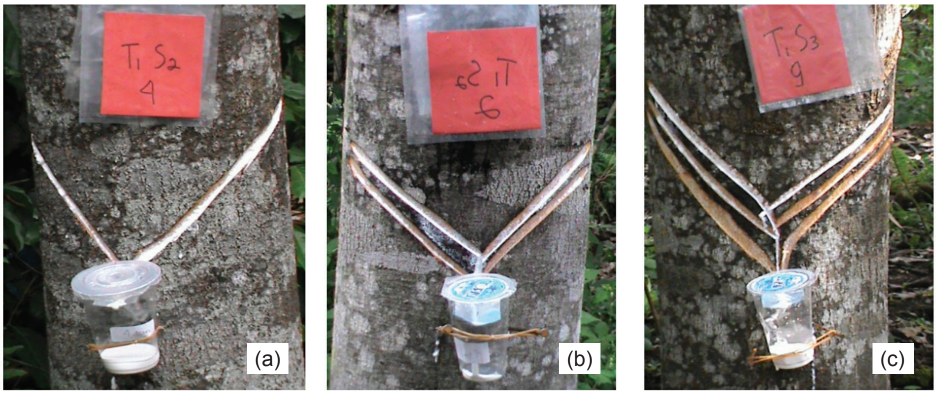

Figure 1 Tapping of jelutong sap following the V-shape pattern: (a) first, (b) second and (c) third incisions

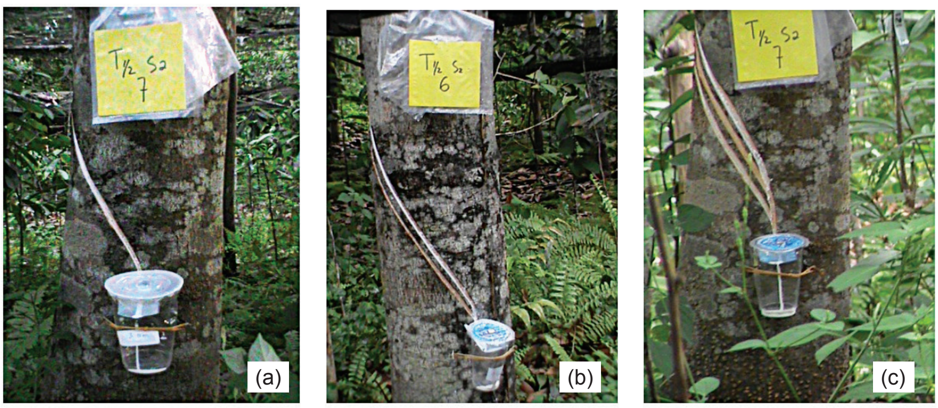

Figure 2 Tapping of jelutong sap following the half-spiral pattern: (a) first, (b) second and (c) third incisions

randomised design in factorial pattern (T and S). The T factor comprised the two tapping methods, i.e. half-spiral and V-shape tappings. The S factor consisted of four stimulants, i.e. galangal, lime, wood vinegar and the no-stimulant control. Replication for each combination of T and S factors was performed 10 times. When the effect of individual factors (T and S) or their interaction (TS) was significant, further assessment was conducted using the least significant difference test.

RESULTS AND DISCUSSION

Wood vinegar-based stimulant gave an increase in sap yield greater than that of the galangal- and lime-based stimulants (Table 1). Yield of jelutong sap was affected by tapping techniques and types of stimulants. V-shape tapping produced more jelutong sap than half-spiral tapping. Sap (gum) ducts in the wood are oriented in radial direction while in the bark, they are oriented axially or parallel to the stem axes (Wheeler et al. 1989). The angle of the tapping incision path was intended to cut or injure the sap ducts, thereby lengthening the path and accelerating sap flow as well as concurrently slowing down sap coagulation (Sumarmadji (2006). The angle of the incision path for the two tapping methods applied in this field trial was 30–40^{o}, with relatively similar or equal lengths. Half-spiral tapping, which ran from the left to the right could cut sap ducts more optimally, thereby allowing more sap to flow (Waluyo 2010). In the present study, V-shape tapping produced more sap than half-spiral tapping because the former method cut across more sap ducts.

All three organic stimulants increased the production of sap compared with control which had no stimulant applied to the tapping injury

Table 1 Yield of jelutong sap (g) following different tapping methods and types of stimulants

Tapping method and incision	Type of stimulant			
	Galangal	Lime	Wood vinegar	Control
V-shape				
First	30.8	37.6	44.5	13.8
Second	16.2	10.3	15.0	10.7
Third	18.2	12.7	15.8	6.2
Mean	21.9	20.2	25.1	10.2
Half-spiral				
First	34.8	25.4	25.5	18.2
Second	13.3	14.1	16.6	11.2
Third	9.3	8.4	8.2	6.1
Mean	19.1	15.9	16.8	11.8

site (Table 1). The stimulants inhibit coagulation of the sap thereby extending sap flow time (Southorn 1969). Galangal contains anti-fungal compounds (eugenol, caemferol, quercetin and galangin) which lower the surface tension of the cytoplasmic membrane (Hezmela 2006). The use of galangal as organic stimulant has been shown to increase sap production in tapped pine trees (Matangaran et al. 2012, Sukadaryati & Dulsalam 2013, Sukadaryati et al. 2014).

Sulphuric acid has been used as conventional inorganic stimulant in the tapping of sap-containing trees. Lime containing citric acid acts as chelating agent and inhibits sap coagulation in the same way as sulphuric acid and can potentially be used as an organic substitute for sulphuric acid. Lime juice has citric acid content of 7% while lime oil has limonene content of 90% (Rukmana 1995). Lime stimulant increased the production of pine sap by as much as 81.3 g per harvest, which was significantly more than that obtained by using a sulphuric-acid-based stimulant (54.9 g) (Matangaran et al. 2012).

The three main components that exist in wood vinegar are acetic acid (50%), phenol and alcohol. Adding acid to injury sites of tapped trees reduces sap coagulation and extends the duration of sap flow (Rodrigues et al. 2008, 2011, Sharma & Lecha 2013). Wood vinegar stimulant in pine-tree tapping significantly increased the yield of pine sap compared with control although the yield was not as high as when using sulphuric acid stimulant (Sukadaryati et al. 2014). Nevertheless as an organic acid, wood vinegar is a good stimulant to replace strong acids which can be harmful to trees.

V-shape tapping produced greater sap production compared with half-spiral tapping ($F = 5.339$, d.f. = (1, 79), $p = 0.024$, Table 2). Application of stimulants also significantly increased yield compared with no-stimulant control ($F = 9.481$, d.f. = (3, 79), $p = 0.000$, Table 2), with increases of 90, 86 and 64% for wood vinegar, galangal and lime stimulant respectively compared with control (Table 1).

Yield of jelutong sap was significantly greater when using V-shape than half-spiral tappings (Tables 1 and 3). The use of the wood vinegar, galangal and lime stimulants in both techniques produced significantly more sap (20.9, 20.5 and 18.1 g respectively) than control (11.0 g).

Lime increased production of jelutong sap (Table 1). Citric acid, the main compound in lime, is a weak acid yet it is able to play a role similar to that of sulphuric acid, whereby it can lower the surface tension of the parenchyma cell wall causing the sap to become more dilute and to keep flowing. Additionally, citric acid contains one hydroxyl and three carboxylic (COOH) groups and is therefore able to attract and form stronger hydrogen bonds with water molecules in the sap ducts compared with sulphuric acid, which only has two OH groups (Kirk & Othmer 1985). The stronger hydrogen bonds cause more of the sap cells to incur hydrolysis, thereby causing more sap to flow out (Matangaran et al. 2012).

Table 2 ANOVA results for the effects of tapping techniques and types of stimulants on the yield of jelutong sap

Source of variation	Degree of freedom	Sum of square	Mean square	F- calculated	p
Tapping method (T)	1	235.675	235.675	5.339	0.024*
Stimulant (S)	3	1255.689	418.563	9.481	0.000**
Interaction T × S	3	252.066	84.022	1.903	0.137
Error	72	3178.532	44.146	5.339	
Total	79	29796.863			

* and ** significant at 5 and 1% levels respectively

Table 3 LSD test on the yield of jelutong sap according to treatments

Treatment /source of variation	Differences in sap yield between treatment			
Tapping techniques (T)	Half-spiral		V-shape	
Half-spiral	-		-4.43 b	
V-shape	4.43 a		-	
Type of stimulant (S)	Galangal	Lime	Wood vinegar	Control
Galangal	-	2.40	-0.45	9.46
Lime	-2.40 c	-	-2.85	7.06
Wood vinegar	0.45	2.85 e	-	9.91
Control	-9.46 d	-7.06 f	-9.91 g	-

Values followed by the different letters within the same column are significantly different

Jelutong sap collected in the present study was relatively free of foreign matter such as leaves and dirt because the lids on the collection containers excluded debris while allowing sap to flow into the containers. The impurity content in jelutong sap varied but did not appear to be affected by the types of stimulants (Table 4). Impurities, when found, consisted of small pieces of bark produced during tapping. When workers performed the second and third incisions without first removing the containers from the previous day, sap impurities could easily enter the containers through the sap channel. Stimulants did not affect the quality of the sap produced.

CONCLUSIONS

Mean sap yields when using wood vinegar, galangal and lime stimulants were 20.9, 20.5, and 18.1 g respectively compared with control (11.0 g). V-shape tapping produced more sap than half-spiral tapping. Impurity content of the sap ranged from 0.45 to 0.70% but it was not due to the stimulants. Based on results of our study, the use of organic stimulants, particulary wood vinegar, can potentialy be used to increase sap productivity of tapped jelutong trees.

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Table 4 Impurity content in jelutong sap

Type of stimulant	Impurity content (%)
Ginger	0.70
Lime	0.54
Wood vinegar	0.45
Control	0.70

REFERENCES

Coppen JJW. 1995. *Gum, Resins, and Latexes of Plant Origin.* Non Wood Forest Products Series No. 6. Food and Agriculture Organization, Rome.

Handadhari T. 2004. *Pohon Jelutung (Dyera spp.) Tanaman Dwiguna yang Konservasionis dan Menghidupi.* No. S.504/II/PIK-1/2004. Departemen Kehutanan, Jakarta.

Hezmela R. 2006. Daya anti jamur ekstrak lengkuas merah (*Alpinia purpurata* K. Schum.) dalam sediaan salep. Bachelor dissertation, Bogor Agricultural Institute, Bogor. (In Indonesian)

Kirk BE & Othmer DF. 1985. *Encyclopedia of Chemical Technology*. Interscience Encyclopedia Inc, New York.

Martin DM, Gershenzon J & Bohlmann J. 2003. Induction of volatile terpene biosynthesis and diurnal emission by methyl jasmonate in foliage of Norway spruce. *Plant Physiology* 132: 1586–1599.

Matangaran J, Santoso G & Azis F. 2012. Peningkatan produktivitas getah pinus melalui penggunaan stimulansia jeruk nipis dan lengkuas. *Jurnal Ilmu dan Teknologi Hasil Hutan* 5: 29–32. (In Indonesian).

Pari G & Nurhayati TJ. 2009. Cuka Kayu dari Tusam dan Limbah Campuran Industri Penggergajian Kayu untuk Kesehatan Tanaman dan Obat. Laporan Hasil Penelitian. Pusat Penelitian dan Pengembangan Hasil Hutan, Bogor. (In Indonesian)

Rodrigues KCS, Azevedo PCN, Sobreiro LE, Pelissari P & Fett-Neto AG. 2008. Oleoresin yield of *Pinus elliottii* plantations in a subtropical climate: effect of tree diameter, wound shape and concentration of active adjuvants in resin stimulating paste. *Industrial Crops and Products* 27: 322–327.

Rodrigues KCS, Apel MA, Henrique AT & Fett-Netto AG. 2011. Efficient oleoresin biomass production in pines using low cost metal containing stimulant paste. *Journal Crops and Product* 35: 4442–4448.

Rukmana R. 1995. *Jeruk Nipis*. Penerbit Kanisius, Yogyakarta. (In Indonesian)

Sharma KR & Lecha C. 2013. Tapping of *Pinus roxburghii* (chir pine) for oleoresin in Himachal Pradesh, India. *Advances in Forestry Letters* 2: 31–55.

SNI (Standard Nasional Indonesia). 2012. *Getah Pinus SNI 7837:2012*. Badan Standardisasi Nasional, Jakarta.

Southorn WA. 1969. Physiology of *Hevea* (latex flow). *Journal of the Rubber Research Institute of Malaya* 21: 494–512.

Sumarmadji. 2006. *Teknik Eksploitasi Tanaman Karet (Hevea brasiliensis)*. Pusat Penelitian Karet, Medan. (In Indonesian)

Sukadaryati & Dulsalam. 2013. Teknik penyadapan pinus untuk peningkatan produksi melalui stimulan hayati. *Jurnal Penelitian Hasil Hutan* 31: 221–227. (In Indonesian)

Sukadaryati, Santosa G, Pari G, Nurrochmat DR & Hardjanto. 2014. Penggunaan stimulan dalam penyadapan pinus. *Jurnal Penelitian Hasil Hutan* 32: 329–340. (In Indonesian)

Waluyo TK. 2010. Penentuan metode penyadapan getah jelutung hutan tanaman industri berdasarkan sebaran saluran getah pada kulit batang. MSc thesis, Bogor Agricultural University, Bogor. (In Indonesian)

Wheeler EA, Baas P & Gasson PE. 1989. IAWA List of microscopic features for hardwood identificatation. *IAWA Bulletin n.s.* 10: 219–332.

Wijana S, Arief H & Nur H. 2005. *Tekno Pangan: Mengolah Minyak Goreng Bekas*. Penerbit Trubus Agrisarana, Surabaya. (In Indonesian)

