Asian Journal of Plant Sciences 14 (2): 89-93, 2015
ISSN 1682-3974

RESEARCH ARTICLE OPEN ACCESS

DOI: 10.3923/ajps.2015.89.93

A Study on Production of Resin from *Pinus merkusii* Jungh. Et De Vriese in the Bosscha Observatory Area, West Java-Indonesia

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ARTICLE INFO
Article History:
Received: May 30, 2015
Accepted: July 11, 2015

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ABSTRACT
We investigated the variability in resin production of a pine stand in Bosscha Observatory Bandung (Indonesia) with the aim to exploit this natural resource in a sustainable way. The potential resin productivity of the pine stand in observatory bosscha area has been known. Therefore, it is necessary to investigate the use of methods (quarre and drill method) in pine resin productivity. The tapping method resulted in differences in resin production in 20-25 year-old trees. The production of extracted with the quarre method was 19.34 g tree^{-1}, meanwhile, the drill method resulted in 32.64 g tree^{-1}. The potential annual resin production in bosscha observatory area were 9.29 and 15.640 t year^{-1} for quarre and drill method, respectively. The resin production capacity of pine species (*P. merkusii* Jungh. Et de Vriese) were affected by tree diameter.

Key words: Pine resin, *Pinus merkusii*, observatory bosscha, quarre method, drill method

INTRODUCTION

Pinus merkusii (Jungh. et de Vriese) is one tropical pine species with great ecological, biological and economic importance. Among all pine species products, resin is the produc that can be processed into gumrosin and turpentine. Turpentine and gumrosin, produced by processing pine resin, are used in a very wide variety of applications, such as soap, paints, adhesives, printing inks, coatings, paper-sizing (Greenhalgh, 1982), varnishes, perfume, disinfectants and cleaning agents (Coppen and Hone, 1995). Along with the population increase, the demand for pine resin is also increasing. Over 40 countries imported rosin from China, amounting to more than 200,000 t annually (Liu, 2001). During the 2014, Indonesia exported a total of 13.6 t of rosin to India annually, which was nearly 10% of rosin traded in international markets all over the world (Perum Perhutani, 2012). Indonesia lost much of China, which was ranked first in the world production of rosin tapping pine forests covering 1.3 million hectares with a production of 6 kg/tree/tapping/year or production reached 60,000 t year^{-1}.

Pinus merkusii (Jungh. et de Vriese) is perhaps the only pine species that extends its distribution and naturally grows in Indonesia. The wood of *P. merkusii* can be used in construction, matches, pulp for paper and furniture. Although, historically, the species had been used for various wood-based products, but it also produces resin that can be processed into gumrosin and turpentine (Sutigno, 1983). *Pinus merkusii* has high resin content and one of the principal tree species planted for reforestation and soil erosion control (IUCN., 2001). The process of acquiring of this resin, called resin tapping (tapping technique), generally used in Indonesia are quarre method. However, this method still has many shortcomings not only in terms of resin productivity but also the sustainability of the trees and quality of the resin. One of the improved tapping techniques is by using the drill method.

A stand of pine trees from the species *Pinus merkusii* Jungh de Vriese) was established in the bosscha observatory area in the early 1989's (Officer of the bosscha observatory, personal communication). At the end of 2014, there were 4,000 trees growing on approximately nine hectares of land within the bosscha observatory area, which is managed by

Institute of Technology Bandung (ITB). The pine stand was not established as commercial plantation, thus despite being source of gum naval stores (turpentine and rosin), until now the pine trees have never been exploited.

This study reports the productivity of resin from *P. merkusii* bosscha observatory area estimated using various tapping methods. This study was the first step in evaluating the standing resource of Bosscha pine plantations as potential source for the production of naval stores of resin. Results of this study can be used for planning the management of Bosscha pine plantations by ITB.

MATERIALS AND METHODS

Study site: The study was conducted in the *Pinus merkusii* stands of the Bosscha Observatory area, in West Bandung District. It is situated 50 km north of Bandung city. The elevation at the Observatory area varies between 1,000-1,500 m.a.s.l. The mean annual rainfall is 1163 mm. The mean monthly temperature is 17-27°C. The *P. merkusii* is a 20-25 year old pine stand, the average diameter at breast height and height ware 35 cm dan 15 m, respectively. The condition of *P. merkusii* stands on the study site is located is presented in Fig. 1.

Sampling design and methods: A total of 100 sample trees were marked for resin collection. The diameter at breast height of all sampled trees were measured to assess the effect of size on resin production capacity of the species. The sample trees were distributed equally for each diameter class. Based on various tree diameter found in study site, all trees were classified into five classes of diameter (Table 1).

The number of samples trees in each diameter classes and resin tapping method each with 10 replications, so the number of samples tree used 100 samples tree. They all were numbered to identify each single tree to record its monthly resin production. The resin was collected by wounding or tapping using quarre and drill method as described by Lekha (2002) and Kumar and Sharma (2005). The crude exude will be dropped in the cups/plastic bags hung just below the wounded area.

The process of quarre method is done with the first step was the stem of pine that will be tapped cleaned of bark, then wounded with tools kedukul, with the size of the quarre of 5 cm width, height 15 cm and thick of ±2 cm. The direction of quarre was vertical so that the resin can flow into plastic glass (Fig. 2a). Drill method of tapping was carried out by drilling

Table 1: Classification of experimental trees into five diameter classes

Diameter of tree (cm)	Diameter class
30.00-32.00	I
32.01-34.00	II
34.01-36.00	III
36.01-38.00	IV
38.01-40.00	V

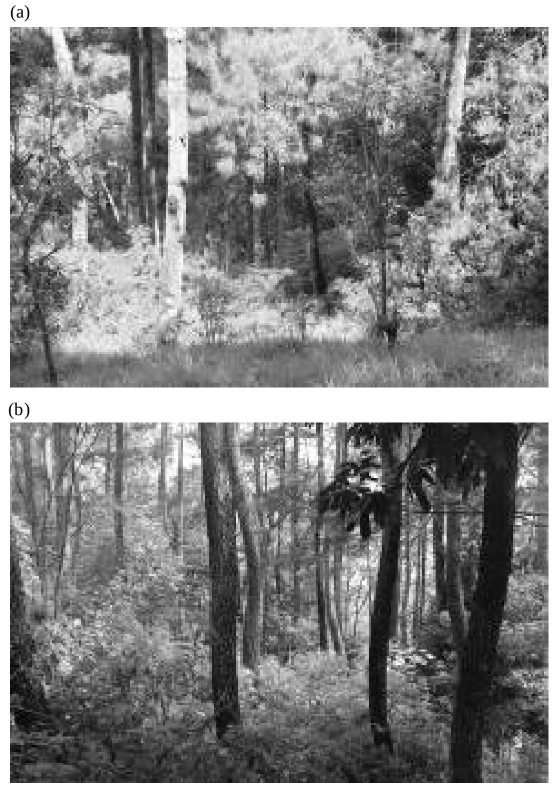

Fig. 1(a-b): *Pinus merkusii* (Jungh. et de Vriese) stands in the bosscha observatory area

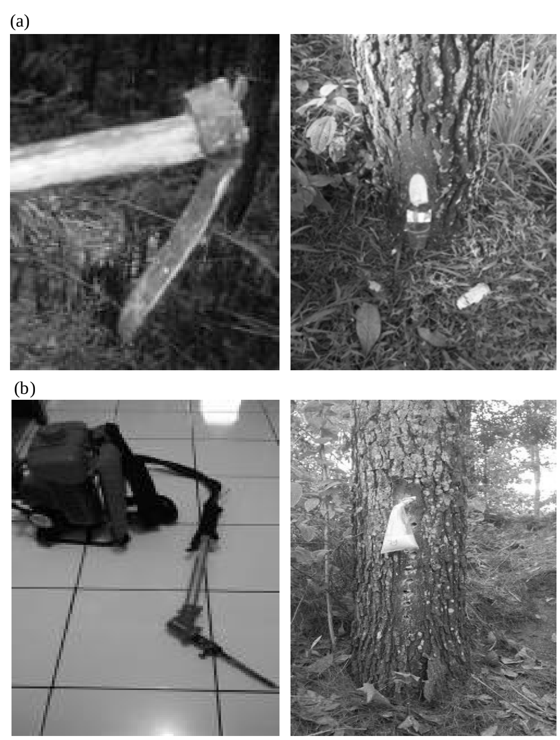

Fig. 2(a-b): Resin tapping of *Pinus merkusii*, (a) Quarre method and (b) Drill method a slight sloping hole (45°) into the wood (depth of ±2 cm) at 20 cm height from the ground. The equipment used was hand drill with the drill size of 16 mm. A plastic bag was tightly inserted into the hole via a plastic pipes (Fig. 2b) to collect the resin. Resin collection from each diameter classes and tapping method was carried out every 3 days for 1 month to get reliable data. The resin collected each three days was cleaned to remove all extraneous material and weighed.

Statistical analysis: All results were statically analyzed by univariate Analysis of Variance (ANOVA) and the significance of differences was calculated by Duncan's multiple range test and $p<0.05$ were considered to be significant. All statistical tests were performed using SPSS version 16.0 at a 95% confidence level.

RESULTS AND DISCUSSION

Based on samples taken from five diameter classes, results of resin production for the different resin tapping techniques are presented in Fig. 3. These results showed significant differences in resin production between the two tapping method. The highest resin production of 32.64 g/hole/tree was recorded from the drill method of tapping and the lowest resin production of 19.34 g/quarre/tree was found in the quarre method of tapping. Thus, the estimate of annual productions were 9.29 t year^{-1} using the quarre method and 15.64 t year^{-1} using the drill method. The estimate minimum and maximum of annual resin production per tree were 2.32 and 3.56 kg/tree/year, respectively. According to classification from Papajiannopoulos (2002), such level of production is considered as economically profitable.

The resin production was significantly affected by the wound size (quare size and diameter of boreholes). Sharma and Lekha (2013) reported that the significantly highest resin (637g/hole/tree) was recorded in the borehole diameter 1.25" (3.125 cm) followed by 1.00", 0.75" and 0.50". Meanwhile, quarre method of tapping produce optimum of resin production on quare thick 3.0 cm compared 2.0, 2.5, 3.5 and 4.0 cm (Sharma *et al*., 2014). According to Sukarno *et al*. (2013) the drill size 21 mm showed the highest mean resin production and the drill size 7 mm showed the lowest. They considered that tapped production will continue to increase along with increasing the size of the drill.

The conventional of tapping (quarre method) leads to the destruction of some wood and the production of poor quality resin than tapping by drill method (Fig. 4). The wound caused by tapping may influence the tree growth (Zhang, 1990; Wang, 1993; Nanos *et al*., 2001). Study by Li (1991) show that the influence of tapping method on tree growth are often due to the damage of cambium and seem to be some kind of tree reaction for the lack of woody tissue in a part of the stem.

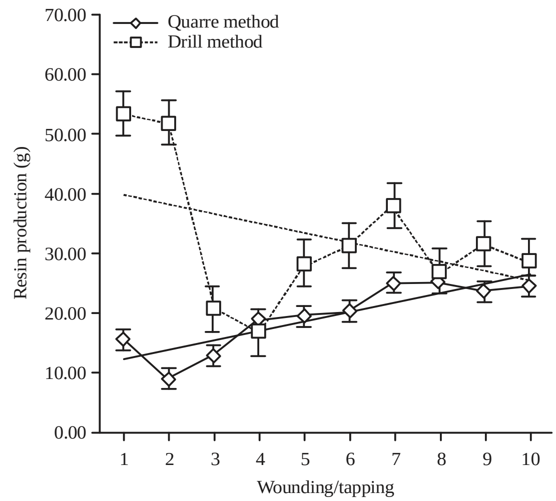

Fig. 3: Mean resin production by resin tapping method

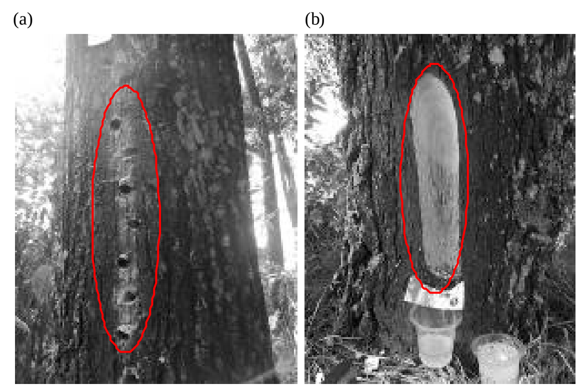

Fig. 4(a-b): Broken stem of a resin tapped *Pinus merkusii*, (a) Drill method and (b) Quarre method

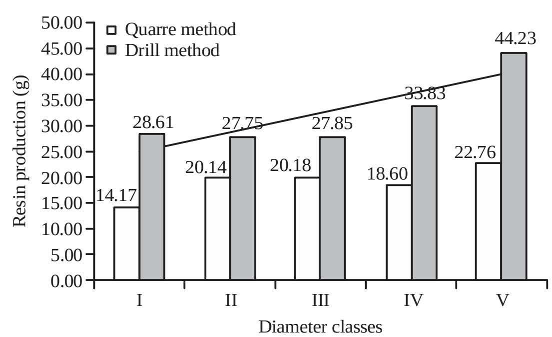

Fig. 5: Comparison of mean value of resin production for five diameter classes of *Pinus merkusii* based on resin tapping method

Figure 5 show the significant difference in resin production among different diameter classes. There is a trend of increase in production of resins with increase of diameter. In other words, the resin production capacity differs

Table 2: Duncan multiple range test for difference in resin production

	Diameter class				
Resin tapping	I	II	III	IV	V
Quarre method (g)	12.16[a]	15.77[b]	19.84[c]	23.96[de]	24.98[ed]
Drill method (g)	18.58[a]	29.71[bc]	29.98[cb]	32.39[d]	52.58[e]

Values in the same column followed by the same letter are not significantly different

among diameter classes. The highest resin production of 44.23 g/hole/tree was recorded from the trees of 38-40 cm diameter class and the lowest resin production of 27.75 g/hole/tree was found in 32-34 cm diameter trees. Meanwhile, the quarre method of tapping resulted in maximum resin production (22.76 g/quarre/tree) on the diameter class 38-40 cm and minimum resin production (14.17 g/quarre/tree) on diameter class of 30-32 cm.

Although, these results showed significant differences in resin production in diameter classes and are supported by several studies (Kaushal *et al*., 1983; Kaushal and Sharma, 1988; Singhal, 1996; Murtem, 1998), however, Chaudhari *et al*. (1992) suggests that resin production will be maximum on diameter increases up to 45 cm. Besides diameter, other factors can affect resin production (through wounding), namely soil (Samanta *et al*., 2012), climate (Zanski, 1970), applied chemicals (Philippou, 1986), tree age (Buchert *et al*., 1997), silvicultural regime (Moulalis, 1981) and genetics of trees (Papajiannopoulos, 2002).

According to Table 2, it was found that the difference in resin production between quarre and drill method was significant ($F = 12.33$, $df = 9$, $p<0.05$). There were also significant difference in resin production between different diameter class of trees ($F = 884.64$, $df = 4$, $p<0.05$). The findings of this study was also supported by other studies done by Tadesse *et al.* (2001), Kelkar *et al.* (2006) and Spanos *et al*. (2010).

This study showed that difference in diameter of 8-10 cm will increase resin production as much 6 and 8 g tree^{-1} on quarre and drill method, respectively. The increase in diameter is believed to increase the volume of sapwood as reported by Coppen and Hone (1995). Sapwood composes of cells that contain physiologically active photosynthesis results, where resin is produced and stored in tree's phloem and xylem (Papajiannopoulos, 1997, 2002; Franceschi *et al*., 2005).

CONCLUSION

The highest resin production was recorded in resin tapping of drill method for all diameter classes. The findings of this study showed that resin production capacity of pine species (*P. merkusii* Jungh. Et de Vriese) differs among diameter classes. The average resin production of diameter class 38-40 cm is higher than the averages for diameter class 30-32, 32-34, 34-36 and 36-38 cm. This result confirms that the greater the diameter of the tree tapped and the bigger the proportion of sapwood, the greater the resin yields. Thus, to increase resin productivity can be done by removing the tree from the less-productive class I and II.

ACKNOWLEDGMENTS

The author would like to thank Institute of Technology Bandung (ITB), Indonesia, for providing Research Grant No.845/AL-J/DIPA/PN/SPK/2014 for this study. The author is also thankful to Prof Dr. Tati Suryati Syamsudin and Dr. Pingkan Adityawati for providing the necessary facilities for preparing the part of research.

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