Oleoresin yield of *Pinus merkusii* trees from East Banyumas

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**Abstract.** *Pinus merkusii* is the main pine found in Indonesia to produce oleoresin. The present study assessed the oleoresin yield treated by various stimulants (ETRAT, SR4, sulphuric acid, sulphuric acid-Ethepon mixtures), and relate it with several tree characteristics. Trees were selected from different two different class ages i.e. IV (16-20 years) and VII (31-35 years) and were tapped for 8 days by bark chipping method in 5 replications. The pine stand was located in East Banyumas of Perhutani. Results showed that the mixture of sulfuric acid and Ethephon gave comparatively high oleoresin yield levels. In general, tree from age class of VII exhibited higher amount of resin production than those of age class of IV. The levels of oleoresin yield were significantly correlated with tree height in 31-35-year-old trees. After combining data from the two age classes, only a positive relationship between tree diameter and oleoresin yield was measured in untreated trees. For stimulated trees, the oleoresin yield exhibited positive significant correlation coefficient with tree diameter, tree height, and crown closure for certain stimulants. The negative significant correlation was observed between oleoresin yield and site elevation. As no consistent pattern of correlations with regard to stimulating agents, it suggests that the role of other factors should be explored in future works.

**Keywords:** pine tapping, resin production, ethylene, quarr method, stimulating agents, tusam

1. Introduction

Gum rosins and turpentines distilled from *Pinus merkusii* oleoresin are the major commodities of Perum Perhutani (state-owned enterprise) in Indonesia. For this reason, a tapping process becomes an important activity in supporting the sustainability of the oleoresin processing industry. Various innovations have been carried out by Perum Perhutani which includes superior tree selection, improved tapping methods, and distribution chain efficiency to the factory.

In our earlier parallel work [1], application several stimulants to increase the productivity of the stand was conducted. Other works also demonstrated the effects of current used stimulants by Perhutani as well as modified stimulants with various results [2-4]. However, the experiments to discover the relations of resin production with tree parameters (tree diameter, tree height, site elevation, etc.) are still limited. The available data in *Pinus merkusii* tapping were the relations between resin production and tree diameters [5][1].

Not only by environmental factors [6], but also is the oleoresin yield affected by various tree factors [7]. Thus, the objectives of this research were to find out the relationships between several tree characteristics and resin production in two different class ages stands in various stimulants. Understanding the effects of those parameters on resin yield would be helpful for improving techniques and management of resin tapping forests.
2. Materials and methods

2.1. Site and tapping preparation

The experiment was carried out in October 2015 at East Banyumas Forest Management Unit (KPH), BKPH Karangkobar, RPH Pandanarum, i.e. compartment of 59E (16-20 years) and 58D (31-35 years). Both stands were formerly thinned with an initial planting distance of 2 x 3 m. The selected trees have been tapped before. The trees were in inner side, sound, and relatively straight. The tree variables i.e tree diameter (diameter tape), tree height (hagameter), crown closure (ground measurement), and site elevation (geographic information system) were measured. Descriptions of sites and tree samples are presented in Table 1.

| Site | Compartment 59E | Compartment of 58D |
|------|----------------|-------------------|
| Age class | IV (16-20 years) | VII (31-35 years) |
| Site quality (boniteit) | IV | II |
| Altitude (m asl) | 680 | 797 |
| Temperature °C | 23-27 | 23-28 |
| Relative humidity (%) | 60-78 | 59-76 |
| Tree diameter (cm) | 26-39 | 42-75 |
| Tree height (m) | 24-38 | 36-55 |
| Crown closure (%) | 30-60 | 40-80 |
| Site elevation (%) | 12-41 | (-2) – 34 |

2.2. Stimulant preparation

The SR4 and ETRAT stimulating agents were provided Perhutani. The sulfuric acid (H₂SO₄) in technical grade purchased from MKR Chemicals (98% concentration). Ethephon solution was produced by PT Indobiotech Agro (concentration of 10 mg /100 ml). Mixing of sulfuric acid and Ethephon based on a certain ratio (v/v) with dilution of distilled water. In detail, the stimulant composition is presented in Table 2.

| Stimulant codes | Composition (v/v) |
|----------------|------------------|
| SA3Et4 | 3.3% sulfuric acid + 4.1% Ethephon |
| SA3Et8 | 3.3% sulfuric acid + 8.3% Ethephon |
| ETRAT | Mainly ethylene and citric acid |
| SR4 | Mainly sulfuric acid |
| SA20 | 20% sulfuric acid |
| SA20Et2 | 20% sulfuric acid + 2% Ethephon |

2.3. Oleoresin tapping and stimulant treatment

Trees were tapped using bark chipping method (quarre) with an axe (kedukul) and the exudates were collected in open container (plastic cup). The wound size was 2 cm (deep) × 6 cm (width) × 20 cm (height). The tapping operation was displayed in Figure 1. The stimulants were sprayed (± 2 ml) with a plastic spray. This spraying was done 5 minutes after making the wound. The results of the oleoresin were weighed with an analytical scale the next day at 10-11 a.m. every day. The containers were replaced with new containers for 8 days as a whole. Spraying was not performed for untreated trees (control). Each treatment in the compartment was carried out with 5 replications so that 70 trees in total were observed.
2.4. Data analysis

The results of oleoresin yield were analyzed with a completely randomized design. The effect of the class age and treatment factors was calculated by two-way ANOVA analysis. Post-hoc test was determined by Duncan's multiple comparison test. The relationship between oleoresin yield and tree variables was analyzed by Pearson's Correlation. All calculations were performed with SPSS 10.0 (Windows) and Excel 2013.

3. Results and discussion

3.1. Oleoresin yield

The comparison between age class IV (16-20 years) and VII (31-35 years) showed a general pattern that older trees give higher production values. From the overall results of 8-day observation, the two-way ANOVA results showed a highly significant interaction ($p < 0.01$) for two factors. Duncan's test results showed that the best stimulants were SA3Et4 and SA3Et8 both for 31-35-year-old trees with an average of 184.0 g/tree/hole and 181.6 g/tree/hole, respectively (Figure 2). The lowest average value was calculated for untreated trees in 16-20 year-old-tree with an average of 33.2 g/tree/hole. The low value was also measured in trees treated with SA20 (16-20 years) as well as with ETRAT and SR for both stands. The effect of the stimulants has been discussed thoroughly in the previous report [1].
Figure 2. The oleoresin yield (8-day observation) from one hole in different age class (average of 5 trees). The same letters on the same graphic are not statistically different at $P<0.05$ by Duncan’s test. Remarks: SA3Et4 = mixture of 3.3% sulfuric acid + 4.1% Ethephon; SA3Et8 = mixture of 3.3% sulfuric acid + 8.3% Ethephon; SA20 = 20% sulfuric acid; SA20Et2 = 20% sulfuric acid + 2% Ethephon.

3.2. Correlation between oleoresin yield and tree factors

Increasing of resin production through silvicultural practice is valuable only if there are significant relationships between tree characteristics and oleoresin yield. Evaluation of Table 3 revealed that the oleoresin yield had significant correlation only with tree height if the data were analyzed separately. The samples were at 31-35-year-old stand treated with SR4 ($r=0.98^{**}$) and SA20 ($r=-0.91^*$). Interestingly, the correlations were inverse from one another. It meant the higher levels of tree height would give higher or lower resin production (Figure 3). The results suggest that other factors could be more affecting and controlling the oleoresin production than the tree height.

If the data were combined, with a wider range, significant correlations were found as expected. The oleoresin yield exhibited positive significant correlation coefficient with tree diameter except for ETRAT and SR4 treatments. Further, oleoresin yield explicated positive and significant correlation coefficient with tree height in trees stimulated with SA3Et4 ($r=0.55^*$) and SA20 ($r=0.65^*$). There was also observed a moderate positively correlation ($r=0.65^*$) between oleoresin yield and with crown closure in trees stimulated with SR4. The negative significant correlation coefficient was observed between oleoresin yield and site elevation in trees treated with SA3Et4 ($r=-0.59^*$) and SA3Et8 ($r=-0.76^*$). In control samples, it was noticed that a positive relationship between tree diameter and oleoresin yield was measured as the correlation coefficients between rests of the combinations were found to be nonsignificant.

In a various degree, tree diameter could be related with resin production in this experiment. The relationship has been explained in the earlier communication [1]. Generally, larger diameters produce more resin than their smaller counterparts in pine species [6][7]. It is thought that the increase in diameter would increase the volume of sapwood [8].
| Sites          | Diameter | Height | Site elevation | Crown closure |
|---------------|----------|--------|----------------|---------------|
| 16-20 years stand |          |        |                |               |
| SA3Et4        | -0.15    | -0.80  | -0.10          | 0.76          |
| SA3Et8        | 0.82     | -0.35  | -0.83          | -0.29         |
| ETRAT         | 0.27     | -0.14  | -0.46          | -0.37         |
| SR4           | -0.59    | 0.72   | 0.18           | 0.28          |
| SA20          | 0.51     | 0.32   | -0.29          | -0.01         |
| SA20Et2       | 0.70     | -0.01  | 0.50           | 0.12          |
| Untreated     | -0.27    | -0.71  | 0.80           | 0.34          |
| 31-35 years stand |        |        |                |               |
| SA3Et4        | -0.71    | 0.14   | 0.29           | -0.02         |
| SA3Et8        | 0.54     | -0.82  | -0.29          | -0.47         |
| ETRAT         | -0.28    | -0.64  | -0.52          | -0.33         |
| SR4           | 0.35     | 0.98** | 0.73           | 0.74          |
| SA20          | -0.33    | -0.91* | -0.71          | 0.33          |
| SA20Et2       | 0.63     | 0.26   | -0.62          | 0.28          |
| Untreated     | 0.01     | -0.09  | -0.19          | -0.01         |
| Total         |          |        |                |               |
| SA3Et4        | 0.75**   | 0.55*  | -0.59*         | 0.30          |
| SA3Et8        | 0.81**   | 0.48   | -0.76*         | 0.32          |
| ETRAT         | 0.01     | -0.03  | 0.33           | 0.40          |
| SR4           | 0.08     | 0.50   | 0.14           | 0.65*         |
| SA20          | 0.64*    | 0.65*  | -0.27          | 0.53          |
| SA20Et2       | 0.70*    | 0.46   | 0.04           | -0.34         |
| Untreated     | 0.68*    | 0.57   | -0.46          | 0.59          |

Remarks: SA3Et4 = mixture of 3.3% sulfuric acid + 4.1% Ethephon; SA3Et8 = mixture of 3.3% sulfuric acid + 8.3% Ethephon; SA20 = 20% sulfuric acid; SA20Et2 = 20% sulfuric acid + 2% Ethephon. Significance levels for correlation coefficients: ** P < 0.01; and * P < 0.05.

Figure 3. The relations between oleoresin yield with tree height in 31-35-year-old stand treated with 20% sulfuric acid and SR4 in East Banyumas FMU
The crown size of trees can influence resin production [8]. However, the effect crown closure was less investigated. Crown closure would affect the light distribution pattern and local temperature or relative humidity. In the present study, the moderate positive correlation (Figure 4) with resin yield only in SR4 treatment may be viewed as the higher levels of crown closure indirectly caused more favourable environmental conditions albeit in a lesser extent. A negative correlation between site elevation and oleoresin yield (Figure 4) implied trees grown in a less steep or flat surface can produce more resin. It probably related to the allocation of photosynthates to primary (compression wood) and secondary metabolic processes.

The yield of oleoresin is affected by number of factors such as diameter, environmental factors, time of tapping, stimulants, etc. [9-11]. No consistent pattern in the correlation analysis in all stimulant tested suggesting that a complex interaction system exists among tree factors, stimulants, and age class. A more thorough analysis of the relationship between tree factors and resin production in widened areas and age class is needed to potentially shed additional light on why the pattern of resin exudation in a pine stand vary so much.

![Figure 4](image.png)

**Figure 4.** The relations between oleoresin yield with site elevation and oleoresin yield with crown closure in two age classes (IV and VII) in East Banyumas FMU

### 4. Conclusions

Oleoresin yields from *Pinus merkusii* depended on interaction between age class and stimulating agents. The highest oleoresin yield was obtained by using 4.1% Ethephon + 3.3% H2SO4 as a chemical stimulant in 31-35-year-old stand. Generally, the older trees or bigger trees were associated with higher oleoresin yield. Due to lack of samples or narrow interval, significant relationship was only found in oleoresin yield and tree height in 31-35 years. By combining data and wider interval of tree variables, tree diameter correlated positively with oleoresin yield in 5 treatments including the controls. No consistent of correlation pattern was observed in other parameters related to the stimulants suggesting that other factors involved. These results indicate that the possibility of combining the tree diameter and stimulants to achieve higher oleoresin yield.

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