The characteristics of *Pinus merkusii* resin productivity flow pattern

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**Abstract.** *Pinus merkusii* Jungh et de Vriese belongs to the pine species that grows naturally in Indonesia, particularly in Sumatra: Aceh, Tapanuli and Kerinci. The Perhutani has managed and developed *P merkusii* as a source for the state revenue. Wood and resin are the most important products of the *P merkusii* tree. The purpose of this study was to understand the effect of the tree growth based on its resin productivity and its characteristic flow pattern per unit time to support the completion of the project. This study was conducted at KPH Banyumas Barat in March-October 2018. The height and periphery of the trees were the data parameters for the growth evaluation. The resin productivity was evaluated for a year based on the characteristic flow pattern approach by using the drill tapping method on 201 sample trees which was repeated weekly. According to the statistical analysis, the tree’s periphery has a positive effect on the resin productivity whereas the height has a negative one, which means that the cultivation of the pine tree is highly affected by the selected sylviculture. The research showed, by conducting a systematic measurement of the resin productivity of the 201 chosen trees reveals the existence of a good characteristic of resin pattern productivity in 10 individuals trees. The characteristic of resin productivity output pattern sequentially increased with a peak in May-August. This characteristic data is very useful for the Perhutani to optimize the cultivation of the entire *P merkusii* class for future endeavors.

1. **Introduction**

Every tree undergo two different growth which are height and diameter [1]. Growth is the increased dimension of one or more individual tree in an area of forest stand in a certain period of time [3] [29]. Height and diameter growth implied at alteration of size and tree shape that will determine in tree or tree stand volume estimation. Sutarahardja [26] mentioned that growth is a continuous physiology process until the tree or tree stand naturally died, as Prodan [11] defined growth as an organic system in a certain period of time and measured in length, width, volume and width units. Nevertheless, tree growth is affected by its genetic ability to interact with environmental factors such as weather, soil and topography.
and also the ability to compete in absorbing food and growth space. Each species or each family of tree have different growth ability and stem size, as a result from interaction within factors mentioned before [3][2].

One of non timber forest product (NTFP) plays an important role in Perum Perhutani industry is pine \((P\ merkusii)\) resin. Pine resin processing produces turpentine oil and rosin gum. Advanced in technology, not only used gum resin as a material for \textit{batik} industry but also as a material for adhesive, paper, ink and gum industries [9]. Turpentine oil be utilized as organic oil solvent and as thinner in paint and polish industry, adhesive industry and wax solvent [17]. Lempang [7] explained that pine resin production were influenced by internal and external factors such as growth sites, age, stand density, genetic traits, elevation, quality and quantity of the pine resin workers and also treatment and resin tapping method.

Resin is one part of result from tree physiology process, therefore, factors that influencing tree growth generally will affect resin production. Sukarno [23] mentioned resin productivity in third age class increased significantly at the 4th age class, this shows that growth affected resin productivity significantly. Accordingly to this research, Hutabalian [4] stated the bigger diameter of pine trees the more resin production, vice versa. Wibowo [30] stated the bigger diameter of pine trees generate more sap wood that will lead to more resin glands in pine trees resulting in increased resin production.

Resin productivity pattern in a period of time resulting different yields, several research explained in Sudrajat [20] that period of time in resin yield significantly affect the average resin production. Sumantri [25] mentioned that daily average of resin yield within 12 times of harvesting shows diverse fluctuation. The purpose of this research is to determine the effect of tree growth with resin productivity and resin output pattern in a periodic of time to support the pine tree improvement program.

2. Method

Tree height data collection were using measuring pole from ground to tree apical growth and periphery data collection were using diameter tape at DBH (diameter at breast height) or 130 cm from ground. Resin productivity measurement was conducted by drill tapping method using 13 mm drill bit. The first hole was at 20 cm above ground with 20° slope directing to pith. Hole depth was 2-3 cm from stem surface (cleaned bark) so the depth of the hole still in the sap wood area.

The research was conducted on 201 chosen individual trees in progeny test stand plot 37c RPH Samudra, BKPH Lumbir, KPH Banyumas Barat, planting year 2005. Resin yield and measurement is conducted at the 7th day and continued with hole renewal horizontally to the stem, distance between hole are 90° circularly following the wind direction. One hole represent one week of observation, in summary, 4 hole equal 1 month of observation. After one month, the next hole is drilled above the first hole of the previous month (±5-7 cm) continuously until the last month of observation (8 months, 32 times of hole renewal).

Plastic container was placed to collect resin from the tree, the used of plastic is to eliminate external litter contamination and rainfall. Resin yield was measured using digital scale with 0.1-1 gram accuracy. To avoid bias in resin production that could exist because of different yield time, drilling management was finish block by block.
Figure 1. Research process flow chart

3. Result and discussion
3.1. Tree periphery and heights distribution
Individual \textit{p. merkusii} observed in this research were 201 sample trees. Measurements of the periphery shows a value between 35-100 cm in average of 69.48 cm. Tree heights are between 8.5-15.5 m in average of 13.79 m. The periphery distribution based on its height as in Tabel 1 and spread diagram as in Figure 2.

| Class of periphery (cm) | 8.5-11 | 11.5-13 | 13.5-15.50 | Sum |
|-------------------------|--------|---------|------------|-----|
| 35-51                   | 6      | 11      | -          | 17  |
| 52-62                   | 5      | 13      | 15         | 33  |
| 63-73                   | 1      | 13      | 60         | 74  |
| 74-84                   | -      | 6       | 51         | 57  |
| 85-100                  | -      | -       | 20         | 20  |
| Sum                     | 12     | 43      | 146        | 201 |
3.2. Correlations between tree periphery and height
According to Table 1, generally, tree individual periphery are between 63-73 cm and height 13.5-15.5 m, it indicates the growth of progeny test stand have reached maximal growth by the time this research was conducted. Correlations between tree periphery and height analyzed using Pearson correlation test (Tabel 2).

| Correlations between tree periphery and height |
|-----------------------------------------------|
| Pearson Correlation                           |
| periphery                                     |
| Height                                        |
| ,684                                          |
| 1,000                                         |
| Sig. (1-tailed)                               |
| periphery                                     |
| .                                             |
| .                                             |
| N periphery                                   |
| 201                                           |
| 201                                           |
| Height                                        |
| 201                                           |
| 201                                           |

Tree periphery and height have a significant correlation shown by the positive value and 0.000 probability, this means the bigger tree periphery correlate with higher tree height, as we can see its regression equation in Tabel 3.

| Regression coefficients of tree samples periphery and height |
|-------------------------------------------------------------|
| Model Unstandardized Coefficients Standardized Coefficients |
|-------------------------------------------------------------|
| model B Std. Error Beta t Sig. a. Dependent Variable: periphery |
| 1 (Constant) 22,828 7,013 -3,255 001 |
| heights 6,694 ,506 ,684 13,224 ,000 |

3.3. Resin productivity distributions
The observation of resin productivity was conducted in 8 months from March through October, resin yield was collected weekly with total yields 32 times. The average of resins productivity during the observations are 29.5 grams/tree from total of 201 tree sample.
3.3.1. Weekly resin productivity

Resin was tapped using drill method and yielded in weekly period for 32 weeks sequentially. The drilling was conducted circular clockwise, the distance between each drill hole are according to wind direction. Tabel 4 explains the weekly resin productivity variations.

**Tabel 4. The weekly resin productivity variations**

| Tests of Between-Subjects Effects |  |
|----------------------------------|--|
| Source                           | Type III Sum of Squares | df | Mean Square | F   | Sig. |
| Corrected Model                  | 474,532^a               | 3  | 158,177     | .299 | .826 |
| Intercept                        | 5572864,588             | 1  | 5572864,588 | 10519,848 | .000 |
| ahad                             | 474,532                 | 3  | 158,177     | .299 | .826 |
| Error                            | 3404158,213             | 6426 | 529,748     |     |     |
| Total                            | 8977542,902             | 6430 |            |     |     |
| Corrected Total                  | 3404632,745             | 6429 |            |     |     |

a. R Squared = .000 (Adjusted R Squared = .000)

From the table above, the F value is 0.299 with probability 0.826 these value shows that drilling in every wind direction part of the stem did not shows different resin productivity which is mean that drilling for resin can be conducted in every part of the stem surface.

3.3.2. Monthly resin productivity

Monthly resin yields are the summary of the weekly resin yields which are accumulated as a period of yield. The periodic yields are significant for the average monthly resin production. Sudrajat [20] express that the first and second periodic resin yield did not shows significant difference with the third resin periodic yield. Sukadaryati [22] explained four times periodic resin yield showed a significant probability which is that every periodic time of resin yield has a different value to each time, moreover, Sudrajat [20] explained the highest to lowest average resin productivity respectively second period (62.89 gram/tree), third period (56.32 gram/tree) and the lowest was the first period (47.71 gram/tree). The monthly resin productivity variations in this research showed in Tabel 5

**Tabel 5. The monthly resin productivity variations**

| Tests of Between-Subjects Effects |  |
|----------------------------------|--|
| Source                           | Type III Sum of Squares | df | Mean Square | F   | Sig. |
| Corrected Model                  | 75364,137^a             | 7  | 10766,305   | 20,768 | .000 |
| Intercept                        | 5572408,597             | 1  | 5572408,597 | 10748,910 | .000 |
| months                           | 75364,137               | 7  | 10766,305   | 20,768 | .000 |
| Error                            | 3329268,608             | 6422 | 518,416     |     |     |
| Total                            | 8977542,902             | 6430 |            |     |     |
| Corrected Total                  | 3404632,745             | 6429 |            |     |     |

a. R Squared = .022 (Adjusted R Squared = .021)
From the table above, the F value is 20.768 with probability 0.000 these value shows different monthly value of resin productivity. The different can be caused by different factors that effects resin production. Lempang [7] explained that resin productions are affected by internal and external factors. External factors such as growth site and also silviculture activity could directly or indirectly effects to the internal factors. The internal factors that affect resin productions are genetic (species, or variety in the same species), tree age, tree heights and diameter, crown, volume of sap wood and stand density [27][8][28], and for the external factors [14][21][5][15] are environment (lights and temperature, growth site, nutrient, weather and water), management activity (pastoralism, fire management, branch thinning and tapping method). The variation of monthly resin productivity more clearly served in Figure 3.

Figure 3. The variation of monthly resin productivity

3.3.3. Tree selection for the highest resin productivity

This research was conducted to obtain P merkusii tree with the highest productivity to support the pine tree improvement program “Pinus Bocor Getah” (PBG) in Perum Perhutani. The inductive statistical test shows that the observed tree individuals carrying a high difference variation, explained in Tabel 6, the F value 46.02 with 0.000 individual probability. The variations that occur were explained in the previous section.

The multiple comparisons test and homogenous test shows a grouping of tree individuals with the same resin productivity with probability value 0.864 they are individual number 125, 164, 193, 200, 138, 201, 199, 90, 66 and 27. Those individuals are to be the candidates of PBG that will support the pines tree improvement program in Perum Perhutani. The resin productivity value of the tree candidates explained in Tabel 7.

Tabel 6. Individual variation difference in monthly resin productivity

| Tests of Between-Subjects Effects |
|----------------------------------|
| Dependent Variable: resin        |
| Source                           | Type III Sum of Squares | df | Mean Square | F    | Sig. |
| Corrected Model                  | 2030475,319             | 200| 10152,377   | 46.02| .000 |
| Intercept                        | 5573904,921             | 1  | 5573904,921 | 25266,285| .000 |
| individual                       | 2030475,319             | 200| 10152,377   | 46.02| .000 |
| Error                            | 1374157,426             | 6229| 220,606     |      |      |
| Total                            | 8977542,902             | 6430|            |      |      |
| Corrected Total                  | 3404632,745             | 6429|            |      |      |

a. R Squared = .596 (Adjusted R Squared = .583)
Table 7. Individual tree candidate for “Pinus bocor getah” (PBG)

| Tree No. | March | April | May | June | July | August | September | October | Total |
|----------|-------|-------|-----|------|------|--------|-----------|---------|-------|
| 125      | 74.9  | 56.8  | 72.6| 128.9| 109.2| 110.1  | 76.3      | 84.6    | 713.4 |
| 164      | 73.8  | 69.4  | 80  | 96.4 | 96.7 | 99.8   | 83.0      | 102.7   | 701.8 |
| 193      | 64.0  | 67.8  | 77.8| 104.0| 86.1 | 103.5  | 87.7      | 89.0    | 679.9 |
| 200      | 87.8  | 62.3  | 54.5| 61.0 | 131.5| 124.8  | 75.5      | 68.7    | 666.1 |
| 138      | 46.8  | 61.0  | 45.2| 91.1 | 81.1 | 109.0  | 105.3     | 105.7   | 645.2 |
| 201      | 85.5  | 66.6  | 53.0| 82.0 | 115.3| 78.2   | 58.7      | 77.5    | 616.8 |
| 199      | 73.6  | 63.5  | 54.3| 72.4 | 74.7 | 83.8   | 97.1      | 94.2    | 613.6 |
| 90       | 58.3  | 52.5  | 36.2| 57.5 | 90.3 | 104.0  | 114.1     | 97.7    | 610.6 |
| 66       | 75.3  | 62.8  | 54.8| 74.7 | 85.5 | 68.1   | 54.4      | 76.1    | 551.7 |
| 27       | 55.18 | 64.65 | 63.83| 68.28| 70.95| 78.63  | 79.20     | 59.98   | 540.7 |
| **Average** | **69.52** | **62.74** | **59.22**| **83.63**| **94.14**| **95.99** | **83.13** | **85.62** |

3.3.4. The characteristic flow pattern P merkusii resin

The result from PBG tree candidates were used to discover the characteristic of resin output pattern that occur in this research. This output pattern is an important information for the management of resin industry.

![Figure 4](image)

**Figure 4.** The characteristic of PBG resin output pattern based on monthly resin productivity

The figure above shows an obvious different of resin monthly yield, this information is required by the management of resin industries and also for the silviculture act towards the pine stand.

3.3.5. The correlation between resin, tree periphery and heights.

As explained previously that tree periphery and height are the internal factor that affected the resin productivity. Based on the PBG tree selection, the periphery are between 53-77 cm with average of 65 cm and tree height are between 9-15.5 cm with average of 13.05 m and resin productivity are between 67.58-89.17 gram/tree with average of 79.23 gram/tree. The relation between the three parameters is explained by regression analysis in Tabel 8.
**Tabel 8. Pine resin correlation with periphery and height**

| Correlations | height | periphery | resin |
|--------------|--------|-----------|-------|
| height       | Pearson Correlation | 1        | 0.735* | -0.027 |
|              | Sig. (2-tailed)    |          | 0.016  | 0.942  |
|              | N                  | 10       | 10     | 10     |
| periphery    | Pearson Correlation | 0.735*   | 1      | 0.156  |
|              | Sig. (2-tailed)    | 0.016    |        | 0.667  |
|              | N                  | 10       | 10     | 10     |
| resin        | Pearson Correlation | -0.027   | 0.156  | 1      |
|              | Sig. (2-tailed)    | 0.942    |        | 0.667  |
|              | N                  | 10       | 10     | 10     |

*: Correlation is significant at the 0.05 level (2-tailed).

The resin productivity is positively correlated with periphery and a negative correlation with height. Santosa [16] mentioned correlation value above shows a significant correlation and vice versa. Widodo [30] explained in a resin productivity research using rill tapping method, the bigger volume of sap wood contained more resin canal in pine trunk correlate with more resin productivity.

In this research, since the correlation between periphery and resin productivity is weak with drill tapping method, hypothetically the resin productivity are more influenced by its genetic with the approach of heritability value. Several research proved that pine resin production were strongly controlled by genetic factor appointed by a high heritability value [6][10][12][19][13], therefore in the effort of increasing pine resin productivity, the act of tree improvement program is an effective choice. By combining previous conducted study, difference result on effect of periphery toward resin productivity with different tapping method, assuming that sylviculture act applied can be different, especially tree spacing as an environmental function in intensive sylviculture that it is now applied by Perum Perhutani.

4. Conclusion

According to the statistical analysis, the tree’s periphery has a positive effect on the resin productivity whereas the height has a negative one, which means that the cultivation of the pine tree is highly affected by the selected sylviculture. The research showed, by conducting a systematic measurement of the resin productivity of the 201 chosen trees reveals the existence of a good characteristic of resin pattern productivity in 10 individuals trees. The characteristic of resin productivity output pattern sequentially increased with a peak in May-August. This characteristic data is very useful for the Perhutani to optimize the cultivation of the entire *P merkusii* class for future endeavors.

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