Leaf nutrient status as a predictor for Mahogany (*Swietenia* sp.) fruit productivity

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Abstract. Soil fertility is one of the limiting factors for tree productivity. Trees as seed sources that have grown in low-fertility soil would not have sufficient edaphic supports for its physiological- and morphological- development, including fruit production. As the ambient environmental conditions are manifested in tree physiology, leaf nutrition status can be used for diagnosing soil fertility. This study aimed to test the possibility of leaf nutrient status as a predictor for Mahogany seed source productivity. The study examined six locations of mahogany fruit productions in West Java from February until December 2018. Soil and leaves samples were collected from fruiting and un-fruiting Mahogany trees, which have similar levels of generative and vegetative phases. Sampling was conducted two months after the fruiting season. Results showed that the fruiting phenomenon was highly correlated with Nitrogen (N) concentration in leaves after the fruiting phase of the tree. The N-total concentration of mahogany leaves obtained from six stands in Bogor and Cianjur were ranged from 1.76% to 3.66%, with an average of 2.33%. Trees that have N concentration above the average indicated a propensity of unproductive (not fruiting) in that year.

1. Introduction

The success of efforts to increase seed source production is closely related to environmental (external and internal), biology and genetics factors. External environmental factors include climate conditions, altitude, soil type, and fertility level [1, 2]. While internal environmental factors include dendrometrics, nutrition, and phytohormones [2, 3].

Flowering and fertilization are generative phases which play an important role during plant growth. Understanding of biological dynamics through observing phenology of fertilization is inseparable from environmental factors, including patterns of climate change that occur that are related to the length of irradiation, temperature, humidity, rainfall, and landscape structure that can affect the activity of pollinator animals [4 - 6]. Besides, cold temperatures and low humidity may limit the occurrence of pollination as the flower’s petals remain closed. These conditions may reduce the capacity of the plants to produce seeds. Thus, the variation in seed production from a seed source will be significantly influenced by the dynamics of annual weather cycles, locations, and genetic factors of the tree, which causes each individual tree to have variation in physiological responses.
Variation of seed production from one stand or one tree at each fertilization period is commonly happening. This makes seed productions are hard to be estimated, which may lead to inappropriate seed-handling both in terms of time and inefficient fruit harvesting. Therefore, to determine the harvesting time and estimate the potential of seed production from a seed source, it is necessary to study the relationship between fruit season and seed production with geographical conditions, soil fertility, tree nutrient quality, tree size and tree age.

Information on the characteristics of the production dynamics, which are very much needed in determining seed source management strategies, is not yet available for mahogany. Several studies have shown that the effect of fertilization on fruit production is also related to changes in leaf nutrition [7 - 9]. In some species, the nutrient status of leaves has been used as an estimator of fertility and plant productivity. For forestry plants, information about leaf nutrient status and its relation to plant productivity is still very little.

The purpose of this study was to determine the extent of the relationship between leaf nutritional status to growth and fruit productivity of mahogany seed sources and how the opportunities for using tree nutritional status as an evaluation or an estimator tools of fruit productivity of mahogany.

2. Materials and Methods

2.1. Time and location

Sampling was conducted in 6 locations of mahogany stands aged of 15 - 25 years old, located in Cianjur and Bogor Districts of West Java Province, i.e., Cirata, Cianjur City, Tanggeung, Campaka, Babakan Madang and Parungpanjang. The research was conducted in February until December 2018.

2.2. Procedure

In each stand, we identified several trees that are fruiting and several trees for comparison that are not fruiting. The number of trees observed for this study is 39 trees. Those selected trees must have the same vegetative phase, which is old leaves (brown or dark yellow-brown colored leaves) or will fall out. Two months after the fruiting period is completed and the tree samples have light green colored leaves to dark green, leaf samples from both types of trees are taken. Those leaf samples at each location are then analyzed for their nutrient content. The analyses were C-organic content using Walkey and Black method, Nitrogen (N) using Kjeldahl Method, Phosphorus (P) using (HNO₃-HClO₄) Spektrofotometri method, Potassium (K) using (HNO₃-HClO₄) Flame Emission method, and Zinc (Zn) using (HNO₃-HClO₄) AAS method.

2.3. Data analysis

Observation results of tree phenology in each stand (vegetative and generative phases of all the tree samples) and analysis of leaf nutrient (C-organic, N, P, K, and Zn) were analyzed using a t-test.

3. Result and Discussion

The mahogany seed stands used as samples of this research came from 6 locations that varied in terms of stand age, altitude, and type of soil. This is done in order to obtain plant nutrition data from various distributions of mahogany. The locations of this study are listed in Table 1.

| No | Location       | Average of stand age (years old) | N total of soil (%) |
|----|----------------|----------------------------------|---------------------|
| 1  | Cirata, Cianjur| 20                               | 0.20                |
| 2  | Cianjur city, Cianjur | 15                     | 0.25                |
| 3  | Tanggeung, Cianjur | 22                     | 0.32                |
| 4  | Campaka, Cianjur | 20                               | 0.35                |
| 5  | Babakan Madang, Bogor | 15                     | 0.28                |
| 6  | Parungpanjang, Bogor | 25                     | 0.19                |
Observations of leaf nutrients obtained from 8 trees from the mahogany stand in Cirata, six trees from the stands in Cianjur city; five trees from Walahir, Tangeung sub-district; 3 trees from stands in Campaka sub-district, four trees from stands in Babakan Madang sub-district, Bogor Regency and nine trees from stands in Parung Panjang research forest. From those sample trees, we can obtain the range of leaf nutrient concentrations for every element, as listed in Table 2. The results of chemical analysis of leaves on fruiting and not fruiting trees in six mahogany stands in Bogor and Cianjur showed that there was a high correlation between N total concentrations of leaves and the productivity of mahogany trees (Table 3).

Table 2. The range of nutrient concentrations of leaves from various mahogany stands in Bogor and Cianjur.

| Element       | Number of leaf samples | Minimum     | Maximum     | Mean ± St. Dev |
|---------------|------------------------|-------------|-------------|----------------|
| C organik (%) | 41                     | 33.74       | 40.78       | 37.22 ± 1.86   |
| N total (%)   | 82                     | 1.76        | 3.66        | 2.33 ± 0.38    |
| P total (%)   | 82                     | 0.06        | 0.68        | 0.23 ± 0.18    |
| K total (%)   | 82                     | 0.78        | 3.28        | 1.82 ± 0.58    |
| Zn total (ppm)| 50                     | 4.60        | 55.00       | 28.75 ± 10.24  |

Table 3. The relation of leaf nutrient concentration with fruit productivity from various mahogany stands in Bogor and Cianjur.

| Element       | Tree Productivity | Range     | Number of leaf samples | Mean ± St. Dev |
|---------------|-------------------|-----------|------------------------|----------------|
| C org. (%)    | Not fruiting      | 33.84 - 40.78 | 17 | 37.4294 ± 2.0538 0.537<sup>mn</sup> |
|               | Fruiting                  | 33.74 - 40.00 | 19 | 37.0379 ± 1.7112  |
| N total (%)   | Not fruiting      | 1.76 - 3.66  | 21 | 2.4971 ± 0.4229 0.007*          |
|               | Fruiting                  | 1.80 - 2.96  | 26 | 2.2069 ± 0.2853          |
| P total (%)   | Not fruiting      | 0.08 - 0.68  | 21 | 0.2576 ± 0.1959 0.186<sup>mn</sup> |
|               | Fruiting                  | 0.06 - 0.53  | 26 | 0.1885 ± 0.1570          |
| K total (%)   | Not fruiting      | 0.99 - 3.28  | 21 | 1.9462 ± 0.5458 0.124<sup>mn</sup> |
|               | Fruiting                  | 0.78 - 3.14  | 26 | 1.6862 ± 0.5819          |
| Zn total (ppm)| Not fruiting      | 19.00 - 45.00 | 21 | 29.0000 ± 6.5879 0.679<sup>mn</sup> |
|               | Fruiting                  | 4.60 - 55.00 | 25 | 30.2000 ± 11.7260         |

* significant at 95 % level of confident,  
<sup>mn</sup> not significant at 95 % level of confident

The range of values in Table 2 can be used as a reference to determine the nutritional status of plants, whether it is low, medium, or high. If the concentration of an element is below the minimum value, additional elements are needed through fertilization or any other silvicultural actions [10].

The N-total concentration of mahogany leaves ranged from 1.76% and 3.66%, with an average of 2.33% (Table 2). Several studies have shown that the leaf nutrient status of woody plants, especially fruit trees, correlates with the flowering and fertilization phenomenon. The addition of N elements can increase the intensity of flowering and fruiting as long as the N concentration is below 1.4%.
However, if N concentration levels are too high (>1.8%), it could interfere with the flowering and fertilization process [11]. In the oranges tree, the optimum N concentration is ranged from 1.7% to 2.4% [8].

When compared with the range of N listed in Table 3, the unfruiting trees have an N concentration of 2.497% (Table 3), which is higher than the average N concentration, viz. 2.33% (Table 2). This phenomenon is logically acceptable as the N content in unfruiting trees were not used for fertilization. Thus, the N concentration level remains high. As it is known that fruit production is closely related to plant photosynthesis, the higher the results of photosynthesis, it is likely to be followed by an increase in fruit production [4]. The results of photosynthesis itself besides being influenced by environmental factors are also influenced by factors derived from plants, including chlorophyll content, leaf N content, stomatal conductivity, leaf stomatal density and leaf area [10]. This can also occur because the N concentration is too high than the average needed so that the process of flowering and fertilization is disrupted, so the tree does not bear fruit [11].

4. Conclusion
From all leaf nutrient elements, there was a high correlation between N total concentrations of leaves and the productivity of mahogany trees. The N-total concentration of mahogany leaves ranged from 1.76% and 3.66%, with an average of 2.33%. The un-fruiting trees showed higher N concentration than the average N concentration of all the trees observed.

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