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Evaluation of soil and leaves nutrient on the growth of cultivated tabatbarito (*Ficus deltoidea* Jack.) in Makroman Village, Sambutan District of East Kalimantan, Indonesia

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Abstract. This study aimed to evaluate the soil and leaves nutrient status on the growth of cultivated tabatbarito (*Ficus deltoidea* Jack) in various level ages. The field experiment was conducted during December 2015 to November 2016 at Makroman Village, Samarinda-East Kalimantan. On 6, 9, and 12 months old after planting (MAP) the data was collected to evaluate the plant height, leaf number, branch number, biomass, soil and leaves nutrient concentrations. The results showed that the average pH of soil was 3.92 ± 0.06 , categorized as a very acid. The concentration of soil nutrients were: nitrogen (1.13 ± 0.31 %), phosphorus (0.01 ± 0.01 ppm), potassium (297.60 ± 50.11 ppm), calcium (2.97 ± 1.79 $\text{cmol}(+) \text{Kg}^{-1}$), and magnesium (3.69 ± 2.30 $\text{cmol}(+) \text{Kg}^{-1}$). The leaf nutrient concentration was 1.74 ± 1.42 % (N), 0.25 ± 0.19 % (P), 1.86 ± 0.15 % (Ca), 1.88 ± 0.29 % (Mg). The soil nutrients concentration (N, P, Mg) and the leaf nutrient (N, P, K, Ca, Mg) has a correlates with plant height increment, branch number increment, and biomass increment. The results indicated that the N, P, K, Ca, Mg played an important role in the growth of *F. deltoidea* and this nutrient should be considered well when this plant will be cultivated as a source of the medicinal plant on a large scale.

1. Introduction

Tabatbarito (*Ficus deltoidea* Jack) belong to the Moraceae family, it is a small shrub and epiphytic[1]and found along shrubland beaches and hilly forest[2]. In Kalimantan of Indonesia, these plants are very valuable and very expensive in traditional markets because it is widely used as a traditional medicine[3]. The leaves of *F. deltoidea* are boiled and the decoction is taken as a medicine after the mother gave birth. It is believed that it helps to contract the uterine and vaginal muscles, improve blood circulation and regain body strength as well as for treating disorders related to the menstrual cycle. It is also taken as medicinal tea for general health and in treating pneumonia, diabetes, hypertension, diarrhea, and gout[4]. In the recent year, *F. deltoidea* has started to be cultivated to supply the increasing market needs. Although tabatbarito is an epiphytic plant, as long as



soil nutrients are well available, this plant can be planted on the ground. Evaluation of growth performance and yield potential of selected emascodek (*Ficusdeltoidea*) accessions on bris soils have reported by Musa[5].

For proper growth and optimal yield of plants, soil nutrients must be available to plants in the correct quantity, proportion and in a usable form at the right time. The Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Other important nutrients are calcium (Ca), magnesium (Mg) and sulfur (S). Plants also need small quantities of iron, manganese, zinc, copper, boron, and molybdenum, known as trace elements because only traces are needed by the plant. The role these nutrients play in plant growth is complex, and this document provides only a brief outline[6].

Nitrogen is a key element in plant growth. It is found in all plant cells, in plant proteins and hormones, and in chlorophyll. Atmospheric nitrogen is a source of soil nitrogen. Some plants such as legumes fix atmospheric nitrogen in their roots; otherwise, fertilizer factories use nitrogen from the air to make ammonium sulfate, ammonium nitrate, and urea. When applied to soil, nitrogen is converted to a mineral form, nitrate, so that plants can take it up [7]. The study by Sheikh and Ishak[8] on the cultivation of tabat baritoshowed that the nitrogen application improved growth, chlorophyll contents and antioxidant activity of leaf. Information about total flavonoid and antioxidant activity in leaves and stem extract of wild and cultivated tabatbarito also has been reported by Manurung et al.[9].

Phosphorus helps transfer energy from sunlight to plants, stimulates early root and plant growth, and hastens maturity[10]. The soil solution potassium is readily taken up by the plant's root system and is then replaced by the potassium on the exchange sites it increases vigour and disease resistance in plants, helps form and move starches, sugars, and oils in plants, and can improve fruit quality[11]. Calcium is essential for root health, the growth of new roots and root hairs, and the development of leaves. Magnesium is a key component of chlorophyll, the green coloring material of plants, and is vital for photosynthesis (the conversion of the sun's energy to food for the plant). Sulfur is a constituent of amino acids in plant proteins and is involved in energy-producing processes in plants. The effects of calcium and magnesium on plant growth, biomass partitioning, and fruit yield of winter greenhouse tomato has been reported by Hao and Papadopoulos[12]. In general, the growth rates such as plant height, leaf area, diameter, leaf number, and biomass of plants affected by nitrogen, phosphorus, potassium, calcium, and magnesium that found in the soil as nutrient elements[6].

Keeping in view the increasing future demand of tabatbarito plant, its cultivation was needed to be optimized. This study aimed to evaluate the soil and leaves nutrient on the growth of cultivated tabatbarito (*Ficusdeltoidea* Jack.) in Makroman Village, Sambutan District of East Kalimantan. By getting information about soil and leaf nutrients of this plant, expected to support if this plant will be cultivated as a source of medicinal plants in large scale in Kalimantan region.

2. Materials and method

2.1. Field/experimental procedures

A field study was conducted to evaluate soil and leaves nutrient on the growth of cultivated tabatbarito (*Ficusdeltoidea* Jack.) in Makroman Village, Sambutan District of East Kalimantan, Indonesia(Coordinates: 0°21'18"-1°09'16" South and 116°15'36"-117°24'16" East). Tabatbarito seedlings from 16-week-old stem cuttings are used as plant material. They were planted in the field area (20m x 50m) that consisted 10 rows, each row consisted 50 plants. Single row planting with 100 cm between plants in the row and 200 cm between rows were used (this is the first method that used in the cultivation process of tabat barito in Kalimantan). Plants were maintained until 12 months old after planting (MAP). On 6, 9, and 12 MAP, measurements were taken on plant height, leaves number, branches number, biomass, and concentration of soil and leaf nutrient. Soil and leaf nutrient analysis were conducted in the Soil Science Laboratory at the Faculty of Forestry Universitas Mulawarman, Samarinda, East Kalimantan,Indonesia.

2.2. Soil sampling and soil nutrient evaluation

Composited soil samples were taken 500 g of each row, put into a plastic bag and analysed for pH and concentration nutrients elements (N, P, K, Ca, Mg) in the laboratory. After 6, 9, and 12 MAP, the measurements of pH, N, P, K, Ca, Mg element was evaluated. The soil sample was taken from the depth of 0-30 cm and the results were calculated after being dried in the oven with the temperature of 150°C until constant weight was reached. The composite sample was air-dried and its pH, total Nitrogen (Kjehdal), available phosphor (Bray), available potassium, calcium, and magnesium were analysed [18].

2.3. Evaluation of leaf nutrients concentration

The total N concentrate was measured using Kjeldahl method(extraction, distillation, and titration). To measure the element of P and K, the plant components were extracted using High-Pressure Digestion method at the temperature of 180°C for 10 hours with HNO as a reductant. The phosphor was measured by using calorimetric technique and using nitrate-molybdate-vanadate acid as a coloring agent and was measured by using spectrophotometer at the wavelength of 470 nm. Potassium (K), calcium (Ca), magnesium (Mg) was measured by using atomic absorption spectrophotometer (AAS) at the wavelength of 766.5 nm, 489.5 nm, and 245.2 nm[18].

3. Data analysis

The data of soil and leaf nutrient concentration were analysed and described in a tabular form. Correlation between soil N, P, K, Ca, and Mg concentration (X) with leaf N, P, K, Ca, and Mg concentration and growth of *F. deltoidea* (Y) was tested by using regression analysis.

4. Results and discussion

4.1. Soil condition and nutrient element

The results of soil condition and nutrient element analysis well listed in table 1. Data on the soil condition showed that the soil pH average of 3.92 ± 0.06 that categorized as very acid. The pH scale goes from 0 to 14 with pH 7 as the neutral point. When the amount of hydrogen ion in the soil increases, the soil pH decreases, causing the soil to become more acidic. From pH 7 to 0, the soil is increasingly more acidic, and from pH 7 to 14, the soil is increasingly more alkaline or basic[7].

Results of soil nutrient element analysis showed the concentration of N range from 0.93 to 1.49 with mean 1.13 ± 0.31 with a very high status. The concentration of nitrogen in the soil increased when the ages of plant increased. One of the key soil nutrients is nitrogen (N). Plants can take up N in the ammonium (NH_4^+) or nitrate (NO_3^-) form. At pH's near neutral (pH 7), the microbial conversion of NH_4^+ to nitrate (nitrification) is rapid, and crops generally take up nitrate. In acid soils (pH < 6), nitrification is slow, and plants with the ability to take up NH_4^+ may have an advantage[13]. Soils high in organic matter such as chocolate soils are generally higher in nitrogen than podzolic soils. Nitrate is easily leached out of the soil by heavy rain, resulting in soil acidification[14].

Table 1. Soil condition and nutrient concentration of cultivated tabatbarito (*F. deltoidea*) on different plant ages.

Plant Ages (MAP)	pH (H ₂ O)	N (%)	P (ppm)	K (ppm)	Ca (cmol (+)Kg ⁻¹)	Mg (cmol (+)Kg ⁻¹)
6	3,94	0,93	0,01	355,05	4,65	2,19
9	3,97	0,97	0,01	274,85	3,17	2,53
12	3,86	1,49	0,001	262,90	1,08	6,34
Mean	3.92 ± 0.06	1.13 ± 0.31	0.01 ± 0.01	297.60 ± 50.11	2.97 ± 1.79	3.69 ± 2.30

The concentration of P has the status extremely low with the average 0.01 ± 0.01 ppm. The concentration of K nutrient status is medium (262.90) to high (355.05) with the average 297.60 that

categorized as high refers to McCauley[7]. The concentration of Ca element is very low ($1.08 \text{ cmol}(+)\text{Kg}^{-1}$) to medium $4.65 \text{ (cmol}(+)\text{Kg}^{-1})$ with mean $2.97 \pm 1.79 \text{ (cmol}(+)\text{Kg}^{-1})$ were categorized as low. Calcium is essential for root health, the growth of new roots and root hairs, and the development of leaves. It is generally in short supply in the acid soils. Mg nutrient categorized as high element with average $3.69 \pm 2.30 \text{ (cmol}(+)\text{Kg}^{-1})$. Magnesium is a key component of chlorophyll, the green coloring material of plants, and is vital for photosynthesis (the conversion of the sun's energy to food for the plant). Deficiencies occur mainly on sandy acid soils in high rainfall areas, especially if used for intensive horticulture or dairying. Heavy applications of potassium in fertilizers can also produce magnesium deficiency. The three main nutrients that needed by plants for growth are nitrogen (N), phosphorus (P) and potassium (K). Other important nutrients are calcium, magnesium, and sulphur[14]. In general, the growth rates such as plant height, leaf area, diameter, leaf number, and biomass of plants affected by nitrogen, phosphorus, potassium, calcium, and magnesium that found in the soil as nutrient elements. The study by Fukunawa et al.[15] reported that the soils in East Kalimantan were less fertile

4.2. Leaf nutrient concentration

The results of leaves nutrient analysis (N, P, K, Ca, and Mg) well listed in table 2. It showed that the cultivated *F. deltoidea* leaves on 6, 9, 12 MAP had the varied concentration of different N, P, K, Ca, and Mg. The concentration of N leaves during growth proses of *F. deltoidea* ranged from 0.11 (%) to 2.67 (%), with average 1.74 ± 1.42 (%). The concentration P ranged from 0.47 to 0.14 with the average 0.25 ± 0.19 . The concentration of K ranged from 1.69 (%) to 1.98 (%) with the average 1.86 ± 0.15 (%). The concentration of Ca ranged from 2.02(%) to 4.83(%), with the average 3.82 ± 1.56 (%). Concentration of Mg ranged from 1.59 (%) to 2.16 (%) with the average 1.88 ± 0.29 (%). The present study showed that concentration of N, P, K, Ca decreased until the age of 12 MAP, whereas the concentration of Mg decreased until the age 9 MAP and then increased until 12 MAP. The lower N availability could be ascribed to the loss of N from soil ecosystems and the insufficient recovery of soil N pools under poor vegetation regrowth due to intensive land use in this area[16]. Styger et al.[17] recommended that upland agricultural intensification and diversification based on improved soil fertility through optimized organic and inorganic inputs and fire-less land management that encourages the re-establishment of nutrient stocks. The negative correlation was observed from the soil nutrient K and growth of diameter and high, the positive correlation was observed from the P and K content in the leaf of plant and growth of diameter, height, and volume increment of *Macaranga gigantean*[18].

Table 2. Leaf nutrient concentration of *F. deltoidea* that cultivated in Makroman village Samarinda at 6, 9, and 12-month-old after planting (MAP)

Plant ages (MAP)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
6	2,67	0,16	1,98	4,83	1,88
9	2,45	0,13	1,92	4,61	1,59
12	0,11	0,47	1,69	2,02	2,16
Mean	1.74 ± 1.42	0.25 ± 0.19	1.86 ± 0.15	3.82 ± 1.56	1.88 ± 0.29

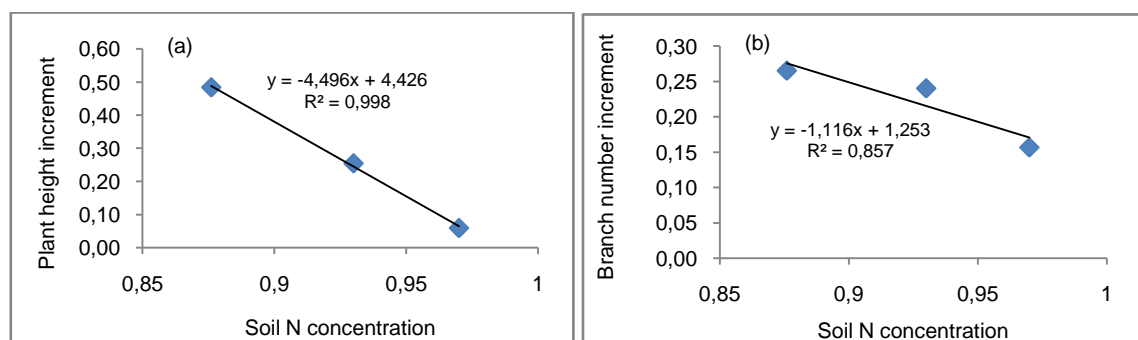
4.3. Plant Growth and correlation with soil and leaf N, P, K, Ca and Mg concentration

The growth result of cultivated *F deltoidea* on 6, 9, and 12-month-old after planting were showed in table 3. The highest plant height, leaves number, branches number, and biomass found on 12 MAP as compared to 6 and 9 MAP. The highest growth increment found on leaves number followed by biomass, plant height, and branch number.

Table 3. The plant growth and plant growth increment of *F. deltoidea* on different ages.

Plant ages (MAP)	6	9	12	Mean
Plant Height (cm)	28,38	39,02	54,14	40.51±12.94
Leaves number	58,60	154,68	381,68	198.32±165.90
Branches number	9,02	22,23	34,83	22.03±12.91
Biomass (gr/plant ⁻¹)	12.35	55.60	93.30	53.75±40.51
Plant Height increment (cm month ⁻¹)	4.73	4.33	4.51	4.53±0.20
Leaves number increment	9.77	17.19	31.81	19.59±11.21
Branches number increment	1.50	2.47	2.90	2.29±0.72
Biomass increment (gr/plant ⁻¹ month ⁻¹)	2.06	6.17	7.78	5.34±2.95

The soil nutrient: nitrogen, phosphorus, and magnesium concentration correlate with height increment, branch number increment, and biomass increment; the potassium correlate with branch number, plant height increment, and leaf number increment; calcium concentration correlate only with plant height. Relationships between soil N nutrient concentration and growth (plant height increment, branch number increment, and biomass increment) of cultivated *F. deltoidea* describe in figure 1. All of the leaf nutrient (N, P, K, Ca and Mg) had a correlate with plant height increment, branch number increment, and biomass increment. The highest average of plant height increment, leaf number increment, branch number increment, biomass increment found on 12 MAP. The growth increased rapidly in the first years of cultivation. In general, nitrogen (N), potassium, calcium, magnesium, and sulfur are more available within soil pH 6.5 to 8, while boron (B), copper, iron, manganese, nickel (Ni), and zinc are more available within soil pH 5 to 7. Phosphorus is most available within soil pH 5.5 to 7.5 At pH less than 5.5, high concentrations of H, aluminum and manganese in soil solution can reach toxic levels and limit crop production[7]. In the tropical rainforests of East Kalimantan servings of nutrient base class (K, Ca and Mg) more accumulates on vegetation than in the soil, while the portion of nutrient N largely accumulates in the soil [19], and in forest plantation reported that plant forests of *Eucalyptus deglupta* and *Paraseriantesfalcataria* at the age of 5-10 years in East Kalimantan also accumulate nutrient element of K in the largest amount, followed by calcium, nitrogen, and magnesium. In the other parts of natural forests in East Kalimantan show that 70 to 94% of base elements exist in the standing biomass [20]. Sheikh and Ishak reported that the nitrogen application improved the growth of *F. deltoidea* [8].



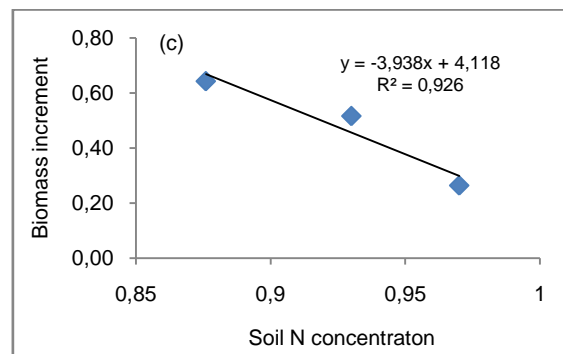


Figure 1. Relationships between soil N concentration and growth of *F. deltoidea* at different plant ages. (a) plant height increment Vs Soil N concentration (b) branch number increment Vs soil N concentration, and (c) biomass increment Vs soil N concentration.

5. Conclusions

The soil pH in the growth of *Ficus deltoidea* in Makroman Village, Sambutan District of East Kalimantan categorized as a very acid. The concentration of soil nutrients, nitrogen categorized as a very high, phosphorus: extremely low, potassium: high, calcium: very low, and magnesium: high. The soil nutrients concentration such as nitrogen, phosphorus, and magnesium have a correlate with plant height increment, branch number increment, and biomass increment; potassium correlates with branch number, plant height increment, and leaf number increment; calcium concentration correlates only with plant height. All of the leaf nutrient (N, P, K, Ca and Mg) concentration had a correlate with plant height increment, branch number increment, and biomass increment.

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