*Journal of Tropical Forest Science* 10(4): 431 - 437 (1998)

# FOLIAR SAMPLING GUIDELINES FOR DIFFERENT AGED *ACACIA MANGIUM* PLANTATIONS IN PENINSULAR MALAYSIA

**Nik Muhamad Majid, Mohd. Azani Alias & Bimal K. Paudyal**

*Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

*Received October 1995*

**NIK MUHAMAD, M., MOHD. AZANI, A. & PAUDYAL, B.K. 1998. Foliar sampling guidelines for different aged *Acacia mangium* plantations in Peninsular Malaysia.** Foliar analysis is a useful tool for evaluating the nutritional status of a crop. There are, however, no guidelines for foliar sampling of *Acacia mangium* plantations in Peninsular Malaysia. This study was thus aimed to determine the best time for foliar sampling in *Acacia mangium* plantation. The study was conducted in Kemasul Forest Reserve, Pahang. Foliar samples were collected monthly from *Acacia mangium* stands of five different ages over a period of one year. The results show that foliar sampling in *Acacia mangium* stands should be performed as follows: for one-year-old stand in January-March and June-July; for two-year-old stand in December-January and June-July; for three-year-old stand in June-July; for four-year-old stand in February-March and June-July; for six-year-old stand in February-March. In general, July is the best time for foliar sampling of one- to four-year-old stands whereas February-March would be the best time for six-year-old stands. The results are based on the fact that foliar nutrients are generally constant over these periods.

Key words: Foliar - plantation - nutritional - sampling - fertiliser

**NIK MUHAMAD, M., MOHD. AZANI, A. & PAUDYAL, B.K. 1998. Panduan pensampelan daun bagi ladang *Acacia mangium* yang berbeza umurnya di Semenanjung Malaysia.** Analisis daun sangat berguna untuk menilai status pemakanan tanaman. Bagaimanapun, tiada garis panduan bagi pensampelan daun di ladang *Acacia mangium* di Semenanjung Malaysia. Oleh yang demikian, kajian ini bertujuan untuk menentukan masa terbaik bagi melakukan pensampelan daun di ladang *Acacia mangium*. Kajian dijalankan di Hutan Simpan Kemasul, Pahang. Sampel daun diambil setiap bulan daripada dirian *Acacia mangium* dengan lima umur yang berbeza dalam tempoh satu tahun. Keputusan kajian menunjukkan bahawa pensampelan daun dalam dirian *Acacia mangium* perlu dijalankan seperti berikut: bagi dirian berumur satu tahun pada bulan Januari- Mac dan Jun - Julai; bagi dirian berumur dua tahun pada bulan Disember - Januari dan Jun - Julai; bagi dirian berumur tiga tahun pada bulan Jun - Julai; bagi dirian berumur empat tahun pada bulan Februari - Mac dan Jun - Julai; bagi dirian berumur enam tahun pada bulan Februari - Mac. Secara umumnya, bulan Julai adalah masa yang paling baik untuk melakukan pensampelan daun bagi dirian berumur 1-4 tahun manakala Februari - Mac adalah masa yang paling baik untuk dirian berumur enam tahun. Keputusan tersebut adalah berdasarkan kenyataan bahawa nutrien daun pada umumnya adalah berterusan di sepanjang tempoh tersebut.

## Introduction

Nutrient elements are very important for the growth and development of plants. Foliar analysis is now universally accepted as a tool in the evaluation of the nutritional status of crops and is commonly used in plant nutrition studies. This method is particularly useful in detecting nutrient deficiencies before they become acute and symptoms appear.

Foliar sampling guidelines for several agricultural crops such as rubber, oil palm, tea and cocoa have already been established (Duranti 1974, Kumar & Dandey 1979, Prusinkiewicz 1982). These guidelines have been used to detect nutrient deficiencies in these crops. The guidelines also offer information on sampling time and also the appropriate time for fertilising the crops. For example, in rubber (*Hevea brasiliensis*), de Waard (1978) suggested that three periods of sampling per year are sufficient. These are critical periods of the dry season, rainy season and an intermediate season. Srivastava (1965) recommended that sampling should be carried out when most of the nutrients are constant. This occurs during May to June and January to February in *Shorea robusta*. Others like White (1954), Tamm (1964) and Wells (1969) prefer to sample during late autumn and winter when the nutrient content of the foliage is constant. For rubber, Shorrocks (1962) recommended the period between August and December as the time for leaf sampling, especially when leaf analysis is to be used for diagnosis of fertiliser application.

In Malaysia, the use of foliar analysis in forestry has not been adopted widely as a diagnostic tool as in agriculture. Will (1965) indicated that foliar analysis is useful for determining the adequacy of nutrient supply to many types of plants, including forest trees. Waring (1971) used the technique to diagnose the nutritional status of six plantation trials of *Pinus caribaea* in Malaysia. Results from the foliar analysis showed that all the plantations were deficient in phosphorus.

Another important purpose of foliar analysis is to investigate the effects of fertiliser application. Kennedy (1981) used the technique to study the influence of cultural treatments on foliar nutrient concentrations and hardwood growth. Schonau and Herbert (1982) made use of the technique to evaluate the effects of NPK fertiliser on *Eucalyptus grandis* in South Africa. The same technique was used by Mohd. Kassim (1985) in the fertiliser trial on *Gmelina arborea* plantation in Malaysia.

Foliar analysis is also important in the determination of the relationship between nutrient concentrations and growth of hardwood species. The technique has been used to establish the relationship between foliar nutrient content and growth (Lamb 1977, Srivastava & Chin 1978, Chai 1980).

In Malaysia, there are still no foliar sampling guidelines developed for forest trees. It is imperative that such guidelines be developed for *Acacia mangium* and other fast-growing timber species because of the importance of these species in the plantation forestry programme in the country. *Acacia mangium* is widely planted in Malaysia. The flowering time for this species is in the month of April.

The objective of this study was to evaluate the variation in the nutrient elements of *Acacia mangium* leaves with respect to sampling time and stand age. It is hoped that the information obtained will provide foliar sampling guidelines for detecting nutrient deficiencies for subsequent fertiliser application. The study was conducted at the Kemasul Compensatory Forest Plantation in Pahang, Malaysia over a period of one year.

## Materials and methods

### *Study site*

The study site at the Kemasul Forest Reserve is located approximately 120 km east of Kuala Lumpur and 13 km west of Mentakab, Pahang, Malaysia. The soil in the area is of the Durian, Bungor and Batu Anam series (Ultisols). The parent material is mainly of sedimentary and low grade metamorphic rocks. Mean monthly temperature averages between 27 °C and 33 °C, while the annual rainfall is about 2100 mm with the heaviest rainfall occurring during December and January.

Five plots, each measuring 70 × 70 m from *Acacia mangium* stands of five different ages, were selected for the study. The five plots were one, two, three, four and six years old.

### *Sample collection*

Collection of foliar samples was made from 20 trees in each of the five plots every month for twelve months from November 1985 to October 1986. A composite sample was made from 10 trees in each of the plots.

The samples were collected at a position approximately one-third from the top of the crown. The samples were collected at heights of 2, 3.5, 5.5, 8 and 10 m from the one-, two-, three-, four- and six-year-old stands respectively. The samples were chosen from areas exposed to sunlight. Collection was made between 0700 h and 1000 h and no collection was made after a rainy day.

### *Laboratory analysis*

The foliar samples were dried at 60-80 °C for about 72 h before being ground in a stainless steel grinder with a mesh screen of 0.5 mm. The sample powder was further dried in an oven at 105 °C until the weight was constant. The samples were kept in a desiccator before analysis.

The powdered samples were digested by the wet digestion method of Parkinson and Allen (1975). These samples were analysed for macronutrients (N, P, K, Ca, Mg). Total N and P were determined using an autoanalyser and K, Ca and Mg were determined by atomic absorption spectrophotometer.

## Results and discussion

The data for foliar nutrient levels of N, P, K, Ca and Mg in different aged *A. mangium* stands are given in Table 1. In the one-year-old stand, foliar N concentration reached the highest peak of 1.17 % in April and lowest of 1.11 % in May. Foliar N remained almost constant during the months of December to March and June to October at about 1.14 - 1.16 %. For P, the trend shows that it was highest in December at 0.15 % and relatively constant in January to May and July to October at about 0.12 - 0.14%. Foliar K reached the highest level at 0.60 % in August and lowest at 0.30 % in December, March and April. K remained almost constant during the months of January to February and May to June at 0.45 - 0.53%, and during March to April at 0.30 %. Foliar Ca reached the highest peak at 0.31 % in August and lowest at 0.12 % in July. Foliar Ca was relatively constant during the months of November to June at about 0.17 - 0.24 %. For foliar Mg, the trend shows that it was highest in November at 0.20 %, lowest in March and April at 0.10 % and relatively constant from December to February (0.12 - 0.14 %) and from June to August (0.14 - 0.15 %).

In the two-year-old stand, the highest value of 1.21 % for foliar N was recorded in February and the lowest of 1.13 % in November (Table 1). However, foliar N was relatively constant from December to January (1.13 - 1.15 %) and from June to October at 1.16 - 1.20 %. For P, the highest value was in the months of November, February and August at 0.17 % and the lowest (0.13 %) in December. Foliar P was relatively constant from March to July at 0.14 - 0.15 %. Foliar K reached the highest peak of 0.70 % in October and the lowest of 0.25 % in December. Foliar K was relatively constant at 0.30 - 0.35 % during the months of June and July. Foliar Ca exhibited the highest value in February and August at 0.28 %, the lowest value of 0.14 % in July with a relatively constant value of 0.17 - 0.21 % from March to June. The highest value for foliar Mg at 0.17 % was recorded in November and lowest was in May, June, September and October at 0.12 %. Foliar Mg was relatively constant from December to April at about 0.13 - 0.15 % and from May to October at 0.12 - 0.14 %.

Foliar N reached the highest peak of 1.20 % in February and the lowest value of 1.08% in August for the three-year-old stand (Table 1). Foliar N was relatively constant from November to January (1.16 -1.17 %) and from May to July (1.14 - 1.16 %). Foliar P recorded the highest at 0.18 % in October and the lowest value of 0.14 % in August with relatively constant value of 0.14 - 0.16 % from November to March and from May to August. The highest value of 0.76 % was recorded for foliar K in May and August and the lowest value of 0.46 % in February. Relatively constant values of 0.56 - 0.62 % in December to January and 0.74 - 0.76 % in July to August were observed. Foliar Ca reached the highest value of 0.24 % in April and lowest of 0.10 % in September with almost constant value of 0.13 - 0.14 % from May to June and 0.10 - 0.12 % from September to October. Foliar Mg showed the highest value (0.21 %) in November, the lowest (0.10 %) in October and relatively constant values of 0.15 - 0.16% in January-February and 0.12 - 0.14 % from May to September.

**Table 1.** Mean foliar nutrient concentrations (%)

(a) One-year-old stand

| Month | Element | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Nov 85 | 1.14 | 0.12 | 0.50 | 0.19 | 0.20 |
| Dec 85 | 1.16 | 0.15 | 0.30 | 0.20 | 0.12 |
| Jan 86 | 1.16 | 0.13 | 0.45 | 0.24 | 0.14 |
| Feb 86 | 1.15 | 0.14 | 0.50 | 0.21 | 0.13 |
| Mar 86 | 1.15 | 0.13 | 0.30 | 0.22 | 0.10 |
| Apr 86 | 1.17 | 0.13 | 0.30 | 0.22 | 0.10 |
| May 86 | 1.11 | 0.13 | 0.45 | 0.19 | 0.16 |
| Jun 86 | 1.14 | 0.15 | 0.45 | 0.17 | 0.14 |
| Jul 86 | 1.15 | 0.12 | 0.35 | 0.12 | 0.15 |
| Aug 86 | 1.14 | 0.14 | 0.60 | 0.31 | 0.14 |
| Sep 86 | 1.15 | 0.12 | 0.50 | 0.23 | 0.12 |
| Oct 86 | 1.15 | 0.12 | 0.55 | 0.19 | 0.19 |

(b) Two-year-old stand

| | Element | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Nov 85 | 1.13 | 0.17 | 0.60 | 0.20 | 0.17 |
| Dec 85 | 1.16 | 0.13 | 0.25 | 0.17 | 0.13 |
| Jan 86 | 1.15 | 0.15 | 0.45 | 0.24 | 0.13 |
| Feb 86 | 1.21 | 0.17 | 0.58 | 0.28 | 0.15 |
| Mar 86 | 1.16 | 0.15 | 0.65 | 0.18 | 0.13 |
| Apr 86 | 1.17 | 0.14 | 0.30 | 0.19 | 0.14 |
| May 86 | 1.14 | 0.15 | 0.50 | 0.21 | 0.12 |
| Jun 86 | 1.20 | 0.15 | 0.35 | 0.17 | 0.12 |
| Jul 86 | 1.18 | 0.14 | 0.30 | 0.14 | 0.13 |
| Aug 86 | 1.19 | 0.17 | 0.60 | 0.28 | 0.14 |
| Sep 86 | 1.16 | 0.16 | 0.50 | 0.16 | 0.12 |
| Oct 86 | 1.17 | 0.15 | 0.70 | 0.23 | 0.12 |

(c) Three-year-old stand

| Month | Element | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Nov 85 | 1.17 | 0.16 | 0.70 | 0.12 | 0.21 |
| Dec 85 | 1.16 | 0.15 | 0.62 | 0.16 | 0.12 |
| Jan 86 | 1.16 | 0.16 | 0.56 | 0.11 | 0.15 |
| Feb 86 | 1.20 | 0.15 | 0.46 | 0.22 | 0.16 |
| Mar 86 | 1.16 | 0.16 | 0.54 | 0.19 | 0.11 |
| Apr 86 | 1.19 | 0.17 | 0.74 | 0.24 | 0.17 |
| May 86 | 1.14 | 0.14 | 0.76 | 0.14 | 0.12 |
| Jun 86 | 1.16 | 0.16 | 0.62 | 0.13 | 0.12 |
| Jul 86 | 1.15 | 0.16 | 0.74 | 0.23 | 0.13 |
| Aug 86 | 1.18 | 0.15 | 0.76 | 0.16 | 0.14 |
| Sep 86 | 1.18 | 0.17 | 0.65 | 0.10 | 0.12 |
| Oct 86 | 1.13 | 0.18 | 0.70 | 0.12 | 0.10 |

(d) Four-year-old stand

| | Element | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Nov 85 | 1.18 | 0.17 | 0.70 | 0.21 | 0.19 |
| Dec 85 | 0.20 | 0.16 | 0.45 | 0.12 | 0.12 |
| Jan 86 | 1.18 | 0.18 | 0.65 | 0.14 | 0.13 |
| Feb 86 | 1.18 | 0.17 | 0.70 | 0.18 | 0.12 |
| Mar 86 | 1.15 | 0.16 | 0.90 | 0.17 | 0.13 |
| Apr 86 | 1.07 | 0.16 | 0.50 | 0.24 | 0.14 |
| May 86 | 1.03 | 0.15 | 0.45 | 0.16 | 0.15 |
| Jun 86 | 1.16 | 0.16 | 0.80 | 0.16 | 0.15 |
| Jul 86 | 1.15 | 0.16 | 0.90 | 0.16 | 0.14 |
| Aug 86 | 1.20 | 0.15 | 0.95 | 0.07 | 0.11 |
| Sep 86 | 1.18 | 0.15 | 0.55 | 0.14 | 0.12 |
| Oct 86 | 1.14 | 0.15 | 0.70 | 0.12 | 0.12 |

(e) Six-year-old stand

| Month | Element | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Nov 85 | 1.17 | 0.17 | 0.62 | 0.11 | 0.16 |
| Dec 85 | 1.18 | 0.16 | 0.50 | 0.10 | 0.12 |
| Jan 86 | 1.19 | 0.16 | 0.82 | 0.17 | 0.15 |
| Feb 86 | 1.18 | 0.18 | 0.66 | 0.16 | 0.11 |
| Mar 86 | 1.18 | 0.18 | 0.66 | 0.16 | 0.11 |
| Apr 86 | 1.18 | 0.15 | 0.72 | 0.16 | 0.15 |
| May 86 | 1.14 | 0.16 | 0.74 | 0.17 | 0.13 |
| Jun 86 | 1.14 | 0.17 | 0.74 | 0.17 | 0.13 |
| Jul 86 | 1.18 | 0.17 | 0.68 | 0.16 | 0.14 |
| Aug 86 | 1.16 | 0.18 | 0.82 | 0.21 | 0.13 |
| Sep 86 | 1.16 | 0.19 | 0.70 | 0.10 | 0.12 |
| Oct 86 | 1.14 | 0.16 | 0.80 | 0.11 | 0.19 |

In the four-year-old stand, foliar N was highest in December and August at 1.20 % and lowest at 1.03 % in May. Foliar N was relatively constant (1.18 %) in

January- February and 1.15 - 1.16 % from June to July. For P, the highest value (0.18 %) was observed in January and lowest (0.15 %) in May, August, September and October followed by a relatively constant value of 0.15 - 0.17 % from March to October. The highest value for foliar K was 0.95 % in August and lowest in May and December at 0.45 % with relatively constant value of 0.90 - 0.95 % from July to August and 0.65 - 0.75% from January to February. Foliar Ca recorded the highest peak of 0.24 % in April, lowest 0.07 % in August and a constant value of 0.16 % from May to July. For foliar Mg, the highest value was observed at 0.19 % in November and lowest at 0.11 % in August. Relatively constant foliar Mg values were observed from December to March and from August to October at 0.11-0.13 %, and from April to July at 0.14 - 0.15 %.

Foliar N, in the six-year-old stand, reached the highest peak of 1.19 % in January and lowest of 1.04 % in May (Table 1). Foliar N was almost constant (1.18 - 1.19 %) from December to April. Foliar P was highest (0.18 %) in February, March, August and September and lowest (0.15 %) in April with a relatively constant value of 0.16 - 0.17 % from May to July. The highest value recorded for foliar K was 0.82 % in January and August and lowest (0.50 %) in December. A constant value of 0.66% was observed in February and March and relatively constant value of 0.68 - 0.74% from April to July. Foliar Ca showed the highest value of 0.21 % in August, lowest value of 0.10 % in December and September and a relatively constant value of 0.16 - 0.17 % from February to July. For foliar Mg, the highest value (0.19 %) was recorded in October and the lowest (0.11 %) in February and March. Foliar Mg was relatively constant (0.12 - 0.14%) from May to September.

The results of the study show that foliar nutrients vary with sampling month and age of the trees. The results are in agreement with those of Shorrocks (1964) for *Hevea brasiliensis* regarding nutrient variation due to sampling time. This may be explained by the fact that the physiological processes within the plant are influenced by environmental factors which are not constant. The results are also in agreement with those of Ogasawara (1974) for *Pinus densiflora,* and Das and Ramakrishnan (1987) for *Pinus kesiya.* Smith (1962) indicated that concentrations of N, P and K in the dry matter of plants always decline with age, while others, like those of Ca and Mg, usually increase. These differences probably reflect the mobility of the nutrients within the plants.

## Conclusion

In the one-year-old stand, foliar sampling should be carried out in January-March and June-July. In the two-year-old stand, foliar sampling should be done in December-January and June-July. In the three-year-old stand, June-July is the appropriate time for foliar sampling. For the four-year-old stand, foliar sampling should be carried out in February - March and June-July. In the case of the six-year-old stand, foliar sampling should made during February-March.

In general, July is the best time for foliar sampling for one- to four-year-old stands whereas February-March would be the best time for six-year-old stands.

## Acknowledgement

The help of Muzammal Johan in the collection of samples is highly appreciated.

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