RELATIONSHIP BETWEEN MANGOSTEEN LEAF NITROGEN CONTENTS AND LEAF SPAD VALUES

Eko Setiawan *

Faculty of Agriculture, University of Trunojoyo Madura, Jl. Raya Telang PO BOX. 2 Kamal, Bangkalan, Madura
* Corresponding author: setiawan.eko78@gmail.com

ABSTRACT

We investigated nitrogen contents on mangosteen leaf and related on leaf SPAD value. The experiment was conducted using mangosteen trees grown in commercial orchard in Bogor, Indonesia during May to October 2010. Mangosteen trees of 3 different ages, young (20-year-old), middle-aged (35-year-old), and old (50-year-old) trees, each of five trees, were selected for study, and the canopy of each tree was divided into 9 sectors based on height (bottom, middle, top) and width (inner, center, outer). SPAD values had a negative correlation with leaf N content in all ages and could be explained by regressionl equations N level (% DW) = -0.0099 × SPAD + 2.2366; R^2 = 0.91; N level (% DW) = -0.0177 × SPAD + 2.8001; R^2 = 0.67; and N level (% DW) = -0.0187 × SPAD + 2.7785; R^2 = 0.45 in young, middle-aged and old trees, respectively. It is suggested that the SPAD value determined by a portable chlorophyll meter can be used to obtain a quick estimation of mangosteen leaf N status.

Keywords: age, fruiting position, Garcinia mangostana L., nitrogen, SPAD

INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is a tropical evergreen tree, believed to have originated in the Sunda Islands and the Moluccas (Misra *et al*., 2009). International market demand for mangosteen fruits is increasing with a year. Recent years, Indonesian mangosteen is not only exported to Taiwan, Hong Kong, and Singapore but also to Europe and Middle East (Poerwanto *et al*., 2008). In Indonesia, productivity and quality of mangosteen fruit are still low (Indriyani *et al.* 2002). Low productivity are caused by few flowers and poor fruit set. Quality of mangosteen fruits largely varies among positions in the canopy (Setiawan *et al*., 2005; 2012). It is well known that there is high correlation between C-N ratio (carbon-nitrogen ratio) and flower bud initiation in many fruit trees. Fertilizer nitrogen (N) has become the key input in food production

The leaf chlorophyll content is often well correlated with leaf N status and photosynthetic rates (Evans, 1983). SPAD value had a positive correlation with leaf N concentrations in Pammelo (Jaroonchon, 2010). The objective of this study was to understand the relationship between leaf N content using a portable chlorophyll meter (SPAD-502) to estimate the leaf N levels of mangosteen.

MATERIALS AND METHODS

Plant materials

Mangosteen trees of 3 different ages (young, 20 years old; middle, 35 years old; and old, 50 years old; n = 5 per age) growing in a commercial orchard in Bogor, Indonesia, were studied in May 2010. The canopy of each tree was divided into 9 sectors, based on tree height (bottom, middle, and top) and width (inner, center, and outer), i.e. Sector 1 (inner bottom), Sector 2 (center bottom), Sector 3 (outer bottom), Sector 4 (inner middle), Sector 5 (center middle), Sector 6 (outer middle), Sector 7 (inner top), Sector 8 (center top), and Sector 9 (outer top) (Fig. 1).

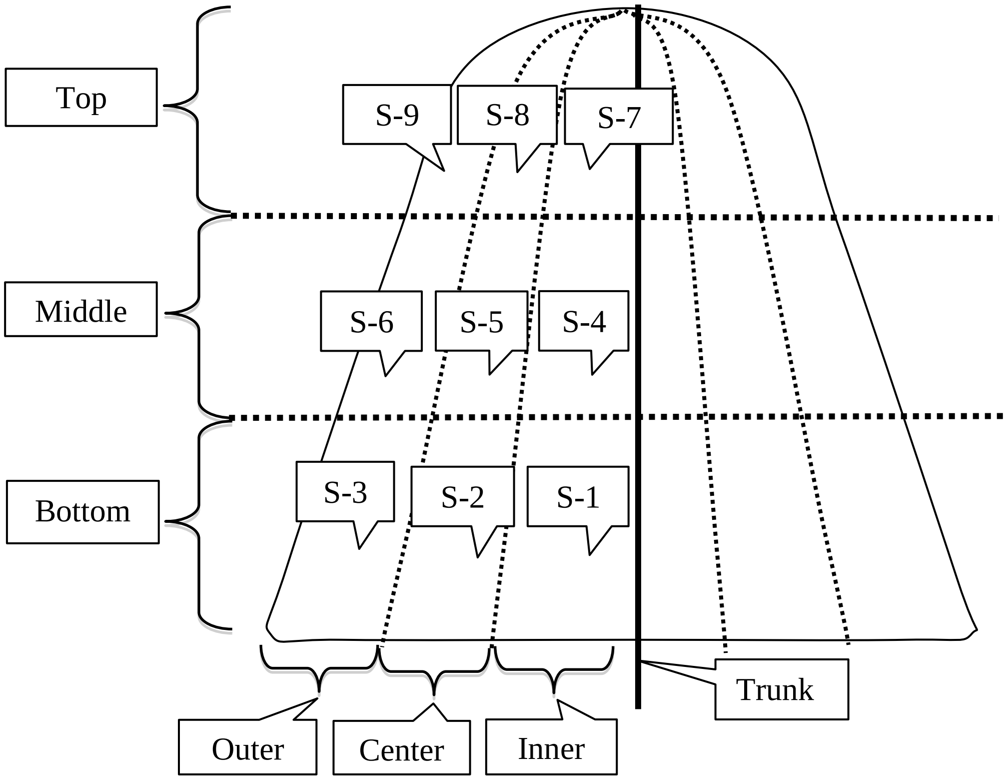

Fig. 1. Illustration of the sectors (positions in the canopy, S-1 to S-9) defined for study of mangosteen trees.

C-N ratio of leaves

Six leaves were collected from each sector at monthly intervals from May to September 2010. Leaf sample was taken from the mature leaf pair at the number two from shoot tip positions. Leaf samples were washed, dried in an oven, and ground into powder with a mill. Carbon and nitrogen contents of leaves were determined by CN analyzer (MT700MC, Yanaco, Tokyo).

Chlorophyll content of leaves

Six leaves of similar age and position were selected in each sector in August, and their SPAD value was determined by chlorophyll-meter (green meter) (SPAD−502, Konica Minolta). The leaves were collected, then chlorophyll was extracted by 85 % acetone and the content was determined by spectrophotometer (UV−VIS 1800, Shimadzu).

Statistical analysis

An analysis of variance was conducted to test the differences among sectors (position in canopy). The results were statistically evaluated by one way analysis of variance (ANOVA). Statistical differences with *p*-values under 0.05 were considered significant and means were compared by Duncan's Multiple Range Test, using SPSS program version 16.0 (SPSS Inc., IBM).

RESULTS AND DISCUSSION

For all sectors, the SPAD (green meter) value of leaves was ranged from 67.5 to 79.1 (Fig. 2). SPAD value in both young and middle-aged trees was higher in inner position of canopy such as Sectors 1, 4, and 7 than in outer one such as Sectors 3, 6, and 9, while in old trees, it was higher in outer position of canopy than in inner one. In spite of tree age, SPAD value of leaves in middle and top positions of canopy such as Sectors 5 to 9 was high compared to bottom one such as in Sectors 1 to 3.

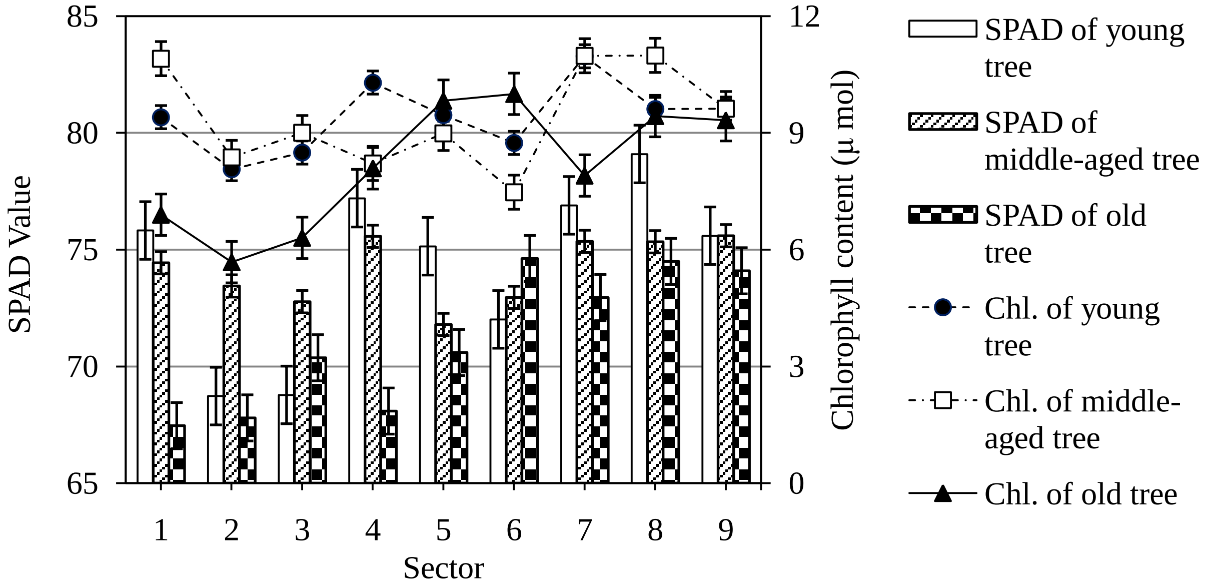

Fig. 2. SPAD value and chlorophyll content of mangosteen leaves as affected by different sectors and tree ages. Error bars indicate ± SE (n=5).

The SPAD value was significantly different among sectors and tree ages. The new leaves are light green colour and soon acquires the characteristic dark-green colour, and relatively thick and coriaceous. In mangosteen, the SPAD value of leaf was high ranged from 60 to 85. Regardless of tree age, nitrogen content of leaf in top position of canopy such as Sectors 7 to 9 was low compared to bottom and middle ones, whereas SPAD value of leaf in top position of canopy was higher than bottom and middle ones (Fig. 3).

The results showed that SPAD values of leaf samples were in the range 67.82-77.61; 69.42-76.13; and 67.96-73.61 in young, middle-aged, and old tree, respectively. The relationship between SPAD value and N level of mangosteen leaf was significant (Fig. 3 left), with the coefficient of determination was high, R^2 = 0.91; 0.67 and 0.45 in young, middle-aged, and old tree, respectively. The result of the current study suggested that non-destructive estimation of mangosteen leaf N status can be rapidly determined using a portable chlorophyll meter. The relationship between SPAD values and leaf N contents could be explained by regression equations 1, 2 and 3 (Fig. 3).

N level (% DW) in young tree
= - 0.0099 x SPAD + 2.2366……………. (1)

N level (% DW) in middle-aged tree
= - 0.0177 x SPAD + 2.8001 …………… (2)

N level (% DW) in old tree
= - 0.0187 x SPAD + 2.7785……………. (3)

N level of mangosteen leaf samples were in the range 1.47-1.56; 1.43-1.56; and 1.37-150 % in young, middle-aged and old tree, respectively. N level and SPAD value of mangosteen leaf samples in each sector of young tree had a high coefficient of determination value R^2 = 0.8 and 0.79, respectively and could be explained by regression equations 4 and 5 (Fig. 3). Both N level and SPAD value in each sector of middle-aged tree have a coefficient of determination value are R^2 = 0.59 and R^2 = 0.65, respectively. N level and SPAD value in each sector of middle-aged tree could be explained by regression equations 6 and 7 (Fig. 3).

In this study N level of mangosteen leaf samples in each sector of old tree had a coefficient of determination value R^2 = 0.53 and could be explained by regression equation 8. The SPAD value of mangosteen leaf samples in each sector of old tree had a high coefficient of determination value R^2 = 0.8 and could be explained by regression equation 9 (Fig. 3).

N level (% DW) in each sector of young tree = - 0.0107x + 1.5514 ……… (4)

SPAD value in each sector of young tree = 0.0998x + 69.643 ………... (5)

N level (% DW) in each sector of middle-aged tree = - 0.0117x + 1.5479 ……… (6)

SPAD value in each sector of middle-aged tree = 0.5669x + 71.297………… (7)

N level (% DW) in each sector of old tree = -0.013x + 1.5083.……….... (8)

SPAD value in each sector of old tree = 0.576x + 68.628 ……… … (9)

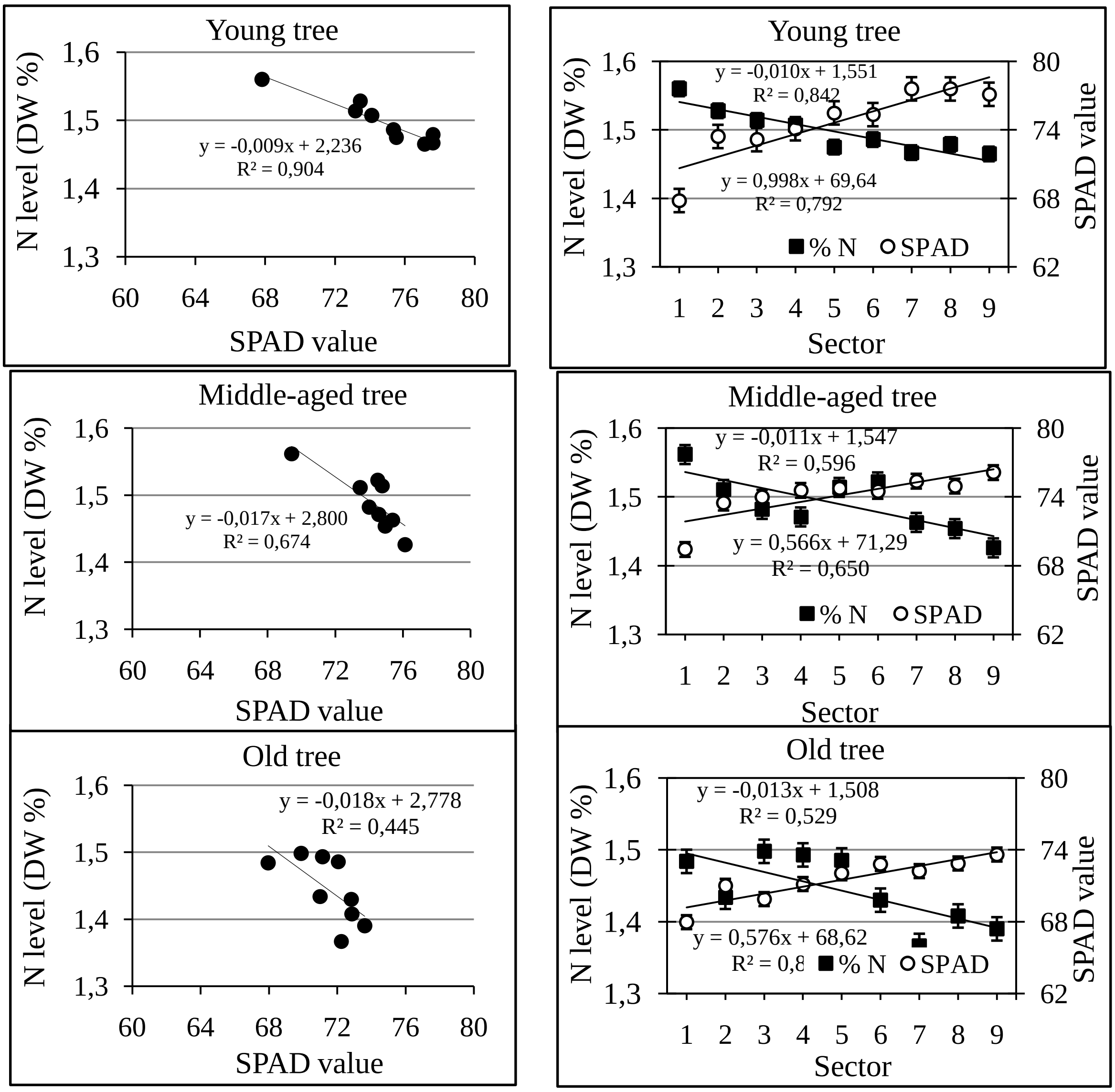

Fig. 3. Relationship between N level and SPAD value in mangosteen leaves, N level, and SPAD value per sector in young tree, middle-aged tree, and old tree.

The seasonal change in nitrogen level was varied largely among tree ages and month, may suggested the blooming is not uniform (Setiawan *et al*., 2012). Regardless of tree age measured, nitrogen level of leaves was higher in bottom position of canopy such as Sectors 1 to 3 than in middle and top ones such as Sectors 5 to 9. This may suggested in bottom position of canopy was high in photosynthetic rate compared to middle and top ones. Makino and Osmond (1991) reported that the photosynthetic rate increased linearly with nitrogen content in leaves.

In Malaysia, it has been reported that flushing starts in July and August when nitrogen content decreases to the lowest level of 1.18 % (Malip and Masri, 2006). Nitrogen remained high from August to September, because there were no vegetative shoots in young trees. In May, when flowering began in old trees, the concentrations of nitrogen remained lowest from 1.2 to 1.4 % (Setiawan *et al*., 2012). In old trees, drought conditions in May caused the C-N ratio increase, and this fact may promote flower bud differentiation. This indicated that the dried condition and C-N ratio in the mangosteen leaf show significant effect on the flowering. Hong-Biao *et al.* (2008) reported that the maximum C-N ratio was significantly correlated with dry weight per boll and boll weight in cotton. The monitoring in Malaysia during 2004 had shown that during flushing, nitrogen was low but reversed during flowering, implying that nitrogen was heavily used for vegetative shoot development (Malip and Masri, 2006).

In spite of tree age, both in SPAD value and chlorophyll content was high in top position of canopy such as in Sectors 7 to 9 than in bottom and middle positions (Sectors 1 to 6). In contrast, the nitrogen level in middle and top positions of canopy was lower compared to bottom one. In this research, the young leaves with green light colour have low SPAD value and in the older leave with dark-green colour was high SPAD value (data not showed). However, the nitrogen content in young mangosteen leaves was higher than in older one. This may suggest that the nitrogen content in mangosteen leaves varied contrarily with SPAD value. Meletiou-Christou *et al.* (1994) reported that the nitrogen content was high in young expanding leaves and decreased considerably during the growth period of Mediterranean evergreen sclerophylls. Similarly, Escobar *et al.* (1999) reported that the concentrations of N, P, K, Zn, and B in olive leaves were higher in younger leaves than in older one. Our results contrasts results observed in pea and wheat, in which chlorophyll content increased in parallel with leaf-nitrogen content because nitrogen partitioning into chloroplasts and mitochondria (Makino and Osmond, 1991). This difference in results may be due to the different colour and thickness of leaves. Nakasone and Paull (1998); Yaacob and Subhadrabandhu (1995) previously reported that new leaves are light green then change to dark-green colour, relatively thick and coriaceous, and believe to live for several years.

In this research, SPAD value and total chlorophyll content in the old tree were lowest compared to the young and middle-aged tree. The results presented here suggest that lower SPAD value and chlorophyll content could be due to higher nitrogen level in the old mangosteen tree. Nitrogen level in the old tree during July was high compared other tree ages in all month. This may suggest productivity in the old tree was higher than in the young and middle-aged tree. Boussadia *et al.* (2010) reported that N−deficient in olive plants had significant lower nitrogen and chlorophyll a contents in leaf, also showed a significant reduction in their photosynthetic capacity.

SUMMARY

In mangosteen leaves, the high SPAD value has low nitrogen content and in the contrast, low SPAD value means the high nitrogen content. SPAD value in both young and middle-aged trees was higher in inner position of canopy such as Sectors 1, 4, and 7 than in outer one such as Sectors 3, 6, and 9, while in old trees, it was higher in outer position of canopy than inner one.

REFERENCES

Boussadia, O., K. Steppe, H. Zgallai, S. B. El-Hadj, M. Braham, R. Lemeur and M. C. V.

Evans, J.R. 1983. Nitrogen and photosynthesis in the flag leaf of wheat. Plant Physiol. 72(2): 297-302.

Escobar, R. F., R. Moreno and M. G. Creus. 1999. Seasonal changes of mineral nutrients in olive leaves during the alternate-bearing cycle. Sci. Hort. **82:**25–45.

Hong-Biao, H. U., Z. Wen-Jing, C. Bing-Lin, W. You-Hua, S. Hong-Mei and Z. Zhi-Guo. 2008. Changes in C-N ratio of subtending leaf of cotton boll and its relationship with cotton boll dry matter accumulation and distribution. Acta Agron. Sin. **34:**254–260.

Indriyani N.L.P., S. Lukitariati, Nurhadi, dan M. Jawal. 2002. Study of mangosteen fruit damage caused by yellow latex staining. J. Hort. 12(4): 276-283.

Jaroonchon, N., K. Krisanapook and L. Phavaphutanon. 2010. Correlation between Pummelo Leaf Nitrogen Concentrations Determined by Combustion Method and Kjeldahl Method and their Relationship with SPAD Values from Portable Chlorophyll Meter. Kasetsart J. (Nat. Sci) 44: 800-807.

Makino, A. and B. Osmond. 1991. Effects of nitrogen nutrition on nitrogen partitioning between chloroplast and mitochondria in pea and wheat. Plant Physiol. **96:**355–362.

Malip, M. and M. Masri. 2006. Establishment of protocol for carbohydrate analysis and monitoring seasonal variations between carbohydrates and nitrogen levels in *Garcinia mangostana* L. (mangosteen). Acta Hort. **727:**569–575.

Meletiou-Christou, M. S., S. Rhizopoulou and S. Diamantoglou. 1994. Seasonal changes of carbohydrates, lipids and nitrogen content in sun and shade leaves from four mediterranean evergreen sclerophylls. Environ. Exp. Bot. **34:**129–140.

Misra, H., B. K. Dwivedi, D. Mehta, B. K. Mehta, and D. C. Jain 2009. Development and validation of high performance thin-layer chromatographic method for determination of α-Mangostin in fruit pericarp of mangosteen plant (Garcinia mangostana L.) using ultraviolet – visible detection. Rec. Nat. Prod. 3(4):178-186.

Nakasone, H. Y. and R. E. Paull. 1998. Mangosteen. p. 359–369. *In* H.Y. Nakasone, R.E. Paull (eds.) Tropical Fruits. CAB International, New York.

Poerwanto, R., D. Efendi, Sobir and R. Suhartanto. 2008. Improving Productivity and Quality of Indonesian Mangosteen. Acta Hort. 769: 285-288.

Setiawan, E., R. Poerwanto and S. Susanto. 2005. Produktivitas dan kualitas buah mangis pada berbagai posisi cabang dalam tajuk. J. Habitat 17(3): 159-174.

Setiawan, E., R. Poerwanto, F. Fukuda and N. Kubota. 2012. Meteorological conditions of mangosteen orchard in West Java, Indonesia and seasonal changes in C-N ratio of their leaves as affected by sector (position in canopy) and tree age. Sci. Rep. Fac. Agr. Okayama Univ. 101:39–47.

Yaacob, O. and S. Subhadrabandhu. 1995. Mangosteen (*Garcinia mangostana* L.). p. 109–114. *In* O. Yaacob, S. Subhadrabandhu (eds.) Fruit with a long juvenile period: The production of economic fruits in South-East Asia. Oxford University Press, Kuala Lumpur.