International Journal of Agricultural Technology 2016Vol. 12(7.1):1307-1317
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Effect of Timing for NPK Fertilizer Application on Flowering and Yield of Longan (*Dimocarpus longan* Lour.)

Sutisa Chaikul*[1], Aphaporn Changthom[1], Worachart Meekrongpool[1], Songsak Thammachamrat[2]

[1]Faculty of Agricultural Technology, Rambhai Barni Rajabhat University, Thailand
[2]Faculty of Agricultural Technology, Phetchaburi Rajabhat University, Thailand

Chaikul S., Changthom A., Meekrongpool W. and S. Thammachamrat (2016). Effect of Timing for NPK Fertilizer Application on Flowering and Yield of Longan (*Dimocarpus longan* Lour.). International Journal of Agricultural Technology 12(7.1):1307-1317.

Off-season longan production needs various techniques to stimulate longan trees to flower, however, if the previous season's store of N is low it may limit flower development and consequently decrease yield. The aim of the study was to examine effect of timing interval of NPK fertilizer application on longan flowering and yield. The field experiment was conducted at 2 sites in Chanthaburi province, with different soil fertilities, in South-East of Thailand. Application of NPK was made at (1) 0, 5 and 10 days after 2nd flushing (DASF); (2) 0, 10 and 20 DASF; and (3) 0, 15 and 30 DASF in a RCBD with 4 replications. Twenty-five branches were labelled at random at the start of the experiment for parameter measurements. Leaf width, leaf length, fresh leaf weight, and concentrations of N, P and K, were determined before flower stimulation. After flower stimulation, percentage of flowering, fruit width, fruit length, fresh fruit weight and total fruit weight per tree were collected. The results showed that leaf growth, flowering percentage, foliar P and K concentrations and fruit weight were not affected by the time of NPK application after the 2nd flushing at both sites, even though the level of soil fertility was different. However, at both sites, application of NPK fertilizer up to 30 DASF increased leaf N concentration than when the fertilizer was applied earlier. At site 2, late application of mineral fertilizer resulted in smaller fruit compared to the other treatments. At site 1 however, fruit size was not affected by time of NPK application. Also, site 2 had about 22% more flowering than site 1. It is suggested that fruit size may have been influenced by the timing of maturation of the foliage flush and also the continuity of supply of N into the tree during flower development. Further research is required to better define fertilizer options for longan production off-season.

Key words: flowering, longan, NPK, yield

Coressponding Author: Sutisa Chaikul **E-mail address:** sutisap@hotmail.com

Introduction

Longan is one of the most economic fruits of Thailand and is widely grown in many parts of the country. Off-season longan production is demanding and management is very expensive. Fertilizer management is of particular concern. Application of excessive nitrogen fertilizers has been reported not only to elevate NO_3^-N concentrations in groundwater and reduce N use efficiency (Wang *et al.* 2011) but also to hamper crop defoliation as a greater proportion of vegetative material is produced in relation to reproductive organs (Heam 1975). To stimulate longan trees to flower, limited use of N fertilizer and water are needed, in addition to low temperature or application of $KClO_3$. However, if the previous season's store of N is low in longan trees, the internal N supply may limit flower development. Therefore, N fertilizer application may be necessary to promote longan flowering and fruit yield, but the timing for optimum application is unknown.

Objectives: To examine the timing interval of mineral fertilizer application on longan flowering and yield.

Materials and methods

Field experiments were conducted in Amphoe Makham (site 1) and Amphoe Thamai (site 2), Chanthaburi, Thailand on 4-5 year-old longan 'Daw' variety with canopies of 4 metres diameter. A randomized complete block design with 4 replications was applied at each site. Three timing of fertilizer treatments were applied as follows: (Tr1) application at 0, 5 and 10 days after 2nd flushing (DASF), (Tr2) application at 0, 10 and 20 DASF, and (Tr3) application at 0, 15 and 30 DASF (Fig. 1). Mineral fertilizer was applied at the rate of the Longan Research and Development Center (LRDC)'s recommendation that takes into account the nutrient demand when flushing in relation to tree canopy size. The fertilizer was applied at the rate 85-16-64 N-P_2O_5-K_2O per tree, with half given at the 1st flushing on the same day for all 3 treatments and the second half according to treatment (Tr1 on 5 and 10, Tr2 on 10 and 20, Tr3 on 15 and 30 days after 2nd flushing, Fig. 1). The fertilizer was broadcasted by hand under each canopy using 46-0-0, 15-15-15, and 0-0-60 by weight according to the treatment. All the fallen leaves under the canopy were removed prior to the application of Potassium Chlorate ($KClO_3$) at 250 g/tree on 27th August 2014 on site 1 and on 7th September 2014 on site 2. After flowering, mineral fertilizer at the total rate of 279-72-336 N-P_2O_5-K_2O per tree was gradually applied, for all treatments, for fruit development until harvest (Fig. 1). The soil chemical properties for the 2 sites are shown in Table 1. Twenty five branches were randomly labelled at the start of the experiment.

Data collection before stimulating longan flowering (July-August 2014) on the labelled branches included leaf width, leaf length, fresh leaf weight, and concentration of N (Kjeldhal method by Bremner and Keeny, 1982), P (nitric-perchloric acid digestion and determination by yellow molybdate method by Murphy and Riley, 1962) and K (atomic absorption spectrophotometry, Jackson and Mahmood, 1994) on acid digested dried leaf material. After stimulating longan flowering, percentage of flowering, fruit width, fruit length, and fresh fruit weight were collected at harvest on 28th March 2015 (site 1) and 10th April 2015 (site 2) (Fig. 1).

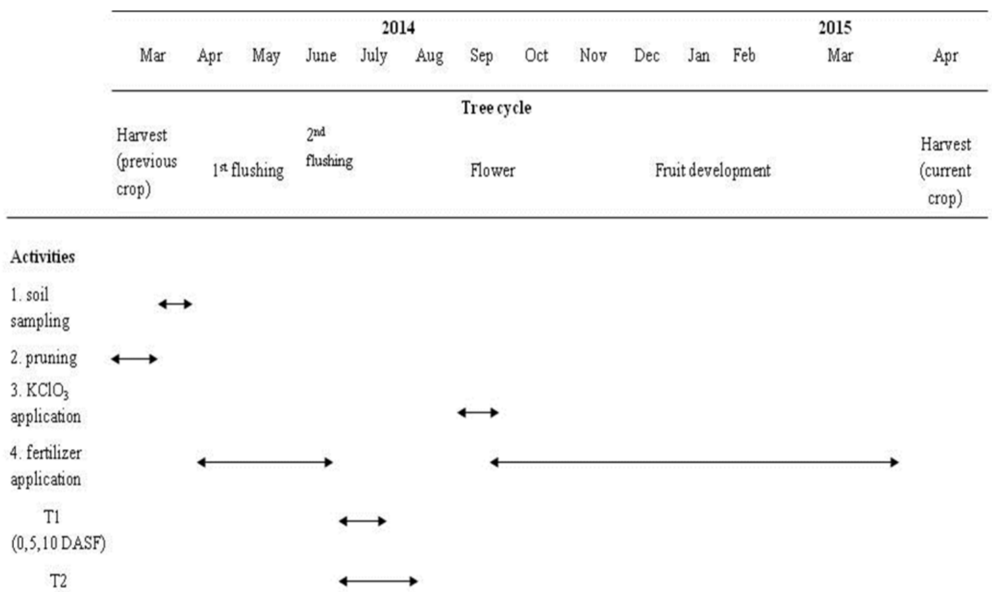

Fig. 1. Timeframe of the experiment and treatments applied

Results

Leaf growth

Leaf size and weight

Leaf size and weight were unaffected by time of fertilizer application at either site (Fig. 2).

Table 1 Soil chemical properties

Property	Site 1 (Amphoe Makham)	Site 2 (Amphoe Thamai)
Soil texture [1/]	Sandy clay loam	Sandy clay loam
pH [2/]	4.1	4.0
Organic Matter [3/] (%)	2.66	2.12
E.C.[4/] (dS/m)	1.35	1.31
Bray II extractable P [5/] (mg kg^{-1})	35.6	6.12
Exchangeable K [6/] (mg kg^{-1})	47.5	29.5
Exchangeable Ca [6/] (mg kg^{-1})	106.6	92.9
Exchangeable Mg [6/] (mg kg^{-1})	25.1	14.9

[1/] Hydrometer (Attananda and Chancharoensuk, 1999); [2/] 1:1, soil:water (Attananda and Chancharoensuk, 1999); [3/] Walkley & Black (Attananda and Chancharoensuk, 1999); [4/] Soil saturation (Attananda and Chancharoensuk, 1999); [5/] Bray II method (Attananda and Chancharoensuk, 1999) [6/] extraction by 1 *N* NH_4OAc analyse by Atomic Absorption Spectrophotometer (Attananda and Chancharoensuk, 1999)

Leaf N, P and K concentrations

Application of fertilizer at 15 day intervals resulted in a greater leaf N content before longan flower stimulation than application of fertilizer at 5 or 10 days interval at site 1 (Fig. 3A) which contrasted with site 2 where no significant differences were observed (Fig 3B). Leaf P and K were not affected by time of fertilizer application at either site (Fig. 3C-3F).

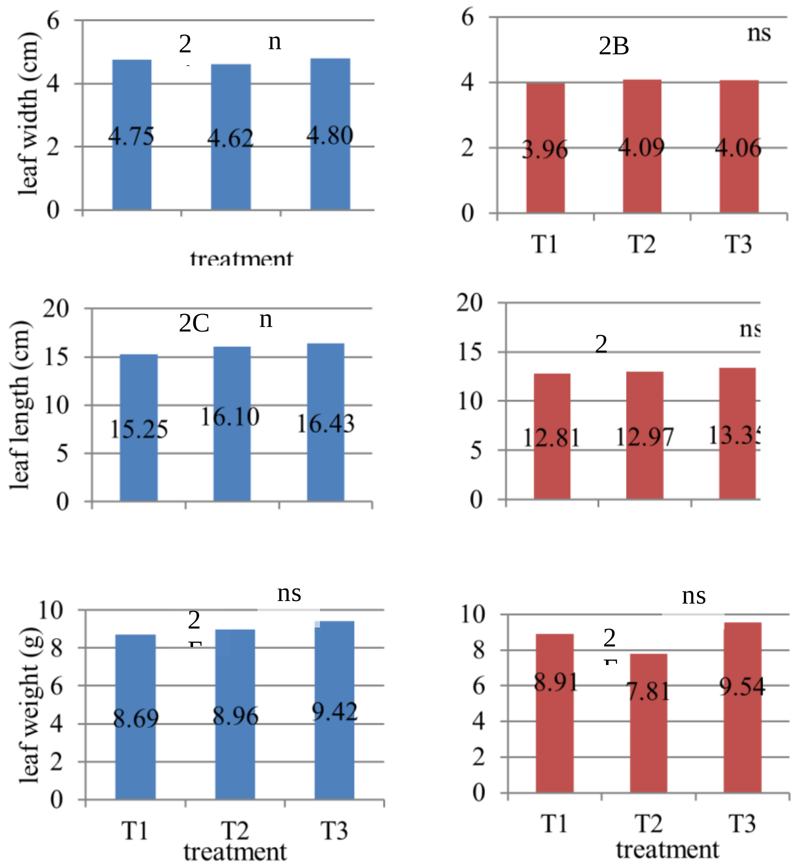

Fig. 2. Leaf size and weight at maturity stage before longan flower stimulation where T1is application of fertilizer at 0,5 and10 days after 2nd flushing (DASF), T2 is application of fertilizer at 0, 10 and 20 DASF, and T3 is application of fertilizer at 0, 15 and 30 DASF. Figs 2A, 2C, 2E refer to leaf width, length and weight, respectively, at site 1, Figs 2B, 2D and 2F refer to leaf width, length and weight, respectively, at site 2. Non significant results (ns) refers to the treatments which showed non statistical difference using DMRT at $p \geq 0.05$. CV% of Figs 2A, 2B, 2C, 2D, 2E and 2F were 5.06, 8.54, 5.85, 6.68, 7.42 and 18.6%, respectively.

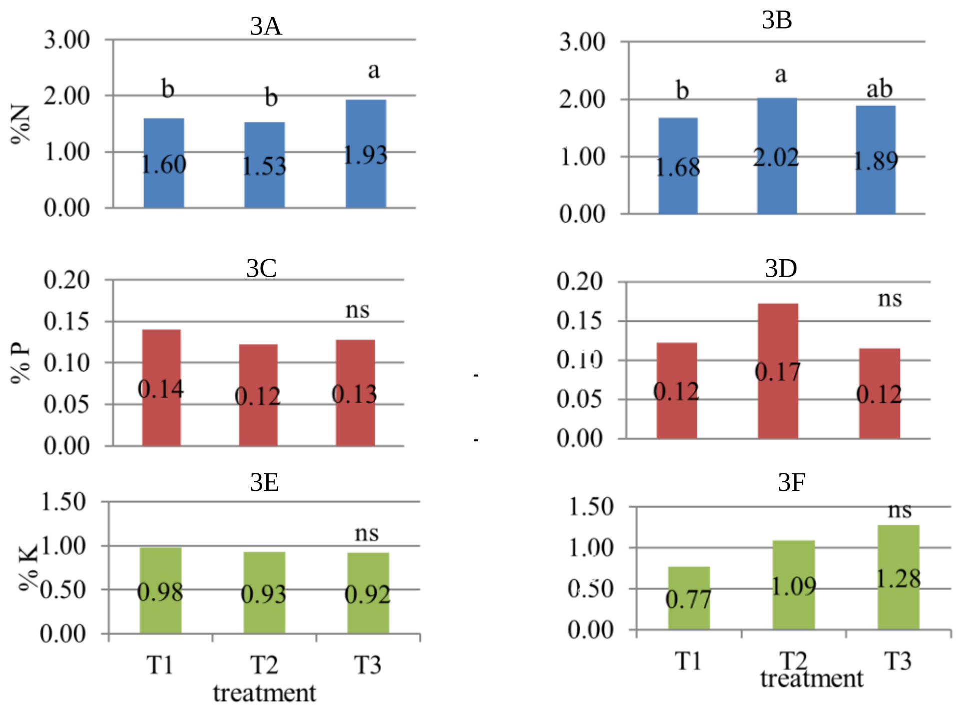

Fig. 3. N, P and K concentrations in foliage prior to longan flower stimulation. Figs 3A, 3C and 3E are N, P and K concentrations, respectively, at site 1; and 3B, 3D and 3F are N, P and K concentrations, respectively, at site 2. Different letters above columns indicate significant difference in each parameter. See Fig. 2 for captions. CV% of Figs 3A, 3B, 3C, 3D, 3E, 3F were 9.19, 6.79, 0.00, 32.7, 8.88 and 23.4%, respectively.

Percentage of flowering

Percentage of flowering was unaffected by time of fertilizer application at either site (Table 2).

Yield

Fruit size and weight

Fruit size was not affected by time of fertilizer application at site 1 (Fig. 4A, 4C) whereas at site 2, it showed a different result. At site 2, application of fertilizer at 5 and 10 days interval, respectively, resulted in bigger fruit than application of fertilizer at 15 days interval (Fig. 4B, 4D).

Fruit weight was not affected by time of application at either site (Fig. 4E, 4F)

Table 2 Percentage of flowering among 4 time periods

Site	Treatment	Percentage of flowering (%)				
		30 days after applying $KClO_3$	35 days after applying $KClO_3$	40 days after applying $KClO_3$	45 days after applying $KClO_3$	Total flowering*
1 (Amphoe Makham)	T1: 0, 5, 10 DASF	24.8^{ns}	20.8^{ns}	12.9^{ns}	1.1^{ns}	59.6^{ns}
	T2: 0, 10, 20 DASF	30.6	22.0	21.7	7.9	82.3
	T3: 0, 15, 30 DASF	30.6	20.0	12.2	3.7	66.6
	CV%	119.9	69.1	46.5	119	42.9
2 (Amphoe Thamai)	T1: 0, 5, 10 DASF	58.0^{ns}	10.8^{ns}	16.2^{ns}	5.1^{ns}	90.0^{ns}
	T2: 0, 10, 20 DASF	64.3	11.5	9.8	6.5	92.1
	T3: 0, 15, 30 DASF	63.5	3.1	14.7	10.5	91.8
	CV%	14.7	78.4	39.8	73.2	6.09

* calculated from the accumulation percentage of flowering among 4 periods (30, 35, 40 and 45 days after applying $KClO_3$)

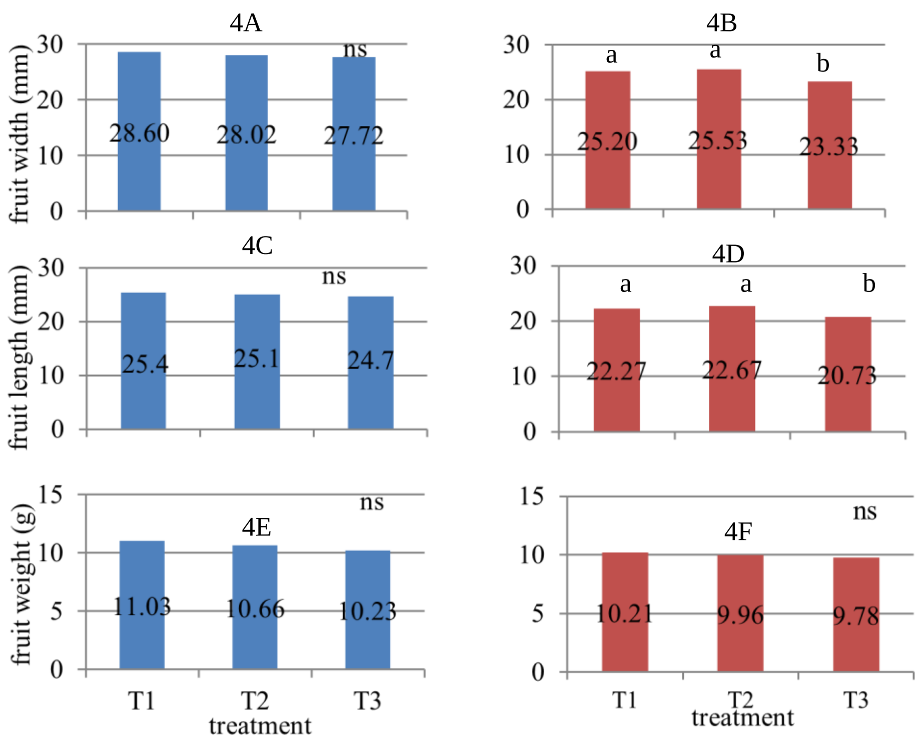

Fig. 4. Fruit size and weight at harvest. Figs 4A, 4C and 4E are fruit width, length and weight, respectively, at site 1; and 4B, 4D and 4F are fruit width, length and weight, respectively, at site 2. See Fig. 3 for captions. CV% of Figs 4A, 4B, 4C, 4D, 4D and 4F were 3.24, 2.57, 3.32, 2.48, 9.19 and 16.2%, respectively.

Total weight of fruit per tree

Application of fertilizer at 5 days interval resulted in a higher total weight of fruit than application of fertilizer at 10 and 15 days interval at site 1 (Fig. 5A), whereas at site 2, the total weight of fruit was not affected by time of application (Fig. 5B).

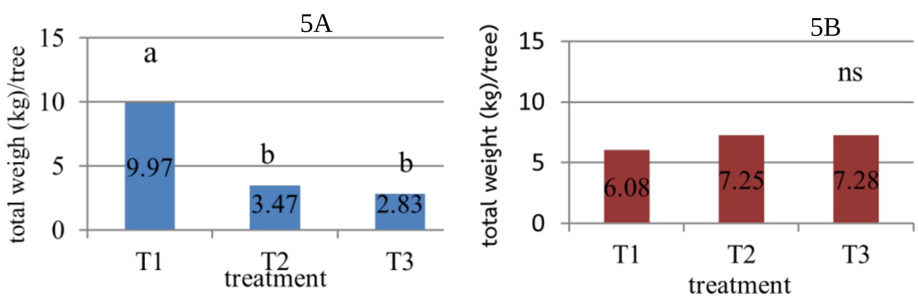

Fig. 5. Total weight of fruit per tree at harvest . Fig.5A is the weight of fruit at site 1. Fig. 5B is the weight of fruit at site 2. See Fig. 3 for captions. CV% of Figs 5A and 5B were 23.4 and 43.4%, respectively.

Discussion

Soil properties

Both sites had acidic soils with pH 4.0 - 4.1 which is below the recommended range (5.5 - 6.5) for longan orchards (Khaosumain *et al.*, 2013). Moreover, extractable K, Ca and Mg were lower than the recommended ranges which are 100 - 120, 800 - 1500 and 250 - 450 mg/kg for K, Ca and Mg, respectively (Khaosumain *et al.*, 2013). However, site 1 had higher soil fertility as soil organic matter content, available phosphorus and extractable K, Ca and Mg were higher than site 2. This may be due to the fact that at site 1, the farmer broadcast organic fertilizer and NPK fertilizer and supplemented this via foliar application of NPK and micronutrient fertilizers more intensively than the farmer at site 2 in the previous crop season.

Growth and flowering

After applying mineral fertilizer according to treatments, it appeared that leaf nitrogen concentration differed with the timing of mineral fertilizer application without any effect on leaf growth parameters. Our results showed that leaf N, P and K concentrations were in the range suggested by Khaosumain *et al.* (2013) who reported that the mature leaf of longan should contain 1.47 - 1.88% N, 0.12 - 0.22% P and 0.88 - 1.36% K. Late fertilizer application (Tr2 and Tr3) tended to increase % N in the leaf at both sites. It seems that longan mostly stores N in the leaf (26.5%) compared to other parts such branches, bark and roots (Khaosumain *et al.,* 2005). Therefore, when the tree took up N from fertilizer, the soluble nitrogen was allocated mainly to the foliage for assimilation. Additionally, Mattos *et al.* (2003)'s results support our finding that trees accumulated 10.7 - 60.1% of the total above ground N in the newly emerged organs while lower N concentrations occurred in the older organs such as former emerged leaves and branches (1.7 - 36.1%). Only leaves were examined in the present study. The marginally low leaf phosphorus concentrations may result from reduced P uptake due to acid soil effects, such as increased adsorption to soil minerals (Uexkull and Mutert, 1995). It was observed that even though the extractable K in soil was lower than the critical value, the leaf K concentration was higher than the suggested range (Khaosumain *et al*. (2013). This might be due to the mineralogy of the soil where exchangeable forms of K are released as the soil K pool is depleted (Mengel et al., 2001), thus meeting the large demand of K for longan development (Khaosumain *et al.,* 2013).

The different interval times of NPK fertilizer application did not alter the day of flowering after stimulating with $KClO_3$. It should be noted that site 2 had a greater total flowering, by about 22% than site 1. This might have been due to tree maturity and nutrient contents stored in trees at site 2 being greater than at site 1, indicated by the higher nutrient concentrations in leaves at site 2 compared to site 1. However, our result was not supported by Diczbalis (2002) and Khaosumain *et al.* (2005)' reports which suggested that high leaf N level ($\geq$ 2%) during the period leading up to flowering might cause a detrimental effect to flowering and hence subsequent cropping. Nevertheless, we agree with Diczbalis (2002) that there are other factors such as pruning practices and climate that play an important role in flowering and subsequent yields. Further research is required to elucidate any interaction between the foliar N status and flowering intensity. In the present study study, trees at site 2 had higher foliar N concentrations (~1.86% N) than site 1 (~1.69% N), and higher percentage of flowering (~91.5%) than site 1 (~70%).

Yield

At site 1, complete application of mineral fertilizer within 10 days after the 2nd flushing (Tr1) resulted in the greatest total weight while the later finishing fertilizer applications (Tr2 and Tr3) resulted in lower total fruit weight per tree; the average yield (Tr1-Tr3) was about 5 kg/tree. However, the total weight data did not reflect fruit size and this might be due to differences in tree response from unequitable age among replications.

At site 2, late application of mineral fertilizer (Tr3) resulted in smaller fruit compared to Tr1 and Tr2 where the mineral fertilizers was fully applied within 20 days after the 2nd flushing. The explanation for this is unknown but fruit size may have been influenced by the timing of maturation of the foliage flush and also the continuity of supply of N into the tree during flower development (Lindhard and Hansen, 1997). Moreover, the degree of trimming fruiting branches by farmers could affect fruit size as the average fruit size and weight at site 2 were smaller than at site 1, and the site 2 farmer did less trimming than the farmer at site 1. Also, it is well known that the magnitude of the fruit load affects fruit size and weight (Sritontip *et al.*, 2013). These factors need to be taken into account in future experiments on fertilization and off-season longan fruit production.

Conclusions

1. Timing of NPK fertilizer application after the 2nd flushing did not affect leaf size, P and K concentrations in the leaf, nor the percentage of flowering and fruit weight at both sites.

2. Application of NPK fertilizer within 30 DASF (Tr3) resulted in higher leaf N concentration than the other 2 treatments in soil which had higher soil fertility. At site 2, which had lower soil fertility, there was a trend that Tr3 trees contained higher foliar N than Tr1.

3. Timing for mineral fertilizer application did not affect fruit size in soil which had higher soil fertility. However, Tr3 resulted in smaller fruit compared to the other 2 treatments in soil which had lower soil fertility. This might be due to an effect of fruit load, nutrient storage and withdrawal of nutrient from the previous crop; hence, these factors need to be taken into account in further experiments.

Acknowledgement

The first author thanks Professor Bernard Dell for editing the manuscript.

References

Attananda, T., and Chanchareonsuk, C. (1999). Exercises and Laboratory Manual for Soil and Plant Analysis. Department of Soil Science, Faculty of Agriculture, Kasetsart University. Bangkok.

Bremner, J.M. and Keeny, C.S. (1982). Nitrogen-Total, pp. 595-624. *In* Pages, A.L., Miller R.H. and Keeney, D.R. (eds). Methods of Soil Analysis, Part 2: Chemical A.L. Methods 2nd ed. American Society of Agronomy, Madison, WI.

Diczbalis, y. (2002). Longan: Improving Yield and Quality. Publication No. 02/135. Queensland. Australia.

Hearn, A.B. (1975). Response of cotton to water and nitrogen in a tropical environment. II. Date of last watering and rate of application of nitrogen fertilizer. Journal of Agricultural Science Cambridge 84: 419–430.

Jackson, K.W. and Mahmood, T.M. (1994). Atomic absorption, atomic emission and flame emission spectrometry. Analytical Chemistry 66: 252-279.

Khaosumain, Y. C. Sritornthep and S. Changgenraja. (2005). Management of soil and fertilizer for efficient longan production. Research report. Institution of Agricultural Research and Training. Lampang (In Thai).

Khaosumain, Y. C. Sritornthep and S. Changgenraja. (2013). Nutrient management for longan production. pp. 75-89. *In* Charoenkit, T., Manochai, P., Sangchayosawas, C. and Khaosumain, Y. (eds). Increasing production for off-season Longan.

Lindhard, P.H. and Hansen, P. (1997). Effect of timing of nitrogen supply on growth, bud, flower and fruit development of young sour cherries (*Prunus cerasus* L.). Scientia Horticulture 69: 181-188.

Manochai, P., Ussahatanonta, S., Sutonta, W., Wiriya-alongkorn, W., Jarassamrit N., Ampawan , R. and Pookmanee, T. (2003). A study on controlling flower initiation in longan. Research report to Maejo University foundation (In Thai).

Mattos, D., Graetz, D.A., Alva, A.K. (2003). Biomass distribution and nitrogen-15 partitioning in citrus trees on a sandy Entisol. Soil Science Society America Journal 67: 555–563.

Mengel K., Kirkby, E.A., Kosegarten, H. and Appel, T. (2001). Principles of plant nutrition. 5eds. Springer-Science+Business Media, B.V. 807 p.

Murphy, J. and Riley, J.P. (1962). A modified single solution method for the determination of phosphate in natural waters. Analytica Chimina Acta 27: 31-36.

Sritontip, C., Khaosumain, Y. and Changjeraja, S. (2013). Influence of fruit load on water consumption, leaf photosynthesis and plant nutrient contents of longan trees grown in sand culture. Acta horticulture 984(1) :151-156.

Uexkull, H.R. and Mutert, E. (1995). Global extent, development and economic impact of acid soils. pp. 5-19. *In* Dale, R.A. (eds.), Plant Soil Interactions at Low pH. Kluwer Academic Publishers.

Wang, W., Xu, Z., Zhao, J., Wang, Y. and Yu, Z. (2011). Excessive nitrogen application decreases grain yield and increases nitrogen loss in a wheat–soil system. Soil and Plant Sciences 61(8): 681-692.