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Effects of fertilizer doses on yield and quality of gandaria (*Bouea oppositifolia* (Roxb.) Meisne.) grown in Binh Minh town, Vinh Long province, Vietnam

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ABSTRACT

This study, conducted from May 2016 to June 2017, was aimed to investigate the effect of different fertilizer doses on yield and quality of gandaria (Bouea oppositifolia (Roxb.) Meisne). Experiments were arranged in randomized complete block design, in which the 5 investigated treatments corresponding to the five fertilizer doses, viz 1, 2, 3 and 4 kg/tree/year, and no fertilization as the control. Fertilizers doses were obtained by mixing and adjusting the proportions of mono (Urea, KCl, Diammonium phosphate -DAP) and compound (20-20-15) fertilizer. Every treatment had 10 replications, each of which equalled to one tree. The fertilizer doses were divided into three times of application, i.e. post-harvesting (50% of the investigated doses, at the N-P_2O_5-K_2O ratio of 4:3:2), 30 days after fruit set (25% of the investigated doses, at the N-P_2O_5-K_2O ratio of 1:1:1), and 60 days after fruit set (25% of the investigated doses, at the N-P_2O_5-K_2O ratio of 2:2:3). Leaf and soil samples were collected for further analysis to determine the content of some nutrient elements before and after fertilizer applications. Results of the present study showed that fertilizer application at the dose of 3-4 kg/tree/year resulted in higher yield (2.3 times higher than that of the control treatment) which was due to the increase in number of inflorescences per shoot, number of fruit per bunch and fruit set ratio. The treatment also prolonged flowering duration (79.4 days) as compared to that of the control treatment (39 days). Fruit sweetness was also improved by the application of 3-4 kg of fertilizer per tree per year.

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1 INTRODUCTION

Gandaria (*Bouea oppositifolia*), also known as Marian plum, Ma-prang (Thailand), and Thanh Tra (Vietnam), belongs to the same family as mango (*Anacardiaceae*) (Subhadrabandhu, 2001). According to Lim (2012), the plant is indigenous to various locations of the tropical stripe, i.e. Andaman Islands, Myanmar, Laos, Cambodia, Thailand, Vietnam and South China (Yunnan, Hainan), Indonesia (Sumatra, Java, Kalimantan). In Thailand, the plant has been long a popular fruit tree, with approximately 1,170 hectares of area and 652 metric tons of fruit production recorded in 1993 (Subhadrabandhu, 2001). The average productivity of gandaria in Thailand was 7 metric tons per hectare. In Vietnam, gandaria fruit is a specialty of Binh Minh town, Vinh Long province where the

growing area was reported to be the largest in the Mekong Delta. Also, the fruit can be found at some districts of Kien Giang province, i.e. Ha Tien, Phu Quoc and Rach Gia (Nguyen Thi Huynh Mai, 1998).

In Thailand, according to Subhadrabandhu (2001), gandaria's flowering occurs in November-December, subsequently fruit set commences from April-May. Meanwhile, it is reported that in Indonesia flowering and fruit set period are from June to November and from March to June, respectively. The immature small fruit is pale green, and the colour turns to dark green as the fruit develops. Eventually, at ripening stage, the fruit, sizing 2.5 – 5.0 cm, appears in yellow – orange, similar to mango (Morton, 1987). The fruit shape is like a miniature mango, changing from oval to round or anywhere in between. Fruit taste varies depending on the variety, which is either sour or sweet accompanied by a turpentine smell (Subhadrabandhu, 2001). The fruit has white and pinkish purple endosperm tasted bitter and astringent. For the inflorescences of gandaria, length changes from 4-12 cm, yellowish flowers turn brown. In Vietnam, Nguyen Thi Huynh Mai (1998) reported that gandaria trees adapt well to the local conditions and only flower naturally once a year between November and January (continuing year). Therefore, the production is not sufficient to meet the market's demand.

Until the time of this study, despite the fact that there are quite a few reports stating some biological characteristics of gandaria (Morton, 1987; Subhadrabandhu, 2001; Lim, 2012), not many studies have been conducted on the cultivation techniques of gandaria. In particular, fertilizer regimes for the plant, i.e. timing and doses, have not been mentioned. Therefore, this research was aimed to investigate the effect of different fertilizer doses on yield and quality of gandaria.

2 MATERIALS AND METHODS

2.1 Location and plant materials

All field trials were established at Binh Minh town, Vinh Long province located in the Mekong Delta, Vietnam. Fifty gandaria trees, grown from seeds, at the age of twenty-five years, planted at 6×6 m on alluvial soil along the 'Hau' river (Bassac river – a distributary of the Mekong river), were employed in this study. Those trees were selected on the basis that they were not different in growth and canopy size (6 m approx.).

2.2 Soil characteristics

Two soil samples were collected before and after conducting experiments. For each sample, soil was taken from five different places in the orchard where experiments were conducted, and eventually mixed up to make one homogenized sample. All samples were taken at the depth of 0-20 cm. Soil characteristics and nutrient contents were analysed by standard methods (Table 1) at Soil laboratory of the Department of Soil Science, Can Tho University.

Table 1: Soil analysis and measurement methods

Parameters	Method
pH (H_2O)	Soil: water extract = 1:2.5
Cation exchangeable capacity-CEC	3 times of extraction with $BaCl_2$ 0.1 M. Ba precipitation with $MgSO_4$ 0.02 M, then titration of the excessive amount of Mg^{2+} to calculate CEC
Organic matter	Walkley – Black method
N, total	Kjeldahl method
NH_4^+ and NO_3^-	Extraction, sample: KCl 2 M solution at 1:10 ratio. Absorbance of indophenol blue (NH_4^+) and vanadium chloride reduction (NO_3^-) was measured with a spectrophotometer at λ 640 nm and 530 nm, respectively
P, available	Bray II
Exchangeable cation (K^+, Ca^{2+}, Mg^{2+})	Measured by atomic absorbance spectrophotometer (AAS)

2.3 Leaf analysis

Leaves were collected two times, i.e. before and after field trials. For each investigated tree, 10 mature shoots (2-month-old) were sampled. Two leaves of each shoot were used for analysis of total N (Kjeldahl method), total P (colorimetric method), and total K (measured by AAS) content in leaf.

2.4 Fertilizer treatments

Experiments were arranged in a randomized complete block design with 10 replications for each treatment. Each replication equalled to one tree. Treatments included fertilizer doses made up by mixing and adjusting the proportions of mono (Urea, KCl, diammonium phosphate-DAP) and

compound (20-20-15) fertilizer. These were used for the three stages of gandaria tree, i.e. post-harvest (1 month after the completion of harvesting), 30 and 60 days after fruit set (determined based on only the first flowering if there is more than one course of flowering). In total, there were 5 treatments, i.e. 0 (control), 1, 2, 3, 4 kg/tree/year. Ratios and amount of fertilizers applied for each investigated stage were listed in Table 2.

Table 2: Doses and N-P_2O_5-K_2O ratios of compound fertilizer applied at post-harvest, 30 and 60 days after fruit set on gandaria trees in Binh Minh town, Vinh Long province, 2017

Fertilizer doses	Amount (kg) of fertilizer used for each growth stage		
	Post-harvest (N-P_2O_5-K_2O, 4:3:2 ratio)	After fruit set	
		30 days (N-P_2O_5-K_2O, 1:1:1 ratio)	60 days (N-P_2O_5-K_2O, 2:2:3 ratio)
0 kg/tree/year	0.0	0.00	0.00
1 kg/tree/year	0.5	0.25	0.25
2 kg/tree/year	1.0	0.50	0.50
3 kg/tree/year	1.5	0.75	0.75
4 kg/tree/year	2.0	1.00	1.00
Amount of mono/compound fertilizer used for adjusting N-P_2O_5-K_2O ratio (calculated for 1 kg of mixture)	150 g Urea + 50 g DAP + 800 g compound fertilizer (20-20-15)	925 g compound fertilizer (20-20-15) + 75 g KCl	800g compound fertilizer (20-20-15) + 200 g KCl

2.5 Observed parameters

Besides the content of N, P, and K in leaves, treated gandaria trees were observed for parameters relating to flowering and fruit set, yield, and fruit quality. Flowering ratio was estimated by enumerating the number of vegetative and reproductive shoots appearing in a 50 x 50 cm frame. Average flowering ratios were taken from the 5 counts implemented evenly on the canopy. The prolonged flowering period was calculated based on the duration since the first inflorescence appeared until the finish of pollination process. When the inflorescence emerged, 10 inflorescences were labelled for further observations, i.e. inflorescence length, fruit set and fruit abscission ratio. Fruit yield was obtained by counting and weighing all fruits available on the tree. Fruit quality parameters were based on sampling and analysing three fruits per tree. These included total soluble solid, total acid (TA), content of ascorbic acid, and water.

3 RESULTS AND DISCUSSION

3.1 Changes in soil nutrient contents and some basal properties

Prior to the implementation of field trials, it was shown that the basal soil properties (pH, CEC and organic matter) (Table 3) were relatively suitable for the growth of fruit trees in general (Nguyen Bao Ve and Le Thanh Phong, 2011). While CEC was quite high (15.3 meq/100 g sample), pH (5.58) and organic matter content (4.34%) were at the moderate levels. These properties were not influenced by fertilizer application in this study since they did not change considerably after finishing the field trials. For the nutrient elements, the most significant change occurred to the amount of NO_3^- which surged from 4.94 to 23.5 mg/kg after the completion of fertilizer experiments. Similarly, the amount of available P changed from moderate (16.57 mg/kg) to excessive (41.58 mg/kg) level. On the contrary, plant uptake might result into the lower level of NH_4^+ in soil, 14.4 mg/kg; however, total N amount remained unchanged. The other cations, i.e. Ca^{2+}, Mg^{2+}, and K^+, did not show much variation. It was clear that fertilizer doses applied to gandaria trees in this study did not cause any variation of the monitored soil properties as well as some nutrient elements (Ca, Mg, and K), except NO_3^- and available P contents. These two nutrient contents increased enormously after the application of fertilizer.

Table 3: Soil nutrients and properties observed before and after fertilizing experiments conducted at Binh Minh town, Vinh Long province, 2017

Parameters	Before experiment		After experiment	
	Value	Evaluation*	Value	Evaluation*
pH (H_2O)	5.58	Moderate acidic	5.50	Moderate acidic
NH_4^+- N (mg/kg)	31.6	Low	14.4	Low
NO_3^- - N (mg/kg)	4.94	Very low	23.5	Moderate
N, total (%)	0.196	High	0.196	High
P, available (mg /kg)	16.57	Moderate	41.58	Excessive
K, exchange (meq/100 g)	0.235	Low	0.214	Low
Ca, exchange (meq/100 g)	11.1	High	12.7	High
Mg^{2+}, exchange (meq/100 g)	4.59	High	4.04	High
Organic matter (%)	4.34	Moderate	4.59	Moderate
CEC (meq/100 g)	15.3	High	15.5	High

** Evaluations were made in accordance with these proposed by Ngo Ngoc Hung (2005)*

3.2 Changes of N, P, K content in leaves

For nitrogen, content of the element in leaves after the completion of this study (1.56%) was significantly lower than that observed at the first sampling time (2.08%) (Table 4). As considering the effect of fertilizer doses, N content in leaves of gandaria trees applied 1-4 kg/tree/year (varied from 1.81-1.91%) was higher than that of the control treatment – 0 kg/tree/year (1.69%). Epstein (1972) stated that the nitrogen content in normal vegetative shoots was 1.5%. In addition, Rameshwar and Sultan (1981) reported that, on mango, yield reached to the optimum when nitrogen content in leaves was from 1.4-1.5%. Henceforth, it is likely that the N content in leaves of gandaria was still in the optimum range despite the reduction identified at the completion of the experiment.

Similar to N, the amount of P in gandaria leaves (0.187%) before applying fertilizer was higher ($P<0.001$) than that analysed at the completion of the experiments (0.208%). While there was no difference at the first sampling time, for the second one, P_2O_5 in leaves of trees applied 3-4 kg/tree/year was lower ($P<0.001$) than these of the other treatments. It was possible that at flowering stage and fruit set, the trees applied with 3-4 kg/tree/year mobilized more P in leaves than those of the other treatments. In fact, number of flowering time/year of the two treatments, 3 and 4 kg/tree/year, (4 times per year) doubled that of the other treatments (2 times per year) (Table 5). In addition, the same pattern could be found in fruit yield of the 5 treatments. However, to clarify that phenomenon completely, various factors, e.g. tree ages, higher doses of P, soil conditions, should be considered in further studies.

The percentage of K_2O was also significantly different between the levels observed before (2.74%) and after (1.19%) the completion of experiments. It is recognizable that K_2O percentage in leaves increased in accordance with the increase of fertilizer doses. For example, at the second sampling time, K_2O percentage in leaves of the control treatment (1.79%), 0 kg/tree/year, was the lowest; and it increased gradually toward the higher levels of fertilizer doses, changing from 1.88 to 2.01%. The optimum level of K_2O in shoot is 0.2% (Epstein, 1972), thus the resulted percentage of K_2O in leaves was relatively low, which could be related to the low level of exchangeable K^+ available in soil (Table 3). The reduction of N, P and K content in leaves suggested that these nutrient elements should be supplied continuously.

Table 4: Content of N (%N), P (%P_2O_5) and K (%K_2O) in gandaria leaves sampled before and after the application of fertilizer at Binh Minh town, Vinh Long province, 2017

Fertilizer doses	N (%)			P_2O_5 (%)			K_2O (%)		
	Before[a]	After[b]	Mean (B)	Before[a]	After[b]	Mean (B)	Before[a]	After[b]	Mean (B)
0 kg/tree/year	2.03	1.35	1.69^{A}	0.207^{c}	0.194^{b}	0.201^{B}	2.73^{d}	1.79^{a}	2.26^{A}
1 kg/tree/year	2.05	1.57	1.81^{B}	0.209^{c}	0.194^{b}	0.201^{B}	2.73^{d}	1.89^{b}	2.31^{B}
2 kg/tree/year	2.14	1.68	1.91^{C}	0.206^{c}	0.193^{b}	0.200^{B}	2.75^{d}	1.88^{b}	2.31^{B}
3 kg/tree/year	2.08	1.64	1.86^{BC}	0.209^{c}	0.177^{a}	0.193^{A}	2.76^{d}	2.01^{c}	2.39^{C}
4 kg/tree/year	2.08	1.55	1.81^{B}	0.209^{c}	0.175^{a}	0.192^{A}	2.72^{d}	1.97^{c}	2.35^{BC}
Mean (A)	2.08	1.56		0.208	0.187		2.74	1.91	
F (Sampling time - A)		319.32 (P<0.001)			290.1 (P<.001)			3300.6 P< 0.001)	
F (Fertilizer dose - B)		6.7 (P<0.001)			11.03 (P<.001)			8.01 (P<0.001)	
F (A x B)		2.13 (P<0.085)			13.98 (P<.001)			8.01 (P<0.001)	
CV (%)		8.0			3.2			3.2	

Note: different letters imply significant difference at P< 0.05 level as shown by Duncan multi range test.

For the 'Mean' columns, values are compared vertically, while those in the 'Before' and 'After' column of each analysed element are comparable either horizontally or vertically where significant difference was shown. 'Before' and 'After' column stand for the values obtained before and after fertilizer application, respectively.

3.3 Flowering and fruit set

Generally, gandaria flowered 4 times per crop season. The first flowering time occurred in the middle of December, and the last one was observed at the end of February in the following year. For all the fertilizer doses applied, flowering occurred predominantly in the first (78.1-82.3%) and second (77.3-82.9%) flowering time (Table 5). The other two flowering times, 3rd and 4th, were only observed in the two treatments, i.e. 3 and 4 kg/tree/year. Henceforth, it was possible that the high doses of fertilizer may contribute to the two extra flowering times, which also increased the overall flowering percentage. The flowers of gandaria exhibit both dichogamy and a protogynous nature. Hence, concentrated flowering would cause a serious problem in obtaining high yields. Meanwhile, unconcentrated flowering would increase the chance of overlapping between the phases of receptive of female parts and pollen discharging. Accordingly, it was possible that the two-extra flowering obtained with the two fertilizer treatments, i.e. 3 and 4 kg/tree/year, resulted in higher fruit set percentage as shown in Table 6.

While gandaria and mango share quite a few similarities (Lim, 2012), flowering characteristics of gandaria is different to those of mango. The latter starts to flower from the terminal shoots and has no further flowering from axillary buds. From observations on the field, gandaria trees also commenced flowering from the terminal shoots. However, from the same shoots involved in the first flowering time, inflorescences emerged from the axillary buds. Therefore, the high doses of fertilizer might have an effect on the extra flowering courses of gandaria. Syamal and Mishra (1989) also reported that higher fertilizer doses applied on mango trees resulted in a greater number of flowers.

Table 5: Effect of fertilizer doses on the flowering ratio (%) of gandaria trees grown in Binh Minh town, Vinh Long province, 2017

Fertilizer doses	Flowering ratio (%)				Number of flowering times/year
	1st time	2nd time	3rd time	4th time	
0 kg/tree/year	80.1	77.3	0.0^{b}	0.0^{b}	2.0
1 kg/tree/year	78.1	79.4	0.0^{b}	0.0^{b}	2.0
2 kg/tree/year	82.9	81.6	0.0^{b}	0.0^{b}	2.0
3 kg/tree/year	78.6	78.3	7.6^{a}	6.0^{a}	4.0
4 kg/tree/year	82.3	82.9	8.6^{a}	7.1^{a}	4.0
Mean	80.4	79.9	-	-	2.8
F	*ns*	*ns*	**	**	-
CV (%)	8.07	6.66	65.00	82.40	-

*Within one column, different letters imply significant difference at P< 0.05 level as shown by Duncan multi range test. 'ns': non-significant difference. '**': significant difference at P<0.01.*

During the flowering process of gandaria, the first flowering time occurred simultaneously in all fertilizer dose treatments (Table 5). However, it was clear that the flowering duration, and number of inflorescences per shoot were influenced by the increased doses of fertilizer applied. The flowering

duration (79.4 days) of the treatment applied with 3 and 4 kg of fertilizer per tree in a year was significantly (P<0.01) longer than those of the other treatments (38.7-39.0 days) (Table 6) with lower levels of fertilizer doses, as well as the control treatment. Contrary to the expectation for the flowering duration of mango and other fruit trees, flowering period of gandaria is demanded to be as long as possible. It is because fruits of gandaria are being sold year-round at the tourist spots and some local markets. Hence, longer flowering duration will result in longer harvesting time which in turn maintains the supply of gandaria fruits as well as grower's income. For the inflorescence of gandaria, while there was no significant difference in length with a mean of 6.4 cm, the number of inflorescence per shoot of the 3 and 4 kg/tree/year, changing from 5.2 – 5.3 inflorescences per shoot was significantly higher than these of the other treatments, including the control (2.2 inflorescences per shoot) (Table 6).

Different doses of fertilizers also showed an influence on fruit set ratio (%) and number of fruits per bunch (Table 6). The highest fruit set ratios (15.96% and 16.98%) were observed in the treatments with 3 and 4 kg of fertilizer per tree in one year while these of the control treatment and the treatment with the dose of 1 kg/tree/year were only 12.5 and 13.0 %, respectively. Likewise, the number of fruits per bunch was highest in treatment applying fertilizer at the doses of 3 (2 fruit/bunch) and 4 kg/tree/year (3 fruit/bunch), significantly higher than that of the control treatment (1 fruit/bunch). Similarly, effects of fertilizer doses on fruit set of mango were well documented. It was reported by various authors that the application of fertilizer on mango trees improved the number of fruit per tree and enhanced the initial fruit setting (Ahmed *et al.*, 2001;Nasreen *et al.*, 2015).

Table 6: Effect of fertilizer doses on flowering duration, number of inflorescences per shoot of gandaria trees grown in Binh Minh town, Vinh Long province, 2017

Fertilizer doses	Flowering duration (days)	Number of inflorescences per shoot	Inflorescence length (cm)	Fruit set (%)	Number of fruit per bunch
0 kg/tree/year	39.0^{b}	2^{c}	6.2	12.5^{b}	1^{c}
1 kg/tree/year	38.7^{b}	2^{c}	6.3	13.0^{b}	2^{bc}
2 kg/tree/year	38.9^{b}	4^{b}	6.4	13.9^{ab}	2^{abc}
3 kg/tree/year	79.4^{a}	5^{a}	6.2	16.0^{a}	2^{a}
4 kg/tree/year	79.4^{a}	5^{a}	6.1	17.0^{a}	3^{ab}
Mean	-	-	6.4	-	-
F	**	**	*ns*	**	*
CV (%)	22.8	3.6	7.8	17.9	52.3

*Within one column, different letters imply significant difference at P< 0.05 level as shown by Duncan multi range test. 'ns': non-significant difference. '**': significant difference at P<0.01.*

3.4 Fruit yield

In the present study, fruit yield of gandaria per tree was enormously influenced by fertilizer doses, in which yield increased in accordance with the increase of fertilizer doses (Fig. 1). Similar to the earlier observed parameters, the highest yield (99.5-107.1 kg/tree) was obtained with the two fertilizer treatments applied 3 and 4 kg/tree/year. Meanwhile, yield of the control treatment – 0 kg/tree/year (42.9 kg/tree) was less than half of that of the latter. Sharma *et al.* (2000) reported that application of a fertilizer dose of 800 g N + 200 g P + 300 g K significantly increased the fruit yield of mango. Suryapananont (1992) also obtained the highest mango yield with the composition of 500 g N + 400 g P + 1,500 g K per tree.

Since gandaria is a specialty fruit crop, and not grown widely as mango, the tree has not been applied intensive practices to improve yield and quality. Accordingly, fertilizer was not applied frequently, hence nutritional status in soil was not balanced. In particular, while the availability of the other elements was evaluated as moderate to high (Table 3), K^+ concentration in soil was low. In the case of this study, low concentration of K^+ in soil was likely the limitation factor for gandaria yield. In fact, leaf nutrient analysis showed that the treatments with the highest fruit yield, i.e. 3-4 kg of fertilizer/tree/year (2.35-2.39% K_2O), had higher content of K in leaves than that of the other treatments (2.26-2.31% K_2O). In addition, results in Table 7 showed that there was a strongly positive correlation between yield and the content of N (r = 0.342, P<0.05) and K_2O (r = 0.771, P<0.01) in leaves. Meanwhile, the excessive content of P_2O_5 in soil after fertilizer applications might be linked to the negative correlation between gandaria's yield and P_2O_5 in leaves (r=-0.736, P<0.01). These suggested that the excessive amount of P_2O_5 supplied by treatments in this study may have an impact on gandaria's yield. In particular, relationship

of yield and the amount of K_2O and P_2O_5 was generalized by the below correlation equation:

Yield = 154.741* X_a - 1150.161*X_b – 6,611 (R^2 = 0.706, P<0.01)

with X_a= amount of K_2O in leaf, and X_b= amount of P_2O_5 in leaf.

Generally, it was possible that fertilizer doses in this study, which were split into different growth stages of the plant, brought about high yield, particularly 107.1 kg/tree obtained with the treatment using fertilizer at the rate of 4 kg/tree/year (Fig. 2). However, as stated by the World Agroforestry Center (2012), the maximum yield of gandaria could reach to 200 kg of fruit tree. Hence, further studies are warranted to identify better fertilizer doses in order to achieve higher fruit yield.

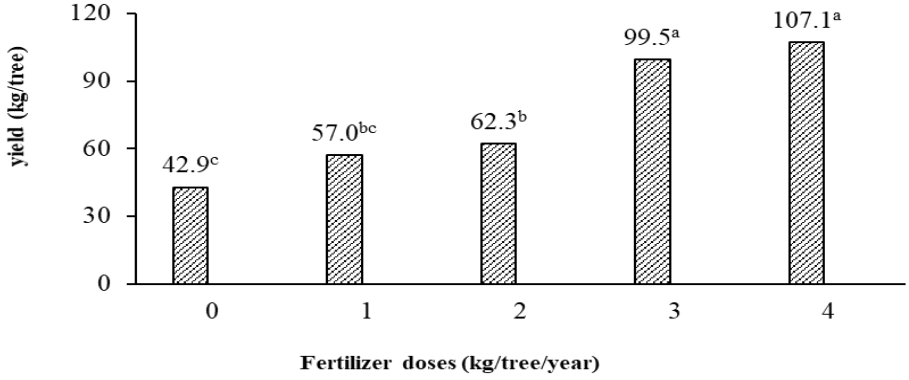

Fig. 1: Effect of fertilizer doses on yield of gandaria grown in Binh Minh town, Vinh Long province, 2017

Table 7: Correlation coefficient value ('r') between yield of gandaria and nutrient elements investigated

		Content in leaf			
		Yield	**N**	**P_2O_5**	**K_2O**
	Yield	1	0.342*	-0.736**	0.771**
Content in	**N**	0.342*	1	-0.085ns	0.433ns
leaf	**P_2O_5**	-0.736**	- 0.085ns	1	-0.612**
	K_2O	0.771**	0.433ns	-0.612**	1

'ns': non-significant correlation; '' and '**': significant correlation at P<0.05 and 0.01 level, respectively*

3.5 Fruit characteristics

There was significant difference (P<0.01) in fruit characteristics of gandaria trees treated with different fertilizer doses (Table). Generally, high doses of fertilizer, i.e. 3 and 4 kg/tree/year, consistently showed better fruits characteristics as compared with these treated with lower doses of fertilizer (0-2 kg/tree/year). For example, fruit weight as shown for the treatments using 3 and 4 kg of fertilizer/tree/year (46.4 and 46.1 g, respectively) was the highest. Fruit length and diameter were also highest in the 3 and 4 kg/tree/year treatment. Henceforth, it is obvious that applying 3 or 4 kg of fertilizer brought about heavier and bigger gandaria fruits than those treated with only 1-2 kg of fertilizer per year (Table 7). Effect of fertilizer on fruits has been studied on different fruit trees, in which, fertilizer application was shown to increase markedly both size and weight of mango fruits (Syamal and Mishra, 1989;Bhuyan and Irabangon, 1992).

Table 8: Effect of fertilizer doses on weight (g), length (cm) and diameter (cm) of fruits of gandaria trees grown in Binh Minh town, Vinh Long province, 2017

Fertilizer doses	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
0 kg/tree/year	37.6b	3.9c	3.9c
1 kg/tree/year	39.6b	4.0bc	3.9bc
2 kg/tree/year	40.1b	4.1b	4.0abc
3 kg/tree/year	46.4a	4.2a	4.1a
4 kg/tree/year	46.1a	4.2a	4.0ab
F	**	**	**
CV (%)	7.53	2.58	3.19

*Within one column, different letters imply significant difference at P< 0.05 level as shown by Duncan multi range test. '**': significant difference at P<0.01*

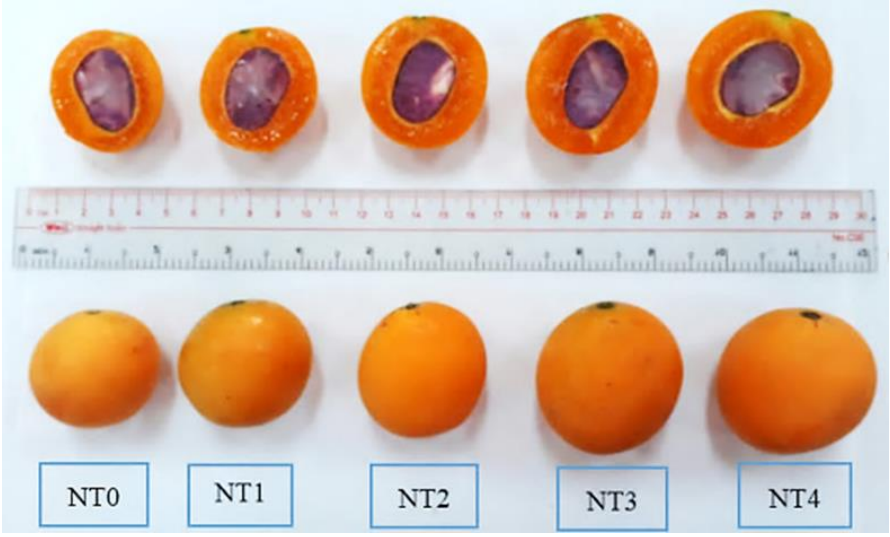

Fig. 2: Fruits of gandaria trees treated with different fertilizer doses

"NT" = treatment. NT0-NT4 corresponds to the fertilizer doses treatments, changing from 0 (control)-4 kg/tree/year

3.6 Fruit quality

The total soluble solids (TSS) content of gandaria fruits was significantly influenced by the fertilizer doses treatment. %TSS of the 3-4 kg/tree/year treatment (14.0 – 14.4%) was significantly higher than those of the other treatments (Table 8). In other words, fruits of trees treated with 3-4 kg of fertilizer per tree per year were the sweetest ones as compared to those of the other treatments. Contents of ascorbic acid and total acid in fruits were not significantly different among the treatments with the average values of 48.9 mg/100 g sample, and 0.52 g/L, respectively. Generally, high fertilizer doses (3-4 kg/tree/year) helped increase fruit sweetness while remaining unchanged for the contents of ascorbic acid and total acid.

Table 8: Effect of fertilizer doses on total soluble solids, total acidity and ascorbic acid contents and fruit skin colour indices of gandaria trees grown in Binh Minh town, Vinh Long province, 2017

Fertilizer doses	TSS [a]	TA [c]	TSS/TA	Water content (%)	Edible part (%)	Ascorbic acid [b]
0 kg/tree/year	12.8^{b}	0.6	23.1^{a}	77.2	56.5^{c}	48.8
1 kg/tree/year	13.2^{b}	0.5	26.6^{bc}	76.5	59.6^{b}	47.8
2 kg/tree/year	13.2^{b}	0.5	25.5^{b}	76.1	61.2^{b}	48.1
3 kg/tree/year	14.4^{a}	0.5	28.5^{c}	75.6	65.7^{a}	50.8
4 kg/tree/year	14.0^{a}	0.5	26.8^{bc}	74.7	65.2^{a}	48.9
Mean	-	0.5	-	76.0	-	48.9
F	**	*ns*	**	*ns*	**	*ns*
CV (%)	5	8.6	10.0	3.3	5.5	16.4

[a] *TSS: Total soluble solids (%)*

[b] *Ascorbic acid content is presented as mg/100 g sample*

[c] *TA: total acid (g/L)*

*Within one column, different letters imply significant difference at P< 0.05 level as shown by Duncan multi range test. 'ns': non-significant difference. '**': significant difference at P<0.01*

4 CONCLUSION AND RECOMMENDATIONS

In short, application of 3-4 kg of fertilizer per tree per year, of which the amount and N-P-K ratio were adjusted for different growth stages, prolonged the duration of flowering and fruit set of gandaria. In addition, the application also increased the number of inflorescences per shoot and fruit yield (2.3 folds higher than that of the control treatment). For fruit quality, fruit sweetness was increased by the application. Due to the time limitation, this study was conducted only on 25-year-old trees. Hence, in order to be able to establish a complete cultivation procedure for gandaria, it is necessary to determine suitable doses of fertilizer and N-P-K ratio to be used on the other tree ages.

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