Working Paper Series

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Resource: A2.1 Fruit productivity and quality improvements through on farm innovations

Study focus - Fertiliser management

Effect of NPK dosage application on Cat Hoa Loc mango yield and fruit quality. Off season production Cai Be District, Tien Giang, Vietnam.

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Summary

The mango industry in the Mekong River Delta often has poor management practices applied, in the case of nutrition it is an overuse of fertilisers. This has the potential to impact fruit quality, disease susceptibility and environmental pollution while not necessarily producing increased yields. The aim of this study is to ascertain the optimal NPK fertiliser dosage for Cat Hoa Loc mango production in terms of yield and fruit quality. The trial was conducted at Hoa Hung commune, Cai Be district, Tien Giang province from March to November 2021 on 15 to 20-year-old trees. The experiment was laid out with four treatments:

- Treatment 1 (T1) (25% NPK): 350 g N – 325 g P_2O_5 – 400 g K_2O
- Treatment 2 (T2) (75% NPK): 1050 g N – 975 g P_2O_5 – 1200 g K_2O
- Treatment 3 (T3) (50% NPK): 700 g N – 650 g P_2O_5 – 800 g K_2O
- Treatment 4 (T4) (100% NPK): 1400 g N – 1300 g P_2O_5 – 1600 g K_2O and five replications with randonmized completely block design (RCBD).

The results showed the different NPK dosage applied effects on fruit length, yield, edible portion, flesh thickness, brix content and flesh colour significantly, but nonsignificant on number of fruit, fruit weight, fruit diameter, fruit width, and peel colors.

- T4 (100% NPK) control showed higher on edible portion (81.30%), flesh thickness (30.03 mm) and yield (45.40 kg/tree) significant compared with T1 (25% NPK) but showed non significantly compared with T2 (75% NPK) edible portion (80.03%), flesh thickness (29.75 mm), (40.00 kg/tree) and T3 (50% NPK) had edible portion (80.85%), flesh thickness (29.53 mm) and yield (36.60 kg/tree).
- T4 (100% NPK) control showed lower on brix content (19.77%) and significant compared with T1 (20.31%), T2 (20.31% and T3 (20.86%).

The results indicated that a reduction of NPK application from what is currently being applied can still maintain yield.

1 Introduction

According to MARD (2020), the area under mango cultivation across the country in 2019 was 81,000 hectares. Predominantly production is in the southern provinces, with the Mekong Delta region accounted for 46,700 hectares (57.65%) and annual output is about 527,800 tonnes (MARD 2020).

Mango is one of the main fruit trees of the Mekong Delta region in general and Tien Giang province in particular. According to statistics in 2019, Tien Giang province has an area of eating food crops of 81,785 hectares, especially Hoa Loc mango growing area is over 1,579 hectares, mainly in the area along the Tien River in Cai Be and south of Cai Lay districts. The annual output is estimated at 35,926 tonnes, the highest yield of 23 tonnes/hectare in the Mekong Delta. Cat Hoa Loc mango with the characteristics of ripe, bright yellow fruit, thin skin, covered with fine white chalk, with small spots, dark brown color, round spots, fresh yellow flesh, high firmness, smooth, flexible, less water, less fiber. The fruit has a very sweet taste with a characteristic mild aroma. Farmers with long experience and the attention of local leaders at all levels are a great advantage of the Cat Hoa Loc Tien Giang mango industry (MARD 2019).

Currently, the production of Cat Hoa Loc mangoes in the area still has many limitations, the most inadequacy is that it is not linked in production, purchasing, processing, preservation, consumption, and prices are still precarious due to the influence of the Covid pandemic and climate change, the current fertilising of mango trees by farmers is mainly based on experience and has not been strictly followed the recommendations of research institutes/schools and the agricultural sector.

There were many domestic and foreign studies related to fertilising mango trees such as Nguyen et al. (2014) recommending to fertilise 7 year old Cat Chu mango trees with a dosage of 1035 g N + 675 g P_2O_5 + 900 g K_2O and increase by 10 to 15% of manure per year. Tran and Nguyen (2005) concluding that fertilising a 7 year old Cat Hoa Loc mango tree with a dosage of 690 g N + 450 g P_2O_5 + 675 g K_2O + 5 kg organic dynamic lifter or 460 g N + 300 g P_2O_5 + 450 g K_2O + 10 kg organic dynamic lifter still achieved good efficiency in yield and fruit quality compared to 920 g N + 600 g P_2O_5 + 900 g K_2O fertiliser. Vo et al. (2016) recommend fertilising mango trees > 11 years old with a dosage of 1600 g N + 1100 g P_2O_5 + 1100 g K_2O. Phan and Tran (2014) recommend applying 1400 g N + 1100 g P_2O_5 + 1600 g K_2O for mango trees < 30 years old. Syamal and Mishra (1989) recommend 950 – 1000 g N + 1000 – 2000 g P_2O_5 + 500 – 1000 g K_2O for 17-year-old mango trees. The highest yield of 12-year-old mango trees was obtained when applying 1500 g N + 1500 g P_2O_5 + 750 g K_2O (Ahmed et al. 2001), the highest yield of 10-year-old mango trees was recorded when applying 1000 g N + 500 g P_2O_5 + 1000 g K_2O + vesicular arbuscular mycorrhiza (VAM) + Azotobacter (Kundu et al. 2011) and Azam et al. (2020) concluded that 1000 g Urea + 750 g TSP + 750 g SOP fertilisation for 12-year-old mango trees achieved yield and quality tallest. However, the results of the investigation of the current status of mango farming techniques in Tien Giang province showed that mango farmers in Tien Giang province are over fertilsing compared to the needs of the tree, leading to increase of investment costs for fertilisers, susceptibility to pests and diseases, effects on fruit quality and shelf life.

Study aim

The aim of this study is to ascertain the optimal NPK fertiliser dosage for Cat Hoa Loc mango production in terms of yield and fruit quality. The study hopes to demonstrate the reduction in the use of excess fertiliser can maintain tree yield improve fruit quality, reduce production costs, and reduce the negative environmental impacts that are associated with over fertilisation.

2 Materials and Methods

Materials

Mango variety: Cat Hoa Loc, 15 to 20 year old trees.

Planting spacing: 8 m x 8 m.

Planting density: 156 trees/hectare.

The experiment conducted from March to November 2021 at Hoa Hung commune, Cai Be district, Tien Giang province.

Fertilisers used:

- Ca Mau urea, 46% N
- Ninh Binh phosphate, 15 to 17% P_2O_5
- Ca Mau potassium chloride, 61 % K_2O
- Calcium chloride 96 % Ca
- Microbial organic fertilisers with content (organic 30%, humic acid 5%, N 3%, P_2O_5 3%, Calcium 2.86%, Silicon 1.5%, Mn 200 ppm, B 180 ppm, Fe 10000 ppm and 1 x 106 Trichoderma)

Experiment Design

The experiment was laid out with four treatments and five replications with randonmized completely block design (RCBD). Each replication 1 tree.

Treatments as following:

- Treatment 1 (25% NPK): 350 g N – 325 g P_2O_5 – 400 g K_2O
- Treatment 2 (75% NPK): 1050 g N – 975 g P_2O_5 – 1200 g K_2O
- Treatment 3 (50% NPK): 700 g N – 650 g P_2O_5 – 800 g K_2O
- Treatment 4 (100% NPK) as control: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O

Fertiliser applications

Timing of the NPK fertiliser was split into four applications:

- First: After harvesting 60% N + 50% P_2O_5 + 40% K_2O
- Second: Before flowering induction 50% P_2O_5 + 30% K_2O
- Third: 3 weeks after fruit setting 20% N + 15% K_2O (fruit about 1 to 2 cm)
- Fourth: 8 to 10 weeks after fruit setting 20% N + 15% K_2O

In addition, these fertilisers were applied equally to all treatments. Organic fertiliser 5 kg/tree, split into three applications:

- First: After harvesting 50%
- Second: Before flower opening 25%
- Third: 6 weeks after fruit setting 25%

Calcium chloride (300 g/tree) split into two applications:

- First: After harvesting 60%
- Second: Before flowering induction 40%.

Data recording

Fruit weight (g/fruit): Weigh 20 fruits per treatment and average for each treatment. Measure pulp percentage (%): Weigh the flesh of 20 fruits per treatment, averaged for each treatment and calculated by the following formula: Fruit pulp (%) = fruit weight - (skin weight + seed weight) x 100

Fruit diameter (mm): Measure 20 fruits, at the widest position of the fruit, at the beginning and end of the fruit for fruit length (mm) and at the widest position fruit for fruit width (mm): Measurements were taken with an electronic caliper Mitutoyo - Japan, scale 0 to 200 mm.

Total number of fruits/tree (fruit) and yield (kg/tree): at the time of harvest.

TSS content (Brix %): Measure 20 fruits at the center of the fruit using Brix meter ATAGO - Japan, scale 0 to 32%.

The color of fruit skin and fruit pulp is expressed by index L*, a*, b*: Measure 20 fruits in the treatment at three points (head, middle and stem) by Minolta CR-200 colorimeter, Japan and averaged for each treatment.

Skin colour was measured one day after harvest and pulp colour was measured after ripening for 24 hours with CaC_2.

Data analysis

The data was statistically processed using the SPSS 22 program, and the mean was compared by Duncan's test at the 5% level of significance.

3 Results and discussion

Effect of NPK dosage on mango yield

The results show that the total number of fruits per plant between treatments was not statistically significant (P≤ 0.05), ranging from 68.00 to 86.00 fruits/tree (Table 1). The highest number of fruits per tree was recorded in T4 (86.00 fruits), followed by T2 (76.40 fruits) and the lowest in T1 (68.00 fruits). This result is also consistent with the study of Tran and Nguyen (2005). Azam et al. (2020) reported that the number of fruits per tree were not affected by the different dose of NPK application per tree.

Table 1. Effect of NPK dosage on number of fruits per tree, fruit weight and yield

TT	Treatment	Number of fruit/tree (fruit)	Fruit weight (g)	Yield (kg/tree)
1	T1: 350 g N – 325 g P_2O_5 – 400 g K_2O	68.00	501.65	33.60 b
2	T2: 1050 g N – 975 g P_2O_5 – 1200 g K_2O	76.40	526.70	40.00 ab
3	T3: 700 g N – 650 g P_2O_5 – 800 g K_2O	71.20	518.55	36.60 ab
4	T4: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O	86.00	532.10	45.40 a
	Significant level	ns	ns	*
	LSD (5%)	25.93	49.00	11.39

Source: Author's analysis

Note: In the same column, values with the same letters are not significantly different at the 5% level of Duncan's test; (*): the difference is statistically significant at the 5% level; ns: no statistically significant difference.

Fruit weight between the treatments was not statistically significant (P≤ 0.05), ranging from 501.65 to 532.10 g (Table 1). The highest fruit weight was recorded in T4 (532.10 g) followed by T2 (526.70 fruits) and the lowest in T1 (501.65 g). This result is also consistent with the research results of Nguyen and Vo (2005), Tran and Nguyen (2005) and Ahmed et al. (2001).

The yield per tree between treatments was statistically significant (P≤ 0.05), ranging from 33.60 to 45.40 kg/tree (Table 1). The highest yield per plant was recorded in T4 (45.40 kg) which was significantly different (P≤ 0.05) compared with T1 (33.60 kg). The results have shown that the reduced levels of fertiliser application in T2 and T3 was not statistical difference compared to the highest application with T4.

Table 2. Effect of NPK dosage on fruit diameter, fruit length and fruit width

TT	Treatment	Fruit diameter (mm)	Fruit length (mm)	Fruit width (mm)
1	T1: 350 g N – 325 g P_2O_5 – 400 g K_2O	85.87	147.96 b	77.89
2	T2: 1050 g N – 975 g P_2O_5 – 1200 g K_2O	87.41	151.07 ab	79.02
3	T3: 700 g N – 650 g P_2O_5 – 800 g K_2O	86.36	150.22 ab	78.86
4	T4: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O	87.60	151.94 a	79.31
	Significant level	ns	*	ns
	CV (%)	1.83	1.60	2.34
	LSD (5%)	2.84	4.27	3.28

Source: Author's analysis

Note: In the same column, values with the same letters are not significantly different at the 5% level of Duncan's test; (*): the difference is statistically significant at the 5% level; ns: no statistically significant difference.

Fruit diameters between treatments were not statistically significant (P≤ 0.05), ranging from 85.87 to 87.60 mm. The highest fruit diameter was recorded in T4 (87.60 mm), followed by T2 (87.41 mm) and the lowest in T1 (85.87 mm) (Table 2).

Fruit width between treatments was not statistical significance (P≤ 0.05), ranging from 77.89 to 79.31 mm. The highest fruit diameter was recorded in T4 (79.31 mm), followed by T2 (87.41 mm) and the lowest in T1 (85.87 mm) (Table 2).

Fruit length between treatments was only statistically significant (P≤ 0.05) between T1 and T4, ranging from 147.96 to 151.94 mm (Table 2) as with fruit yield the lower applications rates of T2 and T3 did not see any significant reduction in fruit length. Shakeel Ahmed et al. (2001) also reported that fruit length was affected by the NPK dose in the 12-year-old Anwar Ratoul mango variety and Azam et al. (2020) in the 12-year-old Dusehri mango variety.

Effect of NPK dosage on fruit quality parameters

Table 3 shows that there is a statistically significant difference (P≤ 0.05) between the treatments on the edible portion which ranged from 78.92 to 81.30%, the treatment with the highest edible portion was T4 (81.30%) was statistically significant (P≤ 0.05) compared with T1 (78.92%) but the difference was not significant (P≤ 0.05) between the two other treatments, T2 (80.33%) and T3 (80.85%).

Table 3. Effect of NPK dosage on edible portion, fruit pulp thickness and brix content

TT	Treatment	Edible portion (%)	Fruit pulp thickness (mm)	Brix content (%)
1	T1: 350 g N – 325 g P_2O_5 – 400 g K_2O	78.92 b	29.23 b	21.29 a
2	T2: 1050 g N – 975 g P_2O_5 – 1200 g K_2O	80.33 ab	29.75 ab	20.31 b
3	T3: 700 g N – 650 g P_2O_5 – 800 g K_2O	80.85 ab	29.53 ab	20.86 a
4	T4: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O	81.30 a	30.03 a	19.77 c
	Significant level	*	*	*
	CV (%)	1.90	1.42	1.92
	LSD (5%)	2.72	0.75	0.70

Source: Author's analysis

Note: In the same column, values with the same letters are not significantly different at the 5% level of Duncan's test; (*): the difference is statistically significant at the 5% level; ns: no statistically significant difference.

Table 3 shows that there was a statistically significant difference (P≤ 0.05) in fruit pulp thickness between treatments T1 and T4, ranging from 29.23 to 30.03 mm, no significant difference (P≤ 0.05) but was not statistically significant (P≤ 0.05) compared with the other treatments, T2 (29.75 mm) and T3 (29.53 mm). This result is also consistent with the records of Tran and Nguyen (2005) reported that the dose of fertiliser has an effect on the fruit pulp thickness, Dao and Pham (2003) concluded that the Cat Hoa Loc mango variety with fruit pulp thickness fluctuating 29.0 mm ± 0.6.

Brix content (Total soluble solids) between the different treatments was statistically significant (P≤ 0.05) ranging from 19.77 to 21.29% (Table 3). The highest brix content was recorded in T1 (21.29%), followed by T3 (20.86%) and the lowest was recorded in T4 (19.77%). This result is also consistent with the records of Dao and Pham (2003) that the Cat Chu mango variety with brix fluctuating 20.8% ± 1.2 and Kundu et al. (2011) also noted that the dose of fertiliser was effect of brix on 10-year-old Amrapali mango.

The L* index represents the lightness and darkness of the fruit, the higher the L*, the brighter the fruit, the higher the gloss. Table 4 show that there is no statistically significant difference (P≤ 0.05) in the brightness of the mango peel between the experimental treatments. This result is similar to the study of Tran and Nguyen (2005).

The index a* represents for the color transition from green to red. Table 4 also shows that there is no statistically significant difference (P≤ 0.05) in the a* index of the peel between the experimental treatments, because the green color of the mango is dominant and there is no red color. This result is similar to the study of Tran and Nguyen (2005).

The index b* represents for the color transition from blue to yellow. There was no statistically significant difference (P≤ 0.05) level in the b* index of fruit pulp between the experimental treatments (Table 4). This showed that the color of mango peel between treatments was uniform because the peel was uniformly green and was not affected by fertiliser.

Table 4. Effect of NPK dosage on fruit peel colour

TT	Treatment	L	a*	b*
1	T1: 350 g N – 325 g P_2O_5 – 400 g K_2O	61.24	17.84	36.72
2	T2: 1050 g N – 975 g P_2O_5 – 1200 g K_2O	60.54	18.12	37.16
3	T3: 700 g N – 650 g P_2O_5 – 800 g K_2O	60.32	18.22	36.51
4	T4: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O	58.75	18.26	36.30
	Significant level	ns	ns	ns
	LSD (5%)	3.59	1.32	1.51

Source: Author's analysis

Note: In the same column, values with the same letters are not significantly different at the 5% level of Duncan's test; (*): the difference is statistically significant at the 5% level; ns: no statistically significant difference.

The L index represents the lightness and darkness of the fruit, the higher the L, the brighter the fruit, the higher the gloss. Table 5 shows that there is statistically significant difference (P≤ 0.05) in the brightness of the mango pulp between the experimental treatments. The highest L index of fruit pulp was recorded in T1 (66.24), followed by T3 (66.00) and and the lowest was recorded in T4 (64.00).

The index a* represents for the color transition from green to red. Table 5 also show that there was no statistically significant difference (P≤ 0.05) level in the a* index of fruit pulp between the experimental treatments, because the mango pulp has a predominant orange-yellow color and no red color. This result is similar to the study of Tran and Nguyen (2005).

The index b* represents for the color transition from blue to yellow. There was statistically significant difference (P≤ 0.05) in the b* index of fruit pulp between the experimental treatments. The highest b* index of fruit pulp was recorded in T1 (58.57), followed by T2 (56.47) and and the lowest was recorded in T4 (53.35).

Table 5. Effect of NPK dosage on fruit pulp colour

TT	Treatment	L	a*	b*
1	T1: 350 g N – 325 g P_2O_5 – 400 g K_2O	66.24 a	7.19	58.57 a
2	T2: 1050 g N – 975 g P_2O_5 – 1200 g K_2O	64.55 ab	7.46	56.47 ab
3	T3: 700 g N – 650 g P_2O_5 – 800 g K_2O	66.00 ab	7.11	55.29 c
4	T4: 1400 g N – 1300 g P_2O_5 – 1600 g K_2O	64.00 b	7.88	53.35 c
	Significant level	*	ns	*
	CV (%)	2.21	18.75	4.01
	LSD (5%)	2.57	2.47	3.57

Source: Author's analysis

Note: In the same column, values with the same letters are not significantly different at the 5% level of Duncan's test; (*): the difference is statistically significant at the 5% level; ns: no statistically significant difference.

4 Conclusion and recommendations

Conclusion

NPK fertiliser application with different dosage affects a number of yield components such as fruit length, yield per tree; and some factors constituting fruit quality such as edible portion, pulp thickness, brix content and colour of pulp. NPK fertilisation at different doses had no effect on the total number of fruits per tree, fruit weight, fruit diameter, fruit width, and colour of peel.

The lower application rates that were applied in T2 and T3 did not significantly affect the yield parameters in weight and fruit size These results do indicate that yield can be maintained with the lower applications of NPK than what currently is being applied by industry.

Recommendations

Continued monitoring the trial over another one to two crops will develop a more accurate assessment of the impact of NPK reduction on yield. Additional measurements of internal break down and disease susceptibility are required to understand the full impact and benefits that can be achieved by the reducing of NPK applications.

Additional work on the timing, formulation and application methods would help in the evaluation of maximising the benefits of fertiliser applied by timing to phenological cycle, reducing fertiliser loss with runoff, leaching and volatilisation

Continue a program of upskilling farmers in fertiliser management, to increases efficiently of applications, reduction in over fertilisation, and ability to make informed economic decisions about their fertiliser program.

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6 Appendices

Appendix 1. NPK trial fruit, Cai Be District, Tien Giang, Vietnam

Outside of fruit after harvesting 1 day

Inside of fruit after harvesting 7 days