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 Chu mano yield and fruit quality. Off season production Cao Lanh District, Dong Thap, 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 Chu mango production in terms of yield and fruit quality. The trial was conducted at My Xuong commune, Cao Lanh district, Dong Thap 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 – 275 g P_2O_5 – 350 g K_2O
- Treatment 2 (T2) (75% NPK): 1050 g N – 825 g P_2O_5 – 1050 g K_2O
- Treatment 3 (T3) (50% NPK): 700 g N – 550 g P_2O_5 – 700 g K_2O
- Treatment 4 (T4) (100% NPK): 1400 g N – 1100 g P_2O_5 – 1400 g K_2O and five replications with randonmized completely block design (RCBD).

The results showed the different NPK dosage applied effects on fruit weight, fruit length, fruit width, yield, edible portion, flesh thickness significantly, but nonsignificant on fruit diameter, brix content, peel and flesh colors. T4 (100% NPK) control showed higher on fruit weight (375.25 g), edible portion (75.01%), flesh thickness (27.32 mm) and yield (53.40 kg/tree) significant compared with T1 (25% NPK) but showed non significantly compared with T2 (75% NPK) fruit weight (364.35 g), edible portion (74.18%), flesh thickness (26.05 mm), (45.60 kg/tree) and T3 (50% NPK) had; fruit weight (352.25 g), edible portion (73.86%), flesh thickness (25.69 mm) and yield (43.60 kg/tree). The results indicated that a reduction of NPK application from what is currently being applied can still maintain yield.

1 Introduction

According to the 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 527800 tonnes (MARD 2020).

Mango is one of dominant perennial crops in the Mekong Delta region with Dong Thap province accounting for 12,000 hectares producing in excess of 129,000 tonnes/year. Of these cultivars Cat Chu and Cat Hoa Loc account for 60% and 30% of production respectively. This is concentrated around Cao Lanh city, Cao Lanh, Lap Vo and Thanh Binh districts (MARD 2019; Dong Thap Department of Agriculture and Rural Development 2020).

Currently, the production of Cat Chu mango in the area has a number of challenges, fluctuation in prices and rising production costs partly due to the impact of the pandemic, changing seasonal conditions all are driving the profitability downwards. Traditional fertiliser practices have been driven by the desire to maximise yields. This has led to excessive applications of fertilisers with much of it going to waste, creating a potential environmental problem as well as exacerbating the fruits susceptibility to disease and internal quality disorders. Potentially contributing the drop in profitability of growing Cat Chu.

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. Vo et al. (2016) recommends 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) recommends applying 1400 g N + 1100 g P2O5 + 1600 g K2O 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 best. However, on the investigation of the current status of mango farming techniques in Dong Thap province in 2019, results showed that mango farmers in Dong Thap province are over fertilising compared to the needs of the tree, leading to increase of costs, susceptibility to pests, diseases, effectIng fruit quality and shelf life.

Study aim

The aim of this is to ascertain the optimal NPK fertiliser dosage for Cat Chu 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 Chu, 15 to 20 year old trees.

Planting spacing: 8 m x 8 m. Planting density: 156 trees/hectares.

The experiment conducted from March to November 2021 at My Xuong commune, Cao Lanh district, Dong Thap 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 (T1) (25% NPK): 350 g N – 275 g P_2O_5 – 350 g K_2O
- Treatment 2 (T2) (75% NPK): 1050 g N – 825 g P_2O_5 – 1050 g K_2O
- Treatment 3 (T3) (50% NPK): 700 g N – 550 g P_2O_5 – 700 g K_2O
- Treatment 4 (T4) (100% NPK) as control: 1400 g N – 1100 g P_2O_5 – 1400 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: Six weeks after fruit setting 25%

Calcium chloride (300g/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 200mm.

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 colour 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 ($P \leq 0.05$), ranging from 110.60 to 138.20 fruits/tree (Table 1). The highest number of fruits per tree was recorded in T4 (138.20 fruits), followed by T2 (125.80 fruits) and the lowest in T1 (110.60 fruits). This result is also consistent with the study of Tran and Nguyen (2005), Ahmed et al. (2001) and 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 – 275 g P_2O_5 – 350 g K_2O	110.60	333.10 b	37.00 b
2	T2: 1050 g N – 825 g P_2O_5 – 1050 g K_2O	125.80	364.35 ab	45.60 ab
3	T3: 700 g N – 550 g P_2O_5 – 700 g K_2O	123.00	352.25 ab	43.60 ab
4	T4: 1400 g N – 1100 g P_2O_5 – 1400 g K_2O	138.20	375.25 a	53.40 a
	Significant level	ns	*	*
	CV (%)	21.97	8.85	18.69
	LSD (5%)	48.61	41.62	14.93

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 statistically significant (P≤ 0.05), ranging from 333.10 to 375.25 g (Table 1). The highest fruit weight was recorded in T4 (375.25 g) which was significantly different (P≤ 0.05) from T1 (333.10 g) but not statistically different from T2 (364.35 g) and T3 (352.25 g). This result is also consistent with the research results of Kundu et al. (2011) on 10-year-old Amrapali mango and Azam et al. (2020) on 12-year-old Dusehri mango. The recorded fruit weight of the treatments was also consistent with the conclusions of Dao and Pham (2003) that the characteristics of the Cat Chu mango variety had an average fruit weight of 350 g ± 50g.

Similarly, the yield per plant between treatments was also statistically significant (P≤ 0.05), ranging from 37.00 to 53.40 kg/tree (Table 1). The highest yield per plant was recorded in T4 (53.40 kg) which was significantly different (P≤ 0.05) from T1 (37.00 kg) with no statistical difference with the other two treatments, T2 (45.60 kg) and T3 (43.60 kg). This result is also consistent with the research results of Ahmed et al. (2001), Kundu et al. (2011), Azam et al. (2020), Tran and Nguyen (2005) reported that the dose of fertiliser and different fertilisers have an effect on plant yield.

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 – 275 g P_2O_5 – 350 g K_2O	75.74	112.45	72.39 b
2	T2: 1050 g N – 825 g P_2O_5 – 1050 g K_2O	78.04	115.04	73.64 ab
3	T3: 700 g N – 550 g P2O5 – 700 g K2O	77.41	114.30	73.24 ab
4	T4: 1400 g N – 1100 g P2O5 – 1400 g K2O	78.69	116.50	74.64 a
	Significant level	ns	ns	*
	CV (%)	3.16	3.07	1.39
	LSD (5%)	4.35	6.25	1.82

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 75.74 to 78.69 mm. The highest fruit diameter was recorded in T4 (78.69 mm), followed by T2 (78.04 mm) and the lowest in T1 (75.74 mm) (Table 2).

Similarly, fruit length between treatments was not statistically significant (P≤ 0.05) ranging from 112.45 to 116.50 mm (Table 2). The highest fruit length was recorded in T4 (116.50 mm) and the lowest in T1 (112.45 mm). 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.

Whereas, Table 2 showed that fruit width between treatments were not statistically significant (P≤ 0.05) ranging from 72.39 to 74.64 mm. The highest fruit width was recorded in T4 (74.64 mm), followed by T2 (73.64 mm) and the lowest in T1 (72.39 mm).

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 72.80 to 75.01%, the treatment with the highest edible portion was T4 (75.01%) statistically significant (P≤ 0.05) compared with T1 (72.80%) but the difference was not significant (P≤ 0.05) between the two other treatments, T2 (74.18%) and T3 (73.86%). Tran and Nguyen (2005) concluded that the dose of fertiliser has an effect on the percentage of mango pulp.

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 – 275 g P_2O_5 – 350 g K_2O	72.80 b	25.41 b	20.06
2	T2: 1050 g N – 825 g P_2O_5 – 1050 g K_2O	74.18 a	26.05 ab	19.82
3	T3: 700 g N – 550 g P_2O_5 – 700 g K_2O	73.86 ab	25.69 b	20.04
4	T4: 1400 g N – 1100 g P_2O_5 – 1400 g K_2O	75.01 a	27.32 a	19.70
	Significant level	*	*	ns
	CV (%)	1.08	3.82	1.95
	LSD (5%)	1.42	1.77	0.69

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.

Similary, Table 3 shows that there is a statistically significant difference ($P \leq 0.05$) in fruit pulp thickness between the treatments, ranging from 25.41 to 27.32 mm. The treatment with the highest pulp thickness was T4 (27.32 mm) statistically significant ($P \leq 0.05$) compared to T1 (25.41 mm) and T3 (25.69 mm) but not statistically significant compared with T2 (26.05 mm). This result is also consistent with the records of Dao and Pham (2003) on the Cat Chu mango variety.

Whereas, Brix content (Total soluble solids) between the different treatments was not statistically significant ($P \leq 0.05$) ranging from 19.70 to 20.06% (Table 3). The highest brix content was recorded in T1 (20.06%), followed by T3 (20.04%) and the lowest was recorded in T4 (19.70%). This result is also consistent with the records of Dao and Pham (2003) of the Cat Chu mango variety with brix content fluctuating 20.2% ± 0.8 and Azam et al. (2020) also noted that the dose of fertiliser was not effect on brix content of 12-year-old Dusehri mango and Phan and Tran (2014) also reported on Cat Hoa Loc mango variety.

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 shows that there is no statistically significant difference ($P \leq 0.05$) 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 transition from green to red. Table 4 also shows that there is no statistically significant difference ($P \leq 0.05$) in the a* index of the peel between the experimental treatments, because the yellow 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 transition from blue to yellow. There was no statistically significant difference ($P \leq 0.05$) level in the b* index of pods between the experimental treatments (see Table 4). This showed that the yellow color of mango peel between treatments was uniform because the peel was uniformly yellow 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 – 275 g P_2O_5 – 350 g K_2O	76.50	3.30	32.30
2	T2: 1050 g N – 825 g P_2O_5 – 1050 g K_2O	74.90	3.39	33.50
3	T3: 700 g N – 550 g P_2O_5 – 700 g K_2O	75.30	3.31	32.49
4	T4: 1400 g N – 1100 g P_2O_5 – 1400 g K_2O	74.35	3.30	34.56
	Significant level	ns	ns	ns
	CV (%)	2.46	25.80	5.37
	LSD (5%)	3.30	1.53	3.17

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

The index b* represents for the transition from blue to yellow. There was no statistically significant difference ($P \leq 0.05$) in the b* index of fruit pulp between the experimental treatments this showed that the color of mango pulp between treatments was uniform at maturity and was not affected by fertiliser.

Table 5. Effect of NPK dosage on fruit pulp colour

TT	Treatment	L	a*	b*
1	T1: 350 g N – 275 g P_2O_5 – 350 g K_2O	69.98	6.63	48.80
2	T2: 1050 g N – 825 g P_2O_5 – 1050 g K_2O	70.71	6.19	50.29
3	T3: 700 g N – 550 g P_2O_5 – 700 g K_2O	70.52	6.09	51.29
4	T4: 1400 g N – 1100 g P_2O_5 – 1400 g K_2O	68.91	6.43	49.57
	Significant level	ns	ns	ns
	CV (%)	2.28	14.88	4.01
	LSD (5%)	2.84	1.68	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 weight, fruit length and width, yield per tree; and some factors constituting fruit quality such as edible portion, fruit pulp thickness. NPK fertilisation at different doses had no effect on the total number of fruits per tree, fruit diameter, brix content, colour of peel and pulp. The 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 of 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 of reducing 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 increase efficiently of applications, reduction in over fertilisation, and ability to make informed economic decisions about their fertiliser program.

5 References

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6 Appendices

Appendix 1. NPK trial fruit, Cao Lanh City, Dong Thap, Vietnam

Outside of fruit after harvesting 1 day

Inside of fruit after harvesting 7 days