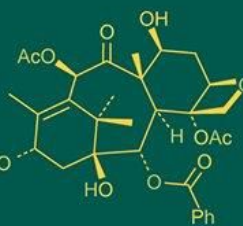
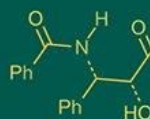


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Effect of integrated nutrient management on growth, yield and quality of kinnow mandarin (*Citrus reticulata* Blanco cv. Kinnow)

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Abstract

The present investigation was conducted during 2024 at the Agricultural Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan) on loamy sand soil. The experiment comprised eleven treatments viz. T₀: Control, T₁: RDF of NPK, T₂: RDF of NPK + FYM (5 kg/year), T₃: RDF of NPK + *Azotobacter*, T₄: RDF of NPK + PSB, T₅: RDF of NPK + AMF, T₆: RDF of NPK + FYM + AZB, T₇: RDF of NPK + FYM + PSB, T₈: RDF of NPK + FYM + AMF, T₉: RDF of NPK + FYM + PSB + AZB and T₁₀: RDF of NPK + FYM + PSB + AZB + AMF were laid out in randomized block design with three replication. Variety PAU Kinnow-1 were used for experiment. Results revealed that application of T₁₀: RDF of NPK + FYM + PSB + AZB + AMF significantly increased the highest plant height (17.00%) and stem diameter (6.09%) were observed along with the maximum number of fruits per plant (164.42), fresh fruit weight (192.06 g), fruit diameter (76.87 mm) and fruit volume (170.23 ml). The same treatment also produced superior fruit quality with the highest juice content (58.32%), total soluble solids (11.76 °Brix) and ascorbic acid content (24.43 mg 100 g⁻¹ pulp) over rest of the treatments

Keywords: Kinnow, nutrient management, yield, growth and quality

Introduction

Citrus species are widely cultivated throughout the worldwide tropics and sub-tropics, and the original native range of the genus citrus can be traced to southeast Asia and India. Citrus is an important fruit crop with a global production of 135 million tonnes (Anonymous a, 2024) [1]. In India, the total area and production under citrus is 1078 thousand hectare and 11147 thousand metric tons, respectively with a productivity of 10.3 metric tons per hectare. In the state of Rajasthan, citrus occupies an area of 250 thousand hectare producing 540.368 metric tons (Anonymous b, 2024) [2].

Amongst the different commercially grown citrus fruits, Kinnow mandarin (*Citrus nobilis* Lour x *Citrus deliciosa* Tenore), a first generation hybrid between the King and Willow leaf mandarins has made predominant place especially in the north-western region of India which include Punjab, Haryana, Himachal Pradesh, Western Rajasthan and Uttar Pradesh by way of replacing the traditional citrus fruits viz., sweet orange and local mandarins to some extent. Integrated nutrient supply/management (INM) aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner (Roy and Ange, 1991) [8]. Consequent to the global energy crisis, efficient and judicious use of fertilizers is imperative not only for obtaining more yield per unit area on sustainable basis, but also to conserve energy, to avoid the problem of environmental quality, health and ecological hazards.

Chemical fertilizers play a crucial role in enhancing the growth, yield, and fruit quality of citrus crops like kinnow, sweet orange, and lemon. Citrus trees are heavy feeders and require balanced nutrition for optimum productivity. The key nutrients include nitrogen (N), phosphorus (P), and potassium (K), along with secondary and micronutrients such as calcium, magnesium, zinc, and iron. Farmyard Manure (FYM) is a traditional and effective organic nutrient source used in citrus cultivation to improve soil fertility, structure, and

microbial activity. FYM provides a balanced supply of macro and micronutrients and enhances nutrient availability by improving cation exchange capacity and organic matter content in soil. In citrus crops like kinnow mandarin, sweet orange, and lime, FYM application improves root development, fruit yield, and fruit quality (e.g., juice content, total soluble solids). Biofertilizers such as *Azotobacter*, *Phosphate Solubilizing Bacteria (PSB)*, and Arbuscular Mycorrhizal Fungi (AMF) play a vital role in enhancing nutrient uptake, improving soil health, and reducing dependence on chemical fertilizers in citrus crops. *Azotobacter* is a free-living nitrogen fixer that colonizes the rhizosphere of citrus roots, improving nitrogen availability and stimulating plant growth through the production of growth-promoting substances. PSB solubilizes the fixed forms of phosphorus in soil, making it available to citrus trees for better root development, flowering, and fruiting. AMF forms a symbiotic relationship with citrus roots, enhancing uptake of phosphorus, zinc, and other immobile nutrients, while also improving drought tolerance and resistance to soil-borne pathogens.

Materials and Methods

The field experiment was conducted during the 2024 at the Agricultural Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan), on loamy sand soil. The study was laid out in a randomized block design eleven treatments viz. T₀: Control, T₁: RDF of NPK, T₂: RDF of NPK + FYM (5 kg/year), T₃: RDF of NPK + *Azotobacter*, T₄: RDF of NPK + PSB, T₅: RDF of NPK + AMF, T₆: RDF of NPK + FYM + AZB, T₇: RDF of NPK + FYM + PSB, T₈: RDF of NPK + FYM + AMF, T₉: RDF of NPK + FYM + PSB + AZB and T₁₀: RDF of NPK + FYM + PSB + AZB + AMF were laid out in randomized block design with three replication. Variety of guava “Kinnow PAU-1” were used for experiment. The experimental farm is located in the south-eastern part of Rajasthan at an elevation of 548 m above mean sea level (26°92' N latitude and 75°77' E longitude) under agro-climatic zone III-A (Semi-Arid Eastern Plain). The region has a semi-arid climate with wide temperature variation, receiving an average annual rainfall of 400–450 mm, about 80–85% of which occurs during the south-west monsoon (July–September). During the cropping period, maximum and minimum temperatures ranged from 31.41–38.71°C and 20.71–27.85°C, respectively, while relative humidity reached up to 91%. Average sunshine hours varied from 0.68 to 5.01 hours and wind velocity ranged between 0.88 and 2.82 km/ha. The recorded observations were statistically analyzed using standard procedures as described by Fisher (1950) [4]. Quality parameters were recorded as follow:

Juice content: Juice content (%) = (Weight or volume of juice / Fresh weight of fruit) × 100, The total soluble solids (TSS) of the fruit pulp was recorded with the help of Erma hand refractometer (0–32° B) according to standard procedure as given in A.O.A.C (1995) and ascorbic acid by Ruck, 1969.

Results and Discussion

The data presented in Table 4.1 revealed that integrated nutrient management (INM) practices significantly influenced the growth parameters of Kinnow mandarin in terms of plant height and stem diameter over the control. The maximum increase in plant height (17.00%) and stem diameter (6.09%) was recorded under treatment T₁₀ (RDF of NPK + FYM + PSB + AZB + AMF), which was statistically

at par with T₉ (RDF of NPK + FYM + PSB + AZB) and significantly superior to the other treatments. The minimum values of plant height (6.00%) stem diameter (2.76%) were observed under T₀ (control). The treatments involving combined application of chemical fertilizers with organic manure and biofertilizers (T₆, T₇, T₈, T₉ and T₁₀) produced better growth compared to sole application of RDF or individual biofertilizers. The enhanced vegetative growth under integrated nutrient management might be attributed to the balanced and continuous supply of nutrients, improvement in soil physical and biological properties and increased microbial activity in the rhizosphere. FYM improves soil structure, water holding capacity and nutrient availability, while biofertilizers such as *Azotobacter*, PSB and AMF enhance nitrogen fixation, phosphorus solubilization and nutrient uptake, leading to better vegetative growth and stem development. The synergistic effect of organic, inorganic and biological sources of nutrients ultimately resulted in improved plant vigor and growth of Kinnow mandarin. Similar findings were also reported by Yadav *et al.*, 2022 [16], Sharma *et al.*, 2021 [11], Meena *et al.*, 2020 [7] and Kumar *et al.*, 2019 [5], who observed significant improvement in vegetative growth of citrus under integrated application of inorganic fertilizers, organic manures and biofertilizers.

The data presented in Table 4.2 indicated that integrated nutrient management practices significantly influenced the yield parameters of Kinnow mandarin. The maximum number of fruits per plant (164.42), fresh fruit weight (192.06 g), fruit diameter (76.87 mm) and fruit volume (170.23 ml) were recorded under treatment T₁₀ (RDF of NPK + FYM + PSB + AZB + AMF), which was statistically at par with T₉ (RDF of NPK + FYM + PSB + AZB) and significantly superior to the remaining treatments. The lowest values for these parameters were observed under T₀ (control), where the number of fruits per plant (119.21), fresh fruit weight (146.03 g), fruit diameter (50.09 mm) and fruit volume (140.15 ml) were recorded. The treatments comprising combined application of inorganic fertilizers with organic manure and biofertilizers (T₆ to T₁₀) exhibited markedly higher yield attributes compared to the sole application of RDF or individual biofertilizers. This improvement may be attributed to the balanced supply of nutrients, enhanced nutrient availability and improved soil fertility resulting from the integrated use of organic, inorganic and biological sources of nutrients. FYM improves soil physical properties and microbial activity, while biofertilizers such as *Azotobacter*, PSB and AMF enhance nitrogen fixation, phosphorus solubilization and nutrient uptake, which ultimately promotes better fruit development and yield in Kinnow mandarin. The improvement in fruit size and weight might also be due to enhanced photosynthetic activity and efficient translocation of assimilates from source to sink under integrated nutrient management conditions. These findings are in close conformity with the results reported by Yadav *et al.*, 2022 [16], Sharma *et al.*, 2021 [11], Meena *et al.*, 2020 [7] and Kumar *et al.*, 2019 [5], who also observed significant improvement in yield attributes of citrus under integrated application of chemical fertilizers, organic manures and biofertilizers.

The data presented in Table 4.3 indicated that integrated nutrient management practices significantly influenced the quality parameters of Kinnow mandarin. Among different treatments, T₁₀ (RDF of NPK + FYM + PSB + AZB + AMF) recorded the maximum juice content (58.32%),

ascorbic acid content (24.43 mg/100 g pulp) and total soluble solids (11.76 °Brix), which remained statistically at par with T₉ (RDF of NPK + FYM + PSB + AZB) and significantly superior to the remaining treatments. The lowest values of juice content (41.03%), ascorbic acid (21.02 mg/100 g pulp) and TSS (9.03 °Brix) were observed under control (T₀). The treatments involving combined application of inorganic fertilizers, organic manure and biofertilizers (T₆ to T₁₀) produced better fruit quality compared to the sole application of RDF or individual biofertilizers. The improvement in juice content, TSS and ascorbic acid may be attributed to balanced nutrient supply,

improved soil fertility and enhanced microbial activity under integrated nutrient management. Biofertilizers such as Azotobacter, PSB and AMF enhance nutrient availability and uptake, while FYM improves soil physical properties and microbial population, which ultimately promote better synthesis and accumulation of sugars and vitamins in fruits. These findings are in close agreement with the results reported by Yadav *et al.*, 2022 ^[16], Sharma *et al.*, 2021 ^[11], Meena *et al.*, 2020 ^[7] and Kumar *et al.*, 2019 ^[5], who also observed improvement in fruit quality parameters of citrus under integrated application of organic manures, chemical fertilizers and biofertilizers.

Table 1: Effect of INM techniques on growth parameters of kinnow mandarin

Treatments	Growth parameters	
	Plant height (% change)	Stem diameter (% change)
T ₀ : Control	6.00	2.76
T ₁ : RDF of NPK (1000:500:750 g)	8.80	3.38
T ₂ : RDF of NPK + FYM (5 kg/year)	10.80	3.94
T ₃ : RDF of NPK + <i>Azotobacter</i> (250 g)	12.83	4.39
T ₄ : RDF of NPK + PSB (250 g)	13.13	4.46
T ₅ : RDF of NPK + AMF (500 g)	13.20	4.53
T ₆ : RDF of NPK + FYM + AZB	14.86	5.01
T ₇ : RDF of NPK + FYM + PSB	15.00	5.13
T ₈ : RDF of NPK + FYM + AMF	15.12	5.19
T ₉ : RDF of NPK + FYM + PSB + AZB	16.90	5.98
T ₁₀ : RDF of NPK + FYM + PSB + AZB + AMF	17.00	6.09
SEm±	0.50	0.15
CD (P=0.05)	1.50	0.15
CV (per cent)	8.67	7.87

Table: 2 Effect of INM techniques on yield parameters of kinnow mandarin

Treatments	Yield parameters			
	Number of fruits/plant	Fresh fruit weight (g)	Fruit diameter (mm)	Fruit volume (ml)
T ₀ : Control	119.21	146.03	50.09	140.15
T ₁ : RDF of NPK (1000:500:750 g)	127.34	153.67	54.41	144.64
T ₂ : RDF of NPK + FYM (5 kg/year)	135.31	161.81	58.93	149.12
T ₃ : RDF of NPK + <i>Azotobacter</i> (250 g)	142.92	169.64	63.29	154.34
T ₄ : RDF of NPK + PSB (250 g)	143.25	170.09	64.48	155.62
T ₅ : RDF of NPK + AMF (500 g)	143.85	172.32	65.04	156.01
T ₆ : RDF of NPK + FYM + AZB	151.17	179.06	69.32	160.43
T ₇ : RDF of NPK + FYM + PSB	153.48	180.98	70.84	162.01
T ₈ : RDF of NPK + FYM + AMF	154.94	182.09	71.28	163.49
T ₉ : RDF of NPK + FYM + PSB + AZB	162.55	189.89	75.32	168.06
T ₁₀ : RDF of NPK + FYM + PSB + AZB + AMF	164.42	192.06	76.87	170.23
SEm±	2.35	2.37	1.37	1.40
CD (P=0.05)	7.07	7.13	4.12	4.21
CV (per cent)	9.56	8.98	8.21	8.45

Table 3: Effect of INM techniques on quality parameters of kinnow mandarin

Treatments	Quality parameters		
	Juice content (%)	Ascorbic acid (mg/100 g pulp)	Total Soluble Solids (°Brix)
T ₀ : Control	41.03	21.02	9.03
T ₁ : RDF of NPK (1000:500:750 g)	44.81	21.41	9.44
T ₂ : RDF of NPK + FYM (5 kg/year)	47.53	21.85	10.02
T ₃ : RDF of NPK + <i>Azotobacter</i> (250 g)	50.41	22.27	10.44
T ₄ : RDF of NPK + PSB (250 g)	50.52	22.32	10.51
T ₅ : RDF of NPK + AMF (500 g)	50.59	22.41	10.58
T ₆ : RDF of NPK + FYM + AZB	53.45	23.03	11.06
T ₇ : RDF of NPK + FYM + PSB	53.52	23.15	11.18
T ₈ : RDF of NPK + FYM + AMF	54.64	23.19	11.25
T ₉ : RDF of NPK + FYM + PSB + AZB	57.57	24.38	11.64
T ₁₀ : RDF of NPK + FYM + PSB + AZB + AMF	58.32	24.43	11.76
SEm±	0.92	0.13	0.12
CD (P=0.05)	3.76	0.39	0.36
CV (per cent)	8.32	3.23	3.65

Conclusion

The results of the present study revealed that integrated nutrient management significantly improved the growth and yield parameters of Kinnow mandarin. The treatment T₁₀ (RDF of NPK + FYM + PSB + AZB + AMF) recorded the highest plant growth, yield and quality attributes compared to other treatments. The combined application of inorganic fertilizers, organic manure and biofertilizers enhanced nutrient availability and uptake, resulting in better plant performance. Therefore, integrated use of chemical fertilizers along with FYM and biofertilizers can be recommended for improving productivity of Kinnow mandarin.

References

1. Anonymous. FAOSTAT statistical database on world citrus production. Rome, Italy: Food and Agriculture Organization of the United Nations; 2024.
2. Anonymous. Horticultural statistics at a glance 2024. New Delhi, India: Ministry of Agriculture and Farmers Welfare, Government of India; 2024. p. 198-200.
3. Davies FS, Albrigo LG. Citrus. Wallingford, UK: CAB International; 1994. p. 254.
4. Fisher RA. Statistical methods for research workers. 11th ed. Edinburgh: Oliver and Boyd; 1950.
5. Kumar P, Singh AK, Meena RS. Effect of organic manures and biofertilizers on growth, yield and quality of citrus. *Journal of Horticultural Sciences*. 2019;14(2):155-161.
6. Ladaniya MS. Citrus fruit: biology, technology and evaluation. San Diego, USA: Academic Press; 2008. p. 558.
7. Meena RS, Meena VS, Yadav GS. Influence of integrated nutrient management on yield and quality parameters of citrus. *Journal of Plant Nutrition*. 2020;43(9):1340-1348.
8. Roy RN, Ange AL. Integrated plant nutrient management for sustainable agriculture. *FAO Fertilizer and Plant Nutrition Bulletin*. 1991;12:1-114.
9. Sharma RC, Singh S. Balanced fertilization for improved growth and productivity of citrus orchards. *Journal of Horticultural Sciences*. 2018;13(1):47-52.
10. Singh IP. Citrus and subtropical fruits. New Delhi, India: Oxford and IBH Publishing Co. Pvt. Ltd.; 2001. p. 320.
11. Sharma RC, Singh S. Integrated nutrient management for improving fruit yield and quality of kinnow mandarin (*Citrus reticulata*). *Indian Journal of Horticulture*. 2021;78(2):214-219.
12. Singh S, Singh G. Kinnow mandarin cultivation and management in north-western India. *Indian Journal of Horticulture*. 2006;63(3):230-235.
13. Smith SE, Read DJ. Mycorrhizal symbiosis. 3rd ed. London, UK: Academic Press; 2008. p. 787.
14. Vessey JK. Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil*. 2003;255(2):571-586.
15. Webber HJ, Batchelor LD. The citrus industry. Berkeley, California, USA: University of California Press; 1943. p. 1028.
16. Yadav RK, Meena RS, Yadav L. Role of integrated nutrient management in enhancing yield and quality of citrus fruits. *Journal of Horticultural Sciences*. 2022;17(2):234-239.