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Evaluating the impact of plant growth regulators and micronutrients on fruit set, yield and chemical characteristics of mango leaves

Thupten Tsomu[1*] • H.C. Patel[2] • Samikhkya Bhuyan[3] • M. M. Sharma[4] • Duyi Samyor • A. Tasung[6]

[1,3,4,5]Faculty of Agricultural Sciences, Rajiv Gandhi University, Arunachal Pradesh

[2] B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat

[6]ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar

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ABSTRACT

The research was conducted over two spring-summer seasons at the Horticultural Research Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, focusing on mango cultivar Mallika during 2013-14 and 2014-15. The objective was to evaluate the impact of foliar application of growth regulators (NAA and GA_3) and micronutrients ($ZnSO_4$ and borax) on mango fruit set, yield, and leaf properties. The study utilized mango trees of uniform size and age (15 years). Fifteen treatments were administered, including varying concentrations of PGRs (NAA at 20 mg/L of water and 40 mg/L, GA3 at 25 mg/L and 50 mg/L) and micronutrients (zinc sulfate at 0.5%, and borax at 0.2%), as well as combinations of these treatments. These combinations included NAA with zinc sulfate or borax, GA3 with zinc sulfate or borax, and a control treatment with water spray (T15). The foliar sprays were applied at key stages of mango fruit growth: full bloom, pea, and marble stages. Among the treatments, the combination of NAA at 20 mg/L with borax at 0.2% showed significant enhancements in fruit set percentages at pea, marble, and harvest stages, as well as an increase in fruit yield (79.97 kg/tree). Notably, treatments combining NAA at 20 mg/L with zinc sulfate at 0.5% (T7) and NAA at 20 mg/L with borax at 0.2% (T8) resulted in the highest zinc and boron content in mango leaves, respectively.

1. Introduction

Mango (*Mangifera indica* L.) holds tremendous significance in India, both culturally and economically. It's often referred to as the "king of fruits" due to its popularity and widespread cultivation across the country. Mango is a succulent stone fruit highly prized for its taste and nutritional value. Originating in the Indo-Burma region, it has become a staple in tropical fruit cultivation. India stands as a global leader in mango production, contributing over 40 percent of the total output, with a staggering 20.78 million tons harvested during 2021-22. Uttar Pradesh leads the country in mango production, yielding 4.67million tons, accounting for 22.45% of the nation's total mango production, followed by Karnataka with 1.62 million tons (7.80%) (India stat, 2023). Maximizing mango productivity demands innovative strategies, and the collective application of micronutrients and plant growth regulators (PGRs) presents a compelling avenue. Synergistic effects of micronutrients and PGRs on diverse horticultural facets, encompassing biometric responses, fruiting potential, and qualitative attributes. Micronutrients are vital for the normal growth, development, and productivity of crops, and they hold equal importance to macronutrients for mango tree health. Micronutrient deficiencies are prevalent in mango trees, impacting their growth and yield. Timely correction of these deficiencies significantly boosts economic yields. Zinc (Zn) is crucial for chlorophyll formation, enzyme activity, and the regulation of growth hormone, auxin. Boron (B) plays a pivotal role in cell division and development, particularly in the growing regions of shoots and roots. Currently, growth regulators like NAA, GA_3, and 2,4 –D play a significant role in regulating and modifying plant growth and development processes.

*Corresponding author: thupten.tsomu@rgu.ac.in

It was noted that applying a foliar spray of NAA at a concentration of 50 ppm on the Amrapali mango variety led to the highest yield of fruits, with a total quantity of 216.50 fruits and an average fruit weight of 224.58g (Ghosh, 2016). Similarly, Dhewareet. al.(2020) found that foliar application of micronutrients such as ZnSO4 at 0.4%, CuSO4 at 0.2%, and Borax at 0.2% increased the fruit number per tree to 173.32 in the Alphonso mango cultivar.

2. Material and methods

The study was conducted over two spring-summer seasons at the Horticultural Research Farm, Horticulture Department, B.A. College of Agriculture, Anand Agricultural University, Anand during 2013-14 and 2014-15, focusing on the mango cultivar Mallika. The selected trees, all 15 years old and of uniform size, were used for the experiment. The experiment involved 15 treatments incorporating various plant growth regulators (PGRs) and micronutrients. Details of the treatments are as follows:

Treatment no.	Treatment details
T_1	NAA 20 mg/l
T_2	NAA 40 mg/l
T_3	GA_3 25 mg/l
T_4	GA_3 50 mg/l
T_5	$ZnSO_4$ 0.5 %
T_6	Borax 0.2 %
T_7	NAA 20 mg/l + $ZnSO_4$ 0.5 %
T_8	NAA 20 mg/l + Borax 0.2%
T_9	NAA 40 mg/l + $ZnSO_4$ 0.5 %
T_{10}	NAA 40 mg/l + Borax 0.2%
T_{11}	GA_3 25 mg/l + $ZnSO_4$ 0.5 %
T_{12}	GA_3 25 mg/l + Borax 0.2%
T_{13}	GA_3 50 mg/l + $ZnSO_4$ 0.5 %
T_{14}	GA_3 50 mg/l + Borax 0.2%
T_{15}	Control (water spray)

Foliar sprays were applied at three critical stages of fruit growth: full bloom, pea, and marble stages. Observations were made on four panicles per tree to assess fruit set percentage at the pea, marble, and harvest stages. For fruit yield assessment, uniform, disease-free, and mature fruits were harvested from each tree, with weights recorded in kilograms for all pickings. Statistical analysis using RCBD was conducted following the method outlined by Gomez and Gomez (1967). To evaluate micronutrient levels shoots were approximately 4-5 months old and devoid of disease and pests were randomly tagged on each tree. Ten leaves from the middle of each tagged shoot were collected both before and after treatment application for micronutrient (Zn and B) estimations, following the method described by Koo and Young (1972).

3. Results and Discussion

Data presented in Table 1 shows significant differences in the fruit set during the pea, marble, and harvest stages. Maximum fruit set at pea stage was recorded with treatment T_8*i.e.* NAA 20 mg/L + Borax 0.2% (32.00, 30.02, and 31.01 %) which was at par with treatments T_{10} (30.18, 28.10, and 29.14 %) in individual years as well as in pooled analysis. During the marble stage, the maximum fruit set (11.16%) was observed again in treatment T_8*i.e.* NAA 20 mg/L + Borax 0.2% which was at par with treatments T_{10}, T_{12}, T_{14}, T_{11}, $T_{9,}$and T_{13} during the first year and the same trend was observed during the second year with higher fruit set in treatment T_8 (10.78%) which was at par with treatments T_{10}, T_{12}, T_{14}, T_{11}, T_9, and T_{13}. The pooled data for both years shows that the maximum fruit set (10.97 %) at the marble stage was found in treatment (T_8), while the minimum fruit set (3.79 %) was registered in control treatment (T_{15}). However, a slight decrease in fruit set was observed in the second year as compared to the first year. Significantly, the highest fruit set at the harvest stage (7.86%) was recorded with treatment T_8*i.e.* NAA 20 mg/L + Borax 0.2%. It was followed by T_{10} (7.40%) and T_{12} (7.02%). In the second year, the highest percentage of fruit set at the harvest stage (6.49%) was recorded again with the same treatment (T_8) which was at par with T_{10} (6.36%), T_{12} (6.04%) and T_{14} (5.78%). In pooled analysis also higher fruit set was found with the same treatment *i.e.* T_8 (7.17%). However, it was at par with T_{10} (6.88%). It is clear from the results that foliar spray of NAA 20 mg/L + Borax 0.2%, once at full bloom stage, pea stage, and marble stage significantly increased the fruit set per panicle. These chemicals showed more or less similar trends in terms of fruit retention in both years. The increase in fruit retention by using different growth regulators and micronutrients showed that the combined application of growth regulators and micronutrients was found better rather than applying these chemicals individually. Auxin serves a pivotal role in abscission, the natural process of shedding plant organs like leaves, flowers, or fruits. Its primary function lies in sustaining ongoing physiological and biochemical processes within the plant. By steadily moving from the attachment point (subtending organ) to the abscission zone, auxin maintains a state of relative dormancy, inhibiting premature organ detachment. External application of auxin further reinforces this inhibition, prolonging the retention of plant organs. Additionally, auxin acts as a facilitator for nutrient mobilization, promoting the translocation of essential resources to developing fruits and other growing parts of the plant. The results were also in accordance with the findings of Naqvi *et al.* (2004), Gupta and Brahmachari (2004), Vejendla *et. al.* (2008), Sondarva (2009), Rajput *et. al.* (2013) and Dheeraj *et. al.* (2016) in mango. Studies have shown that boron supplementation can enhance the pollen-producing capacity of anthers and increase pollen viability, leading to improved fruit set and quality in various crops, including mangoes. Adequate boron supply is essential during critical stages of flowering and fruiting to ensure optimal reproductive development and maximize yield (Singh *et al*., 2013).Similar results were also obtained by Kanapol *et al.* (2002), Bhowmick *et al.* (2012), and Gurjar *et. al.* (2015) in mango.

Data presented in Table 2 revealed the maximum fruit yield *i.e.* 81.37, 78.57, and 79.97 kg/tree during the years 2013-14, 2014-15, and in the pool, respectively was recorded with treatment T_8*i.e.* NAA 20 mg/L + Borax 0.2%.The notable rise in fruit yield per tree and hectare stems from multiple factors, chiefly the augmented fruit count owing to minimized fruit drop, alongside enhanced fruit weight. Furthermore, the facilitation of starch synthesis followed by efficient carbohydrate translocation in plants, facilitated by micronutrients such as zinc and boron, is widely acknowledged, as highlighted by Nehete *et al.* (2011).Data presented in Table2 shows significant differences in zinc content in leaves before and after treatment spray. Significantly higher zinc content (Zn) was found after spraying with the treatment *i.e.* T_7 (39.50, 41.33, and 40.42 ppm) during 1st, 2nd, and pooled data which was at par with T_9 and T_{11}. Treatment NAA 20 mg/L + $ZnSO_4$ 0.5 % (T_7) was found to have higher zinc content and it might be due to the external application of micronutrients which had significantly reflected the increased nutritional status of zinc in mango leaves cv. Mallika. Dutta and Dhua (2002), and Nehete *et al.* (2011) in mango also found similar results.

Data presented in Table 3 shows significant differences in boron (B) content in leaves before and after spray. Significantly higher boron content was found after spraying with treatment *i.e.*NAA 20 mg/L + Borax 0.2 % (T_8) in the first (87.42 ppm), second year (108.02ppm) and in pooled results (97.72 ppm). Thus, it is evident from the data that boron content increases in leaves after the application of NAA 20 mg/L + Borax 0.2 % (T_8) followed by T_6, T_{10}, T_{12}, and T_{14}.This could be attributed to the existence of compounds within the cell that bind to boron, potentially enhancing the mechanism of boron absorption. Comparable findings were also documented by Nehete *et al.* (2011) and Sankar *et al.* (2013) in mangoes.

4. Conclusion

It can be concluded from the study that foliar application of NAA 20 mg/L + Borax 0.2% significantly enhances fruit set and yield in mango trees, with notable improvements in zinc and boron uptake. The combined treatment fosters better fruit retention, leading to increased fruit count and weight per tree. Additionally, micronutrient supplementation, particularly zinc and boron, positively influences nutrient status in mango leaves, essential for optimal reproductive development. These findings underscore the efficacy of combined growth regulators and micronutrients, offering a promising strategy to improve mango yield and quality, aligning with previous research in the field.

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Table 1. Effect of foliar application of PGRs and micronutrients on fruit set (%) at pea, marble, and Harvest stage during the years 2013-14 and 2014-15

Treatment No.	Fruit set (%) at pea stage			Fruit set (%) at marble stage			Fruit set (%) at harvest stage		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	19.51	17.22	18.36	8.91	7.46	8.18	4.03	2.88	3.45
T_2	19.56	17.34	18.45	8.68	7.80	8.24	4.15	3.07	3.61
T_3	17.91	15.88	16.90	8.96	7.75	8.35	3.16	2.82	2.99
T_4	17.80	16.01	16.91	8.93	7.36	8.14	2.90	2.45	2.68
T_5	16.65	14.89	15.77	8.83	7.00	7.92	2.89	2.33	2.61
T_6	19.71	17.41	18.56	8.61	8.16	8.39	4.01	3.53	3.77
T_7	21.13	19.02	20.08	9.04	8.46	8.75	4.34	4.16	4.25
T_8	32.00	30.02	31.01	11.16	10.78	10.97	7.86	6.49	7.17
T_9	24.30	22.50	23.40	10.44	9.61	10.02	5.68	5.37	5.52
T_{10}	30.18	28.10	29.14	11.03	10.64	10.84	7.40	6.36	6.88
T_{11}	25.95	24.03	24.99	10.58	9.82	10.20	5.77	5.45	5.61
T_{12}	27.94	26.38	27.16	10.86	10.21	10.54	7.02	6.04	6.53

T_{13}		23.09	21.53	22.31	10.13	9.55	9.84	4.61	4.43	4.52
T_{14}		27.46	25.37	26.42	10.66	10.03	10.34	6.34	5.78	6.06
T_{15}		12.79	13.57	13.18	4.71	2.88	3.79	1.16	0.87	1.01
T	S.Em ±	0.69	0.75	0.67	0.56	0.63	0.39	0.36	0.31	0.19
	C. D. (P =0.05)	1.98	2.17	1.93	1.62	1.81	1.14	1.03	0.88	0.54
YXT	S.Em ±	-	-	0.38	-	-	0.63	-	-	0.39
	C. D. (P =0.05)	-	-	NS	-	-	NS	-	-	NS
C.V. %		5.31	6.32	3.06	10.31	12.77	12.18	12.96	12.78	15.05

Table 1. Treatment details

Tr. No.	Treatments	Tr. No.	Treatments
T_1	NAA 20 mg/L	T_9	NAA 40 mg/L + $ZnSO_4$ 0.5 %
T_2	NAA 40 mg/L	T_{10}	NAA 40 mg/L + Borax 0.2%
T_3	GA_3 25 mg/L	T_{11}	GA_3 25 mg/L + $ZnSO_4$ 0.5 %
T_4	GA_3 50 mg/L	T_{12}	GA_3 25 mg/L + Borax 0.2%
T_5	$ZnSO_4$ 0.5 %	T_{13}	GA_3 50 mg/L + $ZnSO_4$ 0.5 %
T_6	Borax 0.2 %	T_{14}	GA_3 50 mg/L + Borax 0.2%
T_7	NAA 20 mg/L + $ZnSO_4$ 0.5 %	T_{15}	Control (water spray)
T_8	NAA 20 mg/L + Borax 0.2%		

Table 2. Effect of foliar application of PGRs and micronutrients on fruit yield (kg/tree), Zn content leaves before spray (ppm) and Zn content in leaves after spray (ppm) of mango fruits during the years 2013-14 and 2014-15

Treatment No.		Fruit yield (kg/tree)			Zn content leaves before spray (ppm)			Zn content in leaves after spray(ppm)		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1		65.25	62.68	63.97	24.83	20.67	22.75	25.83	21.33	23.58
T_2		65.46	63.02	64.24	20.67	19.83	20.25	22.67	21.00	21.83
T_3		64.96	60.65	62.81	20.33	20.33	20.33	24.83	19.67	22.25
T_4		64.30	60.39	62.35	21.00	20.83	20.92	22.50	20.50	21.50
T_5		62.93	59.29	61.11	25.33	29.83	27.58	31.83	38.17	35.00
T_6		64.55	63.14	63.84	25.17	22.00	23.58	24.50	22.67	23.58
T_7		72.25	71.39	71.82	31.83	35.33	33.58	39.50	41.33	40.42
T_8		81.37	78.57	79.97	29.17	23.50	26.33	26.00	24.17	25.08
T_9		74.56	72.52	73.54	28.50	33.50	31.00	37.33	39.67	38.50
T_{10}		78.03	77.11	77.57	19.33	18.33	18.83	19.67	19.00	19.33
T_{11}		73.04	72.64	72.84	34.67	31.67	33.17	39.33	38.50	38.92
T_{12}		73.58	72.86	73.22	31.83	24.83	28.33	30.67	26.17	28.75
T_{13}		70.58	70.22	70.40	25.17	29.50	27.33	32.67	35.00	33.83
T_{14}		71.30	71.04	71.17	26.83	26.17	26.50	28.67	27.33	28.00
T_{15}		46.10	42.76	44.43	30.50	21.50	26.00	26.83	20.17	23.50
T		3.53	3.59	2.36	1.20	1.21	2.14	1.32	1.04	1.67
		10.20	10.37	6.82	3.48	3.48	6.50	3.80	3.00	5.05
YXT	-	-	-	3.78	-	-	1.20	-	-	1.19
	-	-	-	NS	-	-	3.41	-	-	3.35
C.V. %		5.64	8.92	9.34	7.92	8.29	8.09	7.90	6.50	7.26

Table 3. Effect of foliar application of PGRs and micronutrients on B content leaves before spray (ppm) and B content in leaves after spray (ppm) of mango fruits during the years 2013-14 and 2014-15

Treatment No.		Boron content in leaves before spray (ppm)			Boron content in leaves after spray (ppm)		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1		67.59	70.56	69.08	69.16	76.16	72.66
T_2		67.98	72.97	70.48	69.55	74.31	71.93
T_3		65.97	73.30	69.64	68.66	76.38	72.52
T_4		69.38	73.42	71.40	70.62	79.97	75.29
T_5		64.51	75.60	70.06	72.24	83.27	77.76
T_6		65.80	85.40	75.60	84.11	106.18	95.14
T_7		64.06	69.78	66.92	66.14	78.01	72.07
T_8		69.61	90.27	79.94	87.42	108.02	97.72
T_9		62.22	70.84	66.53	67.48	73.25	70.36
T_{10}		64.62	83.33	73.98	80.47	102.20	91.34
T_{11}		61.71	66.64	64.18	65.63	71.74	68.68
T_{12}		64.62	82.99	73.81	79.18	98.17	88.68
T_{13}		65.52	72.86	69.19	70.39	76.27	73.33
T_{14}		60.37	79.74	70.12	77.50	96.60	87.05
T_{15}		60.03	56.17	58.10	60.48	55.89	58.18
T		0.57	0.34	3.79	0.49	0.61	3.89
		1.65	0.97	NS	1.43	1.76	11.81
YXT		-	-	0.47	-	-	0.56
		-	-	1.32	-	-	1.58
C.V. %		1.52	0.78	1.16	1.18	1.26	1.23

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