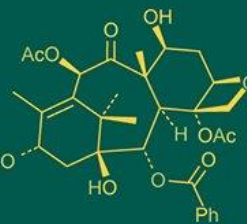
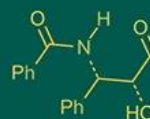


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Influence of foliar application of plant growth regulators on fruit retention and yield of rejuvenated alphonso mango (*Mangifera indica* L.) under konkan conditions of Maharashtra

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Abstract

A field experiment was carried out at the Centre of Excellence for Mango, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri District, Maharashtra, during 2023-24 and 2024-25. The study consisted of a single experiment conducted over two consecutive seasons. It was arranged in a factorial randomized block design involving two factors. Factor A included rejuvenated and non-rejuvenated mango trees, whereas Factor B consisted of seven plant growth regulator treatments. Thus, fourteen treatment combinations were evaluated, with each treatment replicated three times.

The plant growth regulators used in the study included salicylic acid, CPPU [N-(2-chloro-4-pyridyl)-N-phenylurea], n-ATCA (N-acetyl-thiazolidine-4-carboxylic acid) and KNO₃ (potassium nitrate). Foliar application of treatment T₆ (P₁C₆), comprising 10% n-ATCA and 0.2% folic acid, at 1 ml/l during 50% flowering, 1.5 ml/l at the marble stage and 2 ml/l at the egg stage on rejuvenated mango trees improved fruit retention to 1.02% and yield to 3.48 t/ha. Treatment T₃ (P₁C₃), involving the application of 1% KNO₃ at the peanut, marble and egg stages of fruit development, also increased fruit retention and produced a yield of 33.16 kg/tree. The highest yield of 34.79 kg/tree was recorded under treatment T₆ (P₁C₆).

Keywords: Rejuvenated trees, CPPU, fruit retention, yield, n-ATCA, Alphonso

Introduction

Mango (*Mangifera indica* L.), commonly referred to as the “King of Fruits,” is one of the most commercially important fruit crops cultivated in India. Among the many mango cultivars, Alphonso holds a distinguished position because of its superior fruit quality, characteristic flavour, attractive saffron-coloured pulp and considerable export potential. The Konkan region of Maharashtra is regarded as the natural habitat of Alphonso mango, where the crop performs well under humid coastal conditions characterized by moderate temperatures, high relative humidity and well-distributed rainfall. In addition, the red lateritic soils of the region are slightly acidic, well drained and rich in iron and aluminium oxides, creating favourable soil conditions for the successful cultivation of Alphonso mango.

A large proportion of Alphonso mango orchards in the Konkan region comprises old and senile trees that exhibit reduced productivity, poorly structured canopies, low fruit retention and inferior fruit quality. Rejuvenation through systematic pruning has become an effective orchard-management strategy for restoring tree vigour, improving canopy efficiency and increasing the productivity of ageing orchards. Nevertheless, rejuvenated trees frequently experience severe fruit drop during the initial stages of fruit development, which restricts their overall yield potential.

Plant growth regulators have an important role in controlling the physiological and biochemical processes associated with fruit set, fruit retention, growth and quality. Foliar application of these regulators at critical stages of fruit development, including the pea, marble and egg stages, has been reported to increase fruit retention, minimize premature fruit drop and promote fruit growth. Substances such as salicylic acid, CPPU or forchlorfenuron, potassium nitrate and N-acetyl-thiazolidine-4-carboxylic acid have demonstrated the ability to influence source-sink relationships, hormonal balance, stress tolerance and nutrient mobilization.

These effects may contribute to higher yields and improved fruit quality. Therefore, evaluating these plant growth regulators in rejuvenated Alphonso mango orchards under the humid agroecological conditions of Dapoli in the Konkan region is important for improving orchard productivity and maintaining the economic sustainability of Alphonso mango cultivation.

Materials and Methods

The experiment was conducted in a 35-year-old Alphonso mango orchard at the Centre of Excellence for Mango, Dapoli, during two consecutive cropping seasons in 2023-24 and 2024-25. The experiment was arranged in a factorial randomized block design with three replications.

Treatment details

Factor A	Particulars
P ₁	Rejuvenated tree (35 year old)
P ₂	Non Rejuvenated tree (35 year old)
Factor B	
C ₁	Salicylic Acid @1500 ppm (Peanut stage, Marble stage, Egg stage)
C ₂	Salicylic Acid @ 2000 ppm (Peanut stage, Marble stage, Egg stage)
C ₃	KNO ₃ @ 1% (Peanut stage, Marble stage, Egg stage)
C ₄	CPPU @ 3 ppm (Peanut stage, Marble stage, Egg stage)
C ₅	CPPU @ 4 ppm (Peanut stage, Marble stage, Egg stage)
C ₆	n-ATCA 10% and folic acid 0.2% @ 1 ml/l (50% Flowering), 1.5 ml/l (Marble stage) and 2 ml/l (Egg stage)
C ₇	Control

Treatment combinations

Treatment	Treatment Combination	Factor A X B
T ₁	P ₁ C ₁	Rejuvenated tree (35 year old) + Salicylic Acid @1500 ppm
T ₂	P ₁ C ₂	Rejuvenated tree (35 year old) + Salicylic Acid @ 2000 ppm
T ₃	P ₁ C ₃	Rejuvenated tree (35 year old) + KNO ₃ @ 1%
T ₄	P ₁ C ₄	Rejuvenated tree (35 year old) + CPPU @ 3 ppm
T ₅	P ₁ C ₅	Rejuvenated tree (35 year old) + CPPU @ 4 ppm
T ₆	P ₁ C ₆	Rejuvenated tree (35 year old) + n-ATCA 10% and folic acid 0.2% @ 1 ml/L (50% Flowering), 1.5 ml/L (Marble stage) and 2 ml/L (Egg stage)
T ₇	P ₁ C ₇	Rejuvenated tree (35 year old) + Control
T ₈	P ₂ C ₁	Non Rejuvenated tree (35 year old) + Salicylic Acid @1500 ppm
T ₉	P ₂ C ₂	Non Rejuvenated tree (35 year old) + Salicylic Acid @ 2000 ppm
T ₁₀	P ₂ C ₃	Non Rejuvenated tree (35 year old) + KNO ₃ @ 1%
T ₁₁	P ₂ C ₄	Non Rejuvenated tree (35 year old) + CPPU @ 3 ppm
T ₁₂	P ₂ C ₅	Non Rejuvenated tree (35 year old) + CPPU @ 4 ppm
T ₁₃	P ₂ C ₆	Non Rejuvenated tree (35 year old) + n-ATCA 10% and folic acid 0.2% @ 1 ml/L (50% Flowering), 1.5 ml/L (Marble stage) and 2 ml/L (Egg stage)
T ₁₄	P ₂ C ₇	Non Rejuvenated tree (35 year old) + Control

Treatment imposition

Foliar application of plant growth regulators was made at three stages. In the first and second experimental trials, the foliar spraying of plant growth regulators that is salicylic acid (1500 ppm and 2000 ppm), CPPU (3 ppm and 4 ppm), KNO₃ (1%), was done at peanut, marble, egg stage of fruit development. The foliar spraying of n-ATCA 10% and folic acid 0.2% was done @ 1 ml/l 50% flowering, 1.5 ml/l marble stage and 2 ml/l egg stage of fruit development. The

spraying was done with a foot sprayer on the whole canopy. All other recommended cultural practices were followed uniformly. Observation were recorded on fruit retention and yield of mango.

Fruit retention

Fruit retention at the harvest stage of fruit development, expressed as a percentage per panicle, was calculated using the following formula.

$$\text{Fruit retention (\%)} = \frac{(\text{Average no. of retained fruits at harvest stage per panicle})}{(\text{Total no. of flowers per panicle})} \times 100$$

Number of fruits per tree

Total numbers of fruits per tree were counted by manually in each harvesting of fruits.

Yield (kg/tree)

The yield of mango fruits per tree (kg) was recorded by counting the total number of fruits harvested from each tree and measured their weight.

Statistical Analysis

The collected data were subjected to statistical analysis using the procedure described by Panse and Sukhatme (1985) [5]. The standard error of the mean (S.E.m.) was computed, and the critical difference (C.D.) at the 5% significance level was calculated for parameters showing significant treatment effects.

**Fig 1:** Rejuvenated Tree**Fig 2:** Non Rejuvenated Tree

Results and Discussion

Fruit retention

Fruit retention per cent at harvest stage was significantly influenced by different plant growth regulator treatments. Among the stages of application (Factor A), treatment P₁

recorded significantly higher fruit retention (0.77%) as compared to P₂ (0.62%). Among the plant growth regulator treatments (Factor B), C₆ recorded the highest fruit retention (0.86%), which was significantly superior to all other treatments.

Table 1: Effect of plant growth regulators on fruit retention per cent per panicle at harvest stage of mango

	Treatment	Fruit retention (%)		
		2023-24	2024-25	Pooled
Factor A (P)	P ₁	0.75	0.79	0.77
	P ₂	0.65	0.59	0.62
	Mean	0.70	0.689	0.693
	S.E. ±	0.02	0.04	0.02
	C.D. at 5%	0.05	0.10	0.06
Factor B (C)	C ₁	0.67	0.62	0.64
	C ₂	0.71	0.67	0.69
	C ₃	0.68	0.70	0.69
	C ₄	0.73	0.67	0.70
	C ₅	0.70	0.68	0.69
	C ₆	0.80	0.93	0.86
	C ₇	0.60	0.57	0.58
	Mean	0.70	0.69	0.69
	S.E. ±	0.03	0.07	0.04
	C.D. at 5%	0.09	0.19	0.1
Factor (A X B)	P ₁ C ₁	0.70	0.66	0.68
	P ₁ C ₂	0.74	0.76	0.75
	P ₁ C ₃	0.72	0.81	0.77
	P ₁ C ₄	0.78	0.76	0.77
	P ₁ C ₅	0.73	0.76	0.74
	P ₁ C ₆	0.87	1.16	1.02
	P ₁ C ₇	0.68	0.62	0.65
	P ₂ C ₁	0.64	0.57	0.60
	P ₂ C ₂	0.67	0.57	0.62
	P ₂ C ₃	0.63	0.58	0.61
	P ₂ C ₄	0.69	0.57	0.63
	P ₂ C ₅	0.67	0.60	0.64
	P ₂ C ₆	0.73	0.69	0.71
	P ₂ C ₇	0.52	0.51	0.52
	Mean	0.70	0.69	0.69
	S.E. ±	0.04	0.09	0.05
	C.D. at 5%	NS	NS	NS

NS: Non Significance

Factor A (P)	P ₁ -Rejuvenated tree (35 year old)	P ₂ -Non Rejuvenated tree (35 year old)
Factor B (C)	C ₁ -Salicylic Acid @1500ppm	C ₅ -CPPU @ 4%
	C ₂ -Salicylic Acid @2000ppm	C ₆ -n-ATCA @ 1ml/l (50% flowering), 1.5ml/L (Marble stage) and 2ml/l (Egg stage)
	C ₃ -KNO ₃ @ 1%	C ₇ -Control
	C ₄ -CPPU @ 3%	

The lowest fruit retention was observed in C₇ (0.58%). Treatment C₆ was followed by C₄ (0.70%), while treatments C₂ (0.69%), C₃ (0.69%) and C₅ (0.69%) were statistically at par with each other and with C₄. Treatment C₁ (0.64%) recorded lower fruit retention than these treatments. The interaction effect (P × C) was found to be non-significant. However, the maximum fruit retention was recorded in P₁C₆ (1.02%), followed by P₁C₃ (0.77%) and P₁C₄ (0.77%), whereas the minimum fruit retention was observed in P₂C₇ (0.52%). The higher fruit retention observed under C₆ treatment might be attributed to reduced fruit drop and improved source-sink relationship resulting from enhanced hormonal balance and assimilate translocation. Similar findings have been reported by Parulekar *et al.*, (2013)^[16], Haldankar *et al.* (2015)^[4] and Dalal *et al.* (2016)^[1] in mango.

Number of fruits per tree

The total number of fruits per tree was significantly influenced by rejuvenation and plant growth regulator treatments. Among the rejuvenation treatments (Factor A), rejuvenated trees (P₁) recorded significantly higher total number of fruits per tree (121.57) compared to non-rejuvenated trees (P₂) that is (101.46). Among the plant growth regulator treatments (Factor B), n-ATCA applied at 1 ml/l at 50% flowering, 1.5 ml/l at marble stage and 2 ml/l at egg stage (C₆) recorded the highest number of fruits per tree (130.79), which was significantly superior to all other treatments. The lowest number of fruits per tree was recorded in the control (93.21).

Table 2: Effect of plant growth regulators on total number of fruits per tree of mango

	Treatment	Total number of fruits per tree		
		2023-24	2024-25	Pooled
Factor A (P)	P ₁	129.24	113.90	121.57
	P ₂	109.33	93.60	101.46
	Mean	119.29	103.75	111.52
	S.E. ±	1.12	1.24	0.88
	C.D. at 5%	3.27	3.60	2.54
Factor B (C)	C ₁	109.08	96.83	102.96
	C ₂	120.58	99.08	109.83
	C ₃	128.75	114.58	121.67
	C ₄	114.67	97.00	105.83
	C ₅	125.58	107.08	116.33
	C ₆	134.58	127.00	130.79
	C ₇	101.75	84.67	93.21
	Mean	119.29	103.75	111.52
	S.E. ±	2.10	2.32	1.64
	C.D. at 5%	6.11	6.73	4.76
Factor (A X B)	P ₁ C ₁	121.50	104.17	112.83
	P ₁ C ₂	130.50	115.83	123.17
	P ₁ C ₃	136.00	126.33	131.17
	P ₁ C ₄	125.33	105.50	115.42
	P ₁ C ₅	133.50	118.17	125.83
	P ₁ C ₆	141.50	133.33	137.42
	P ₁ C ₇	116.33	94.00	105.17
	P ₂ C ₁	96.67	89.50	93.08
	P ₂ C ₂	110.67	82.33	96.50
	P ₂ C ₃	121.50	102.83	112.17
	P ₂ C ₄	104.00	88.50	96.25
	P ₂ C ₅	117.67	96.00	106.83
	P ₂ C ₆	127.67	120.67	124.17
	P ₂ C ₇	87.17	75.33	81.25
	Mean	119.29	103.75	111.52
	S.E. ±	2.97	3.28	2.32
	C.D. at 5%	NS	NS	NS

NS: Non Significance

Factor A (P)	P ₁ -Rejuvenated tree (35 year old)	P ₂ -Non Rejuvenated tree (35 year old)
Factor B (C)	C ₁ -Salicylic Acid @1500ppm	C ₅ -CPPU @ 4%
	C ₂ -Salicylic Acid @2000ppm	C ₆ -n-ATCA @ 1ml/l (50% flowering), 1.5ml/L (Marble stage) and 2ml/l (Egg stage)
	C ₃ -KNO ₃ @ 1%	C ₇ -Control
	C ₄ -CPPU @ 3%	

Treatment C₆ was followed by KNO₃ @ 1% (C₃) which recorded 121.67 fruits per tree. The treatments CPPU @ 4% (C₅) (116.33) and Salicylic Acid @ 2000 ppm (C₂) (109.83). The lowest number of fruits among treated trees were recorded in Salicylic Acid @ 1500 ppm (C₁) that is (102.96) and CPPU @ 3% (C₄) (105.83).

The interaction effect between rejuvenation and plant growth regulator treatments (P × C) was found to be non-significant, indicating that the response of plant growth regulators was similar in both rejuvenated and non-rejuvenated trees. However, numerically the highest number of fruits per tree was observed in P₁C₆ (137.42), followed by

P₁C₃ (131.17) and P₁C₅ (125.83), whereas the lowest number of fruits per tree was recorded in P₂C₇ (81.25). The increased fruit number under n-ATCA treatment attributed to enhanced flowering, improved fruit set, reduced fruit drop and better translocation of photosynthates towards developing fruits. Rejuvenated trees produced more fruits than non-rejuvenated trees due to improved canopy architecture, better light interception, enhanced nutrient utilization and increased production of fruitful shoots.

Similar findings have been reported by Parulekar *et al.*, (2013) ^[16], Haldankar *et al.* (2015) ^[4] and Dalal *et al.* (2016) ^[1] in mango.

Yield (kg/tree)

The data on yield per tree indicated that rejuvenation and plant growth regulator treatments significantly influenced the yield of mango during both years as well as in pooled analysis.

Table 3: Effect of plant growth regulators on yield of fruits per tree of mango

	Treatment	Yield (kg/tree)		
		2023-24	2024-25	Pooled
Factor A (P)	P ₁	32.63	28.92	30.78
	P ₂	27.61	23.76	25.68
	Mean	30.12	26.34	28.23
	S.E. ±	0.29	0.31	0.22
	C.D. at 5%	0.83	0.91	0.64
Factor B (C)	C ₁	30.67	26.47	28.57
	C ₂	32.94	29.40	31.17
	C ₃	34.27	32.06	33.16
	C ₄	31.71	26.79	29.25
	C ₅	33.75	30.00	31.87
	C ₆	35.73	33.85	34.79
	C ₇	29.37	23.87	26.62
	Mean	24.40	22.72	23.56
	S.E. ±	27.93	20.90	24.42
	C.D. at 5%	30.69	26.09	28.39
Factor (A X B)	P ₁ C ₁	30.67	26.47	28.57
	P ₁ C ₂	32.94	29.40	31.17
	P ₁ C ₃	34.27	32.06	33.16
	P ₁ C ₄	31.71	26.79	29.25
	P ₁ C ₅	33.75	30.00	31.87
	P ₁ C ₆	35.73	33.85	34.79
	P ₁ C ₇	29.37	23.87	26.62
	P ₂ C ₁	24.40	22.72	23.56
	P ₂ C ₂	27.93	20.90	24.42
	P ₂ C ₃	30.69	26.09	28.39
	P ₂ C ₄	26.28	22.47	24.38
	P ₂ C ₅	29.69	24.36	27.03
	P ₂ C ₆	32.27	30.64	31.45
	P ₂ C ₇	21.99	19.14	20.57
	Mean	30.12	26.34	28.23
	S.E. ±	0.75	0.82	0.59
	C.D. at 5%	NS	NS	NS

NS: Non Significance

Factor A (P)	P ₁ -Rejuvenated tree (35 year old)	P ₂ -Non Rejuvenated tree (35 year old)
Factor B (C)	C ₁ -Salicylic Acid @1500ppm	C ₅ -CPPU @ 4%
	C ₂ -Salicylic Acid @2000ppm	C ₆ -n-ATCA @ 1ml/L (50% flowering), 1.5ml/L (Marble stage) and 2ml/L (Egg stage)
	C ₃ -KNO ₃ @ 1%	C ₇ -Control
	C ₄ -CPPU @ 3%	

During 2023-24, rejuvenated trees (P₁) recorded significantly higher yield (32.63 kg/tree) than non-rejuvenated trees (P₂) (27.61 kg/tree). Similar results were observed during 2024-25, wherein P₁ recorded significantly higher yield (28.92 kg/tree) compared to P₂ (23.76 kg/tree). The pooled data also revealed that P₁ produced significantly higher yield (30.78 kg/tree) than P₂ (25.68 kg/tree), indicating the beneficial effect of rejuvenation on productivity of old mango trees. These findings are in line with observations of Rai *et al.* (2022) ^[8] who reported that rejuvenation improves source-sink relationship and enhances productivity in old mango orchards.

During the first year (2023-24), treatment C₆ [n-ATCA @ 1 ml/l (50% flowering), 1.5 ml/l (marble stage) and 2 ml/l (egg stage)] recorded the highest yield (35.73 kg/tree) and was significantly superior to all other treatments. It was followed by C₃ (KNO₃ @ 1%) (34.27 kg/tree), C₅ (CPPU @ 4%) (33.75 kg/tree) and C₂ (Salicylic acid @ 2000 ppm) (32.94 kg/tree). The lowest yield was recorded in control (C₇) (29.37 kg/tree).

During the second year (2024-25), C₆ again recorded the highest yield (33.85 kg/tree) and remained significantly superior over the rest of the treatments. It was followed by C₃ (32.06 kg/tree), C₅ (30.00 kg/tree) and C₂ (29.40 kg/tree), while the minimum yield was observed in control (23.87

kg/tree). Similar results were also reported by Deshmukh *et al.* (2017)^[3], Waghmare *et al.* (2021)^[9] and Zhai *et al.* (2026)^[10].

The pooled data showed that C₆ recorded the maximum yield (34.79 kg/tree) and was significantly superior to all other treatments. The next best treatment was C₃ (33.16 kg/tree), followed by C₅ (31.87 kg/tree) and C₂ (31.17 kg/tree). The lowest yield was recorded in control (C₇) (26.62 kg/tree). Treatments C₃, C₅ and C₂ were statistically at par with each other but significantly superior to C₁, C₄ and C₇.



Fig 3: Effect of n-ATCA on Rejuvenated tree of Mango

The interaction effect between rejuvenation and plant growth regulator treatments was found to be non-significant during both years and in pooled analysis, indicating a similar response of growth regulators under rejuvenated and non-rejuvenated trees. However, numerically the highest yield was recorded in P₁C₆ (35.73, 33.85 and 34.79 kg/tree during 2023-24, 2024-25 and pooled data, respectively), followed by P₁C₃ (33.16 kg/tree pooled) and P₁C₅ (31.87 kg/tree pooled). The lowest yield was recorded in P₂C₇ (20.57 kg/tree pooled). Similar studies by Patil *et al.* (2022)^[7] and Deshmukh *et al.* (2023)^[2] have shown that KNO₃ application significantly improves fruit weight and yield in mango by enhancing metabolic efficiency.

The higher yield obtained under n-ATCA treatment may be attributed to enhanced flowering, improved fruit set, greater fruit retention and reduced fruit drop, resulting in increased number of fruits and overall yield. Rejuvenated trees produced higher yield due to improved canopy structure, better light penetration, enhanced nutrient utilization and increased production of productive shoots.

Conclusion

Rejuvenation of Alphonso mango orchard improve flowering intensity of tree which results improvement in flowering behaviours, fruit setting overall development of fruits. The foliar spraying of plant growth regulators that is (P₁C₆) n-ATCA 10% and folic acid 0.2% @ 1 ml/l (50% Flowering), 1.5 ml/l (Marble stage) and 2 ml/l (Egg stage) in rejuvenated mango trees at developmental stages of fruit improve fruit retention (1.02%) and yield (34.79 kg/tree).

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