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Effect of plant growth regulators on yield and quality of mango (*Mangifera indica* L.) cv. Kesha

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Abstract
Studies to evaluate different PGRs *viz*., NAA (40 ppm) and CPPU (10 and 20 ppm) was undertaken at Instructional-Cum-Research Orchard of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The PGRs were sprayed thrice during mango fruit development stages *viz*. at mustard stage, pea stage and at marble stage. The maximum number of fruit per panicle at pea stage (14.54), marble stage (4.39) and fruit harvested per panicle (1.52) was in the treatment T_{10}. The treatment T_{15} (CPPU-20 ppm: at Marble + at pea) increased fruit length (10.56 cm), diameter (6.43 cm) and average fruit weight (328.73 g) indicating superiority of the treatment for increasing yield. The treatment T_8 (CPPU-10 ppm: Pea Satge) produced maximum number of fruit per tree (362.33). Yield of fruit (107 kg/tree and 10.7 t/ha) was maximum in the treatment T_{10}. The quality of fruit in terms of TSS, total sugars, reducing sugars, non-reducing sugars and acidity were non significant. The results in general indicated that the foliar spray of PGRs during mustard, pea and marble stages of fruit development were beneficial for increasing yield of mango cv. Keshar. Application of PGRs at mustard + pea stage was found effective in increasing fruit number and weight than single application at any stage. Among the different PGRs and stages of application, CPPU 10 ppm at mustard + pea stage recorded maximum yield 107.00 kg/tree and 10.7 t/ha.

Keywords: Mango, plant growth regulators, CPPU, NAA, fruit drop

1. Introduction
Mango (*Mangifera indica* L.) occupies a pre-eminent place amongst the fruit crops grown in India. Due to its wide adaptability, high nutritive value, richness in variety, delicious taste, pleasant flavor, attractive appearance, it enjoys the unique popularity among the masses and classes. Keshar, is a leading mango variety of Gujarat and Maharashtra with a red blush on the shoulders. This variety has export potential. It is observed that, the farmers under western Maharashtra conditions are facing problems of low fruit set, fruit drop and poor quality in terms of size of fruit. Fruit drop is one of the major problems contributing to low yield in mango trees. Deficiency of auxins, gibberellins and cytokinins as well as high level of inhibitors appears to be the cause of fruit drop in mango trees (Krisanapook *et al*., 2000) [7]. Plant growth regulators have primitive role in minimizing fruit drop at different stages. Plant growth regulators have potential to enhance productivity of fruits by bringing out a change in nutritional and hormonal status of the plant (Tripathi *et al*., 2006) [16]. Naphthalene acetic acid and CPPU are fruit drop-reducing PGR. Many investigators found that, spraying mango trees with NAA at different concentrations increased fruit set percentages and fruit retention CPPU, like their natural analogs, is known for promoting cell division and is therefore used for increasing fruit growth. CPPU increased fruit retention in different mango cultivars and growing regions (Burondkar *et al*., 2009 and Notodimedjo, 2000) [4].
Considering the problem of fruit drop and fruit setting, the investigation was carried out to study the effect of different PGRs *viz*., NAA (40 ppm) and CPPU (10 and 20 ppm) on fruiting, yield and quality characters of mango cv. Keshar

2. Material and Methods
The experiment was conducted on 25 years old, healthy and vigorous and uniformly grown mango trees of cv. Keshar at Instructional-Cum-Research Orchard of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri in a Randomized Block Design with Sixteen treatments and three replications with two trees per treatment during the year 2015-16. The trees without any treatment served as control. The PGRs NAA 40 ppm, CPPU10 ppm and CPPU 20 ppm were sprayed thrice at mustard, pea and marble either or at all stages of fruit development. The observations were recorded on fruiting, physioc-chemical parameters and yield.

Treatment details

Treatment No.	Treatment details	Stage	No.of sprays
T_1	Control (Water spray)	M+P+MB	3 sprays
T_2	NAA - 40 ppm	Mustard stage	1 spray
T_3	NAA - 40 ppm	Pea stage	1 spray
T_4	NAA - 40 ppm	Marble stage	1 spray
T_5	NAA - 40 ppm	M+P	2 sprays
T_6	NAA - 40 ppm	M+P+MB	3 sprays
T_7	CPPU-10 ppm	Mustard stage	1 spray
T_8	CPPU-10 ppm	Pea stage	1 spray
T_9	CPPU-10 ppm	Marble stage	1 spray
T_{10}	CPPU-10 ppm	M+P	2 sprays
T_{11}	CPPU-10 ppm	M+P+MB	3 sprays
T_{12}	CPPU-20 ppm	Mustard stage	1 spray
T_{13}	CPPU-20 ppm	Pea stage	1 spray
T_{14}	CPPU-20 ppm	Marble stage	1 spray
T_{15}	CPPU-20 ppm	M+P	2 sprays
T_{16}	CPPU-20 ppm	M+P+MB	3 sprays

M: Mustard stage, P: Pea stage. MB: Marble stage

Result and Discussion

Fruiting characters

The different treatments of PGRs had statistically significant effect on fruiting characters fruits set per panicle at pea stage, marble stage and number of fruits retained per panicle at harvest. The number of fruit per panicle at pea stage was significantly influenced by different treatments over control. It was maximum in treatment T_{10} (14.54) and was at par with T_8 (13.87) and the minimum in control (7.91).

The number of fruit per panicle at marble stage was significantly maximum in T_{10} (4.39) and lowest number of fruit (2.37) was in control. The more number of fruit per panicle were in treatment T_{10} (1.52) and were minimum in control (0.85).

The fruit drop is natural phenomenon. The naturally occurring hormones play a major role in fruit growth and fruit drop of mango. Deficiency of auxins, gibberellins and cytokinins coupled with a high level of growth inhibitors i.e. abscissic acid and ethylene cause fruit drop In fact, when the concentrations of abscissic acid and ethylene increase in the panicle, as a result abscission layer is formed at the site of fruit attachment, which ultimately drops down. The exogenous application of NAA growth regulator increases their concentration in the panicle and antagonises the adverse effects of endogenous inhibitors.

Burondkar *et al*. (2009) [9] showed a positive effect of CPPU on leaf chlorophyll content in mango, it can be deduced that leaf net photosynthesis and subsequently the amount of carbohydrates available in support of fruit growth were also increased and this in turn might have prevented fruit drop. In addition, cytokinins promote vascular tissue differentiation, therefore increasing the transport capacity of resources into the fruit, which might have strengthened CPPU-treated fruits and thus reduced fruit drop.

Guirguis *et al*. (2010) [6] reported promoting effect on fruit set and retention by reducing ABA content, thus the application of NAA and CPPU at different concentrations and at different time of application were beneficial to increase fruit set at pea and marble stage and ultimately for fruit retention at harvest than control. Similar results were obtained by Pujari *et al*. (2016) [11] in Alphonso mango and Bhamare *et al*. (2014) [2] in mango cv. Mallika.

Yield parameters

The maximum number of fruit was recorded in T_8 (362.33) however, minimum number of fruit was recorded in control (258.33). The optimum supply of PGRs to the bearing mango trees helps in retaining more number of fruits. The increase in number of fruit is due to supply of CPPU at different fruit growth stages. CPPU application increases fruit set and fruit retention which ultimately increases number of fruits. CPPU increases fruit set in mango.

The significantly maximum average weight of fruit was recorded in T_{15} (328.73) and was followed by treatment T_{14} (314.17). The Minimum weight of fruit was recorded in control (257.69). Any increase in length, width and thickness of fruit brought a corresponding increase in weight of fruit. This result accepted the hypothesis that, the fruit weight is a function of length, width and thickness of fruit. The possible explanation for increase in fruit size and weight was also due to faster movement of simple sugars into fruit and involvement in cell expansion (Brahmachari *et al.*, 1997). CPPU increases cell size and is also responsible for the production and transport of plant sugars that increased the weight of fruit (Singh *et al*., 2008). Thus, increase in size ultimately increased the fruit weight. Similar results were also reported by Notodimedjo (1999) [9] in mango cv. Arumanis.

The significantly maximum fruit yield was recorded in treatment T_{10} (107 kh/tree & 10.70 t/ha). The minimum fruit yield was recorded in control (66.47) and it was at par with the treatments T_4 (78.49) and T_2 (80.27).

The maximum yield per hectare was recorded in the treatment T_{10} (10.7).It was followed by T_8 (10.38) and T_8 was at par with the treatments T_5 (10.09), T15 (9.96), T_{11} (9.90), T_3 (9.35), T_6 (9.30), T16 (8.73) and T_9 (8.69). The minimum yield per hectare was recorded in control (6.64). The higher number of fruit in the treatment T_8 and T_{10} with little less average fruit weight resulted in higher yield/tree and thereby per ha). Singh (2005) [14] stated that the improvement in fruit yield is related to the increase in fruit retention/panicle and fruit size.

The possible means for increasing fruit retention and number of fruit per tree are explained earlier and could be same for increasing yield. The results are in agreement with the findings of Singh *et al*. (1994) [13] in mango in cv. Langra.

Physical parameters

The length of fruit was in the range of 9.18 to10.56 cm. The maximum length of fruit was recorded in T_{15} (10.56 cm), whereas minimum length of fruit was recorded in control

(9.18)

On perusal of data, it is seen that the results obtained in respect of fruit breadth were similar to those observed in case of fruit length. The breadth of fruit was in the range of 5.33 to 6.43 cm. The significantly maximum breadth of fruit was recorded in T_{15} (6.43) The minimum breadth of fruit was recorded in T_1 control (5.33).

An exogenous application of CPPU acts early cell division in the fruit and also on subsequent growth. Thus, fruit becomes bigger in size due to efficient cells, the building blocks of fruit mass and also because the cells have been able to attract so much water, minerals and carbohydrates that enable the fruit to expand to large size (Kano, 2003). Similar results were also reported by Greene (2001) [5] in McIntosh apple and Said (2002) [15] on Anna apple, Stern *et al.* (2002) [15] on pear and Nampila *et al.* (2010) [8] on grape.

Quality parameters

Total soluble solids (%)

It is observed that the differences due to different treatments were non significant in respect of TSS. The TSS of fruit was in the range of 18.97 to 20.99 per cent. The maximum T.S.S of fruit was recorded in treatment T_{14} (20.99). The minimum T.S.S of fruit was recorded (18.97) in the treatment T_2.

Acidity (%)

It is revealed from the data that the results were non significant. The lowest acidity was recorded in treatment T_{10} (0.25) while, the highest acidity was recorded in control (0.31).

Total sugars (%)

It is has been found that the different PGRs had not significant effect on total sugars content of mango pulp. The maximum total sugar was recorded in T_{15} (15.66) and the minimum total sugars was recorded in T_{10} (14.91).

Reducing sugars (%)

The results were non significant for reducing sugars. The maximum reducing sugars 5.25 was recorded in T_{10} while minimum reducing sugars 4.57 was recorded in T_3.

Non reducing sugars (%)

As regards non reducing sugars results were non significant. The maximum non reducing sugars were recorded (10.15) in T_{15} while the minimum reducing sugars 9.12 were recorded in T_1 (control).

It is revealed from the results that, there is non significant difference between quality parameters due to spraying of PGRs at different stages of fruit development.

Generally quality parameters are genetically controlled. Exposure of fruit tree to adverse climatic conditions may alter the quality parameter of fruit like colour, flavour, TSS, Acidity, Sugars etc. upto the certain level. No such a vibrating conditions were recorded during experiment conduct.

PGRs like NAA, cytokinins are more prone to the retention of fruit i.e. minimizing fruit drop by increasing auxin level and had less or non significant role in improving quality like TSS, Sugars, Acidity etc. Similar results were observed by Pujari *et al*. (2016) [11] in Alphanso mango while evaluating effect of CPPU on fruit retention and post harvest quality of fruit and Patterson *et al.* (1993) [10] in kiwi fruit and Ahmed and Abdel Aal (2007) [1] in pear fruit.

4. Conclusion

On the basis of present investigation the following conclusion can be drawn. That, there was improvement in fruit retention and yield of mango fruit due to application of plant growth regulators. Application of PGRs (NAA and CPPU) was found to be beneficial for increasing yield of mango cv. Keshar. Application of PGRs at mustard + Pea stage were found effective in increasing number of fruit and weight of fruit than single application at any stage. Among the different PGRs and stages of application, CPPU 10 ppm at mustard + pea stage recorded maximum fruit yield 107.00 kg/tree and 10.70 t/ha of mango cv. Keshar.

Table 1: Effect of Plant growth regulators on number of fruit retained per panicle in mango cv. Keshar

Tr. No.	Treatments details	Number of fruit per panicle at		Number of fruit retained per panicle at
		Pea stage	Marble stage	Harvest
T_1	Control (Water)	7.91	2.46	0.85
T_2	NAA - 40 ppm (M)	10.52	3.27	1.13
T_3	NAA - 40 ppm (P)	12.38	3.84	1.33
T_4	NAA - 40 ppm (MB)	10.24	3.18	1.10
T_5	NAA - 40 ppm (M+P)	12.97	4.03	1.39
T_6	NAA - 40 ppm (M+P+MB)	10.70	3.32	1.15
T_7	CPPU- 10 ppm (M)	11.85	3.68	1.27
T_8	CPPU- 10 ppm (P)	13.87	4.31	1.49
T_9	CPPU- 10 ppm (MB)	10.30	3.20	1.10
T_{10}	CPPU- 10 ppm (M+P)	14.54	4.39	1.52
T_{11}	CPPU- 10 ppm (M+P+MB)	11.48	3.56	1.23
T_{12}	CPPU- 20 ppm (M)	11.54	3.58	1.24
T_{13}	CPPU- 20 ppm (P)	12.66	3.96	1.37
T_{14}	CPPU- 20 ppm (MB)	10.36	3.22	1.11
T_{15}	CPPU- 20 ppm (M+P)	10.48	3.26	1.12
T_{16}	CPPU- 20 ppm (M+P+MB)	10.39	3.23	1.11
	S.E.±	0.22	0.22	0.09
	CD at 5%	0.64	0.63	0.28

M: Mustard stage P: Pea stage MB: Marble stage

Table 2: Effect of plant growth regulators on physical characters and yield parameters of mango fruits cv. Keshar

Tr. No.	Treatments details	Average length of fruit (cm)	Average breadth of fruit (cm)	Fruit number (tree^{-1})	Average weight of fruit (g)	Fruit yield (kg tree^{-1})	Fruit yield (t ha^{-1})
T_1	Control (Water)	9.18	5.33	258.33	257.69	66.47	6.64
T_2	NAA - 40 ppm (M)	9.37	5.43	306.00	262.86	80.27	8.02
T_3	NAA - 40 ppm (P)	9.87	5.50	340.33	275.01	93.59	9.35
T_4	NAA - 40 ppm (MB)	9.93	5.63	284.33	276.65	78.49	7.84
T_5	NAA - 40 ppm (M+P)	9.73	6.00	348.33	290.27	100.90	10.09
T_6	NAA - 40 ppm (M+P+MB)	9.83	5.80	322.67	288.65	93.08	9.30
T_7	CPPU- 10 ppm (M)	9.47	5.34	335.67	280.51	94.17	9.41
T_8	CPPU- 10 ppm (P)	9.63	5.70	362.33	285.38	103.8	10.38
T_9	CPPU- 10 ppm (MB)	10.33	6.03	290.00	296.40	86.94	8.69
T_{10}	CPPU- 10 ppm (M+P)	10.13	5.73	361.00	299.12	107.00	10.70
T_{11}	CPPU-10 ppm(M+P+MB)	10.40	5.60	331.33	299.77	99.06	9.90
T_{12}	CPPU- 20 ppm (M)	10.07	6.10	332.33	285.23	94.59	9.45
T_{13}	CPPU- 20 ppm (P)	10.37	5.67	346.33	286.52	98.85	9.88
T_{14}	CPPU- 20 ppm (MB)	10.53	6.23	300.00	314.17	94.10	9.41
T_{15}	CPPU- 20 ppm (M+P)	10.56	6.43	305.67	328.73	99.62	9.96
T_{16}	CPPU-20 ppm(M+P+MB)	10.03	5.83	300.00	291.79	87.30	8.73
	S.E.±	0.28	0.16	22.42	9.69	6.73	0.67
	CD at 5%	0.83	0.47	64.70	27.95	19.42	1.94

M: Mustard stage P: Pea stage MB: Marble stag

Table 3: Effect of plant growth regulators on quality parameters of mango fruits cv. Keshar

Tr. No.	Treatments details	TSS (%)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)
T_1	Control (Water)	19.02	0.31	15.05	4.65	9.12
T_2	NAA - 40 ppm (M)	18.97	0.30	15.10	4.63	9.95
T_3	NAA - 40 ppm (P)	19.38	0.28	15.01	4.57	9.66
T_4	NAA - 40 ppm (MB)	19.86	0.30	15.55	4.85	9.80
T_5	NAA - 40 ppm (M+P)	19.26	0.26	14.69	4.99	9.21
T_6	NAA - 40 ppm (M+P+MB)	20.19	0.27	15.60	4.90	9.83
T_7	CPPU- 10 ppm (M)	19.84	0.28	15.25	5.02	9.72
T_8	CPPU- 10 ppm (P)	18.98	0.26	15.22	4.94	9.29
T_9	CPPU- 10 ppm (MB)	19.97	0.29	15.17	5.03	9.64
T_{10}	CPPU- 10 ppm (M+P)	20.15	0.25	14.91	5.25	9.17
T_{11}	CPPU- 10 ppm (M+P+MB)	19.14	0.27	15.62	5.17	9.93
T_{12}	CPPU- 20 ppm (M)	19.86	0.29	15.10	4.97	9.62
T_{13}	CPPU- 20 ppm (P)	20.04	0.28	15.28	5.10	9.53
T_{14}	CPPU- 20 ppm (MB)	20.99	0.26	14.97	5.04	9.43
T_{15}	CPPU- 20 ppm (M+P)	20.60	0.26	15.66	4.98	10.15
T_{16}	CPPU- 20 ppm (M+P+MB)	20.51	0.29	15.53	4.93	10.07
	S.E.±	0.44	0.02	0.26	0.22	0.349
	CD at 5%	NS	NS	NS	NS	NS

M: Mustard stage P: Pea stage MB: Marble stage

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