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Effect of different growth retardants on fruit maturity and yield of mango (*Mangifera indica* L.) Cv. Keshar

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Abstract
The trees were sprayed with three growth retardants with three concentrations (G_1, paclobutrazol @ C_1: 1000, C_2: 2000 and C_3: 3000 ppm, G_2, cycocel @ C_1: 2000, C_2: 3000 and C_3: 4000 ppm and G_3, ethrel @ C_1: 100, C_2: 200 and C_3: 300 ppm) and were applied three times (D_1: Last week of September, D_2: Second week of October and D_3: Last week of October). The observations for total number of days required for fruit maturity and yield and yield contributing parameters were recorded. The maximum yield per hector (12.9 t.) was recorded in treatment G_2C_2 (cycocel @ 3000 ppm). The mean days required for maturity were less in treated trees (107.44) than control (123.50). Overall results indicated that foliar application of cycocel @ 3000 ppm during last week of September was more effective in improving fruiting and yield of mango cv. Keshar under western Maharashtra conditions.

Keywords: Keshar mango, paclobutrazol, cycocel, ethrel, fruit maturity, yield

Introduction
Mango (*Mangifera indica* L.) is one of the oldest tropical fruit which is rightly known as "King of Fruits". It has intimate association with cultural religious, aesthetic and economic lives of Indians Since time immemorial and hence it is the national fruit of India. India is the major producer of mango in the world with an area of 1.96 million ha with annual production of 226.3 million tones and productivity of 8.7 MT per hectare which is far below than world average, in India mango occupies about 34.9 per cent of the total area under fruits covering all the state. In Maharashtra area under mango cultivation is 0.15 million hectares area is under mango cultivation with 5.14 million tones mango production and 4.8 MT per hectare productivity. Anon [1]

Keshar is the most popular and important commercial cultivar and also leading variety for export. It is also preferred variety for mango pulp processors. The area under Keshar variety is increasing not only in Gujarat but also in nearby states like Maharashtra, Madhya Pradesh, and Rajasthan. Keshar is vigorous in terms of vegetative growth. Hence growth retardants or other chemicals are necessary for inducing early flowering, higher fruit set and greater yield per plant.

Plant growth retardants like paclobutrazol, cycocel, ethrel etc., control tree growth and effective in increasing number of panicles per shoot, fruit set and improved fruit quality. Paclobutrazol is a synthetic plant growth regulator, which is a known antagonist of the plant hormone gibberellin and can be applied to trees as a foliar spray or as soil drench. Cycocel significantly retard linear increase of shoots in young plants. It brings about a reduction in gibberellin production in young leaves which in turn results in a reduced output of auxin from the apical meristem and consequently cycocel treated plants are more compact with shorter internodes, stronger stems, and greener leaves. Ethrel release ethylene gas when it comes in to contact with the plants tissues in turn triggering the mechanism of flowering and also may be due to breaking of dormancy of shoots.

Materials and Methods
The present study was carried out at the Instructional cum Research Farm C.C., Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. This area falls in semi-arid and sub-tropical zone having annual mean maximum temperature of 32 ºC. The range between 24.4 ^{0}C to 40.5 ^{0}C and annual mean minimum temperature is 17.6 ^{0}C with an annual average rainfall of

520 mm. However, the precipitation is erratically distributed in 15 to 45 days in different years. Most of the rainfall is received through South West Monsoon.

Twenty five years old, mango orchard of cv. Keshar planted at 10m x 10m distance was selected for the experiment. The experiment was conducted in a Factorial Randomized Block Design with 28 treatments (27 treatment combinations and one control) and two replications with two trees per treatment. Trees were sprayed with three chemicals (growth retardants) with three concentrations (G_1, paclobutrazol @ C_1: 1000, C_2: 2000 and C_3: 3000 ppm, G_2, cycocel @ C_1: 2000, C_2: 3000 and C_3: 4000 ppm, G_3, ethrel @ C_1: 100, C_2: 200 and C_3: 300 ppm) and were applied three time of application (D_1: Last week of September, D_2: Second week of October and D_3: Last week of October).

The observations for total number of days required for fruit maturity and yield and yield contributing parameters were recorded. The number of days required from fruit set to harvesting of fruit was recorded. The observations on physical parameters were recorded at every harvesting and averages were computed.

Results and Discussion

The present investigation was carried with a view to standardize time and dose of chemicals (growth retardants) through foliar application for yield and quality in mango. The data was analyzed in FRBD and is presented an effect of individual factor as well as for the interactions. It was observed that the tree way interaction was significant only in length of fruit. It was also observed that two way interactions for all observations were not statistically significant. The significant two way interaction with respect to number of fruit per tree, yield per tree, and yield per hectare, length and diameter of fruit are presented. Furthermore data on mean of all treatments was compared with control and is presented.

Total number of days required for fruit maturity

The data revealed significant differences in days required for fruit maturity due to treatments i.e. date of application, growth retardant and concentration recorded significant.

It is observed from Table 1 that, minimum (102.78) days required for fruit maturity was recorded in treatment D_1 (spraying during last week of September) irrespective of growth retardant and its concentration. While considering growth retardant treatment, the minimum (106.61) days required for fruit maturity was recorded in treatment G_1 (Paclobutrazol) which was at par with G_2 (Cycocel) (106.72). In case of level of concentration, the minimum (107.06) days required for fruit maturity was recorded in treatment C_1 (Lower level of concentrations).

It is observed from Table 6 that mean days required for fruit maturity in all treatments was minimum (107.44) than control (123.50). It indicates the effectiveness of treatments than control. It was revealed that the chemicals (growth retardants) were effective in minimizing the days required for maturity rather than type and concentration of growth retardants. The foliar application of paclobutrazol resulted in hastened the maturity by 16-17 days than the normal harvest period in control. It might be due to the early and profuse flowering response to paclobutrazol treatment which was received earlier than flowering. It is probable that the application of chemical caused an early reduction of endogenous gibberllins level within the shoots as observed by Anon [2]. causing them to reach maturity earlier than those of untreated trees.

Number of fruit per tree

The data revealed significant differences in number of fruit due to treatments i.e. date of application, chemicals (growth retardants) and concentration (Table 1). The significantly maximum number of fruit (409.9) were recorded in D_1 (spraying during last week of September). The maximum number of fruit (410.1) were recorded in G_2 (Cycocel) followed by G_1 (Paclobutrazol) (404.0) and these treatments were at par. Considering different levels of concentration of chemical, maximum number of fruit (411.6) were recorded in C_2 (middle level of concentrations) followed by C_3 (Higher level of concentrations) (398.8) and these treatments were at par.

However, interaction effects were recorded to be non-significant, except interaction effects of chemicals (growth retardant) and concentration. The data presented in Table 2 revealed that the maximum numbers of fruit (446.2) were recorded in G_2C_2 (Cycocel @ 3000 ppm). It was followed by G_1C_2 (Paclobutrazol @ 2000 ppm) (420.0) and G_2C_3 (Cycocel @ 4000 ppm) (410.8) and these treatments were at par.

The Table no. 6 shows that, mean number of fruit of all treatments was higher (397.6) than control (327.5). Thus, indicates prevalence of treatments over control. The application of growth retardants particularly cycocel and paclobutrazol have prominent role in minimizing vegetative growth and thereby regulating or increasing food supply to the fruit. This helps in increasing fruit set, retention and yield. Cycocel and paclobutrazol application increases, higher number of hermaphrodite flowers is due to maintenance of physiological concentration of auxins in plant tissues which resulted in increased flowering. This might have been improved fruit set and fruit retention which ultimately increased number of fruit. The similar results were obtained by Choudhari *et al.* [3] and Kulkarni [4].

Average weight of fruit (g)

The data from Table 1 revealed that individual and interaction effects were recorded non significant. However maximum weight (289.5 g, 293.4 g, 293.1 g) were recorded in spraying of chemicals during last week of October, Cycocel higher level of concentrations respectively. It is important to note that the mean weight of fruit of all treatments was maximum (286.0 g) than control (247.5 g) i.e.by 38.5 g improve the weight of fruit and there by yield. It indicates the efficiency of treatments over control.

Increased fruit weight was recorded in cycocel treatment. The increase in fruit weight with the application of cycocel may be attributed to cessation or suppression of vegetative growth led to diversion of metabolites and photosynthates to fruit. Similarly increased level of carbohydrates by cycocel application might be another reason for improvement in fruit weight (Singh and Phogat) [5]. Higher fruit weight under paclobutrazol treatments may be attributed to the earliness in flowering which provided higher number of growing days and biomass accumulation under treatments (Sharma *et al.* 2011) [6].

Average length of fruit (cm)

The data presented in Table 1 revealed significant differences due to chemicals (growth retardants) only i.e. Maximum length of fruit (9.5 cm) was recorded in G_2 (Cycocel) followed by G_1 (Paclobutrazol) (9.4 cm), G_3 (Ethrel) (9.4 cm) and these treatments were at par with each other.

It was observed from Table 3 that the interaction effects of date of application and chemicals (growth retardants), date of

application and concentrations, growth retardant and concentration were recorded significant. In interaction of date of application and chemicals (growth retardants) maximum length (9.8 cm) was recorded in interaction of D_1G_2 (spraying during last week of September with Cycocel) followed by D_1G_1 (spraying during last week of September with Paclobutrazol) (9.7 cm) and D_2G_3 (spraying during second week of October with Ethrel) (9.6 cm) these treatments were at par. In interaction of date of application and concentration the maximum length of fruit (9.9 cm) was recorded in D_1C_2 (spraying during last week of September, Middle level of concentration). In interaction of chemicals (growth retardant) and concentration maximum length (9.7 cm) was recorded in G_2C_2 (Cycocel @ 3000 ppm) it was followed G_1C_1 (Paclobutrazol @ 1000 ppm) (9.5 cm), G_2C_3 (Cycocel @ 4000 ppm) (9.5 cm) and G_3C_3 (Ethrel @ 300 ppm) (9.5 cm) and these treatments were at par.

It is observed from Table 4 the interaction effects of date, chemicals (growth retardant) and concentration were recorded significant. Maximum length of fruit (10.2cm) was observed in $D_1G_2C_2$ (Spraying during last week of September, Cycocel @ 3000 ppm) followed by $D_1G_1C_2$ (Spraying during last week of September, Paclobutrazol @ 2000 ppm) (10.1cm), $D_1G_1C_1$ (Spraying during last week of September, Paclobutrazol @ 1000 ppm) (9.8cm) and these treatment were at par.

The mean length of fruit of all treatments (Table 6) was higher (9.4 cm) than control (8.9 cm). It indicates superiority of treatments over control.

Average diameter of fruit (cm)

The data presented Table 1 revealed significant differences due to chemicals (growth retardant) and concentration. The maximum diameter of fruit (6.4 cm) was recorded in G_1 (Paclobutrazol) and G_2 (Cycocel). When we consider level of chemical concentration, significantly maximum diameter of fruit (6.5 cm) was recorded in C_2 (Middle level of concentration). The non-significant differences were recorded with respect to date of application. However, maximum diameter of fruit was recorded in D_1 (Spraying during last week of September).

Significant differences were observed in interaction effect of date of application and concentration, chemicals (growth retardants) and concentrations, presented in Table 5. The maximum diameter of fruit (6.9 cm) was recorded in D_1C_2 (spraying during last week of September, middle level of concentration). Maximum diameter of fruit (6.7 cm) was recorded in G_1C_2 (Paclobutrazol @ 2000 ppm) followed by G_2C_2 (Cycocel @ 3000 ppm) (6.6cm) and G_2C_3 (Cycocel @ 4000 ppm) (6.6cm) and these treatments were at par.

It is observed from Table 6 that the mean diameter of fruit of all treatments was higher (6.4 cm) than control (5.6 cm). Thus, indicating that any of the treatments was superior over control. The maximum fruit size in terms of length and diameter due to cycocel application might be due to increased level of carbohydrates. Cycocel might have stimulate cell division and cell elongation resulting in larger fruit size as reported by Singh and Phogat [5] and Thakur *et al.* [7] in litchi. Paclobutrazol influences the fruit size. As fruit growth and final size, results from the accumulation of dry matter and water. It is determined by the sink strength of the fruit and the supply of metabolites. The sink strength of fruit measures its potential capacity to accumulate assimilates. This increase in the sink strength results in an increase in final fruit size. Metabolite supply depends on their availability in the tree and on intersink competition. Thus in present investigation the efficiency of cycocel, paclobutrazol and their concentration has been recognized.

Yield/tree (kg)

The data revealed significant differences due to chemicals (growth retardant) and concentration. It is observed from Table 1 that the maximum yield per tree (120.2 kg) was recorded in G_2 (Cycocel) it was followed by G_1 (Paclobutrazol) (115.7kg) and these treatments were at par. While considering levels of concentrations, the maximum yield per tree (118.0 kg) was recorded in C_2 (Middle level of concentrations) it was followed by C_3 (Higher level of concentrations) (116.9 kg) and these treatments were at par.

Interaction effects were recorded significant in interaction of chemicals (growth retardants) and concentration. It is observed from Table 2 that maximum yield per tree (128.6 kg) was recorded G_2C_2 (Cycocel @ 3000 ppm) it was followed by G_2C_3 (Cycocel 4000 ppm) (121.8kg), G_1C_2 (Paclobutrazol @ 2000 ppm) (120.5kg), G_3C_3 (Ethrel @ 300 ppm) (117.1kg), G_1C_1 (Paclobutrazol @ 1000 ppm) (114.9kg) and these treatments were at par.

It is observed from Table 6 that mean yield per tree of all treatments was maximum (113.6 kg) than control (93.9 kg). Thus, indicating that any of the treatments was superior over control.

Yield/ha (t)

The data presented Table 1 revealed significant differences due to chemicals (growth retardant) and concentration. The maximum yield per hectare (12.0 t) was recorded in G_2 (Cycocel). In case of concentration levels, the mximum yield per hectare (11.8 t) was recorded in C_2 (Middle level of concentrations) it was followed by C_3 (Higher level of concentrations) (11.7 t) and these treatments are at par.

The data revealed significant differences were recorded in interaction of chemicals (growth retardants) and concentration. It is observed from Table 2 that the maximum yield per hectare (12.9 t) was recorded G_2C_2 (Cycocel @ 3000 ppm) it was followed by G_2C_3 (Cycocel 4000 ppm) (12.2 t), G_1C_2 (Paclobutrazol @ 2000 ppm) (12.1 t), G_3C_3 (Ethrel @ 300 ppm) (11.7 t), G_1C_1 (Paclobutrazol @ 1000 ppm) (11.5 t) and these treatments were at par.

It is observed from Table 6 that the mean yield per hectare of all treatments was maximum (11.4 t) than control (9.4 t). Thus, indicating that any of the treatments was superior over control. Yield is a product of number of fruit and average weight of fruit. The data revealed higher number of fruit in trees as compared to control. The significant differences within the treatments were also recorded. However, the non significant differences within the treatments in weight of fruit were recorded. Thus, the increase in yield per tree (128.6 kg) and thereby per hector (12.9 t.) could be resulted due to higher number of fruit as a major factor. The improvement in yield is related to increase in fruit set, retention per panicle at maturity stage and there by number of fruit per tree (Chaudhari *et al.*) [3]. The possible means for increase in fruit set and number of fruit per tree are explained earlier and could be same for increasing yield.

Table 1: Effect of individual factor on number of days required for fruit maturity and yield parameters

	Treatment	Number of days required for fruit maturity	Number of fruits/ tree	Average weight of fruit (g)	Average length of fruit (cm)	Average diameter of fruit (cm)	Yield/ tree (kg)	Yield/ ha (t)
A.	**Date**							
	D_1 : Last week of September	102.78	409.9	280.5	9.6	6.5	115.0	11.5
	D_2 : Second week of October	107.22	401.7	287.9	9.4	6.4	115.5	11.6
	D_3 : Last week of October	112.33	381.2	289.5	9.2	6.2	110.4	11.0
	S.E. +	0.29	7.5	5.9	0.03	0.04	2.8	0.3
	CD at 5%	0.82	21.0	NS	NS	NS	NS	NS
B.	**Chemicals(growth retardant)**							
	G_1 : Paclobutrazol	106.61	404.0	286.7	9.4	6.4	115.7	11.6
	G2 : Cycocel	106.72	410.1	293.4	9.5	6.4	120.2	12.0
	G3 : Ethrel	109.00	378.8	277.8	9.4	6.3	105.0	10.5
	S.E. +	0.29	7.5	5.9	0.0	0.0	2.8	0.3
	CD at 5%	0.82	21.0	NS	0.1	0.1	7.9	0.8
C.	**Concentration of chemicals**							
	C_1 : Lower level of Concentration	107.06	382.5	275.7	9.4	6.3	106.0	10.6
	C_2 : Middle level of Concentration	107.17	411.6	289.1	9.5	6.5	118.0	11.8
	C_3 : Higher level of Concentration	108.11	398.8	293.1	9.4	6.3	116.9	11.7
	S.E. +	0.29	7.5	5.9	0.0	0.0	2.8	0.3
	CD at 5%	0.82	21.0	NS	NS	0.1	7.9	0.8

Table 2: Interaction effects of two factors on number of fruit per tree, yield per tree and yield per ha

Treatment (B x C) (Growth retardant x concentration)	Number of fruits/ tree	Yield/ tree (kg)	Yield/ ha(t)
G_1C_1	405.0	114.9	11.5
G_1C_2	420.0	120.5	12.1
G_1C_3	387.0	111.8	11.2
G_2C_1	373.5	110.3	11.0
G_2C_2	446.2	128.6	12.9
G_2C_3	410.8	121.8	12.2
G_3C_1	369.1	92.9	9.3
G_3C_2	368.6	104.8	10.5
G_3C_3	398.7	117.1	11.7
S.E. +	13.0	4.9	0.5
CD at 5%	36.3	13.7	1.4

Table 3: Interaction effects of two factors on length of fruit

Treatment (A x B)	Average length of fruit (cm)	Treatment (A x C)	Average length of fruit (cm)	Treatment (B x C)	Average length of fruit (cm)
Date of application x Growth retardant		**Date of application x concentration**		**Growth retardant x concentration**	
D_1G_1	9.7	D_1C_1	9.6	G_1C_1	9.5
D_1G_2	9.8	D_1C_2	9.9	G_1C_2	9.4
D_1G_3	9.4	D_1C_3	9.4	G_1C_3	9.2
D_2G_1	9.3	D_2C_1	9.6	G_2C_1	9.4
D_2G_2	9.4	D_2C_2	9.4	G_2C_2	9.7
D_2G_3	9.6	D_2C_3	9.3	G_2C_3	9.5
D_3G_1	9.2	D_3C_1	9.2	G_3C_1	9.4
D_3G_2	9.3	D_3C_2	9.1	G_3C_2	9.3
D_3G_3	9.2	D_3C_3	9.5	G_3C_3	9.5
S.E. $\pm$	0.1	S.E. $\pm$	0.1	S.E. $\pm$	0.1
CD at 5%	0.2	CD at 5%	0.2	CD at 5%	0.2

Table 4: Interaction effects of three factors on length of fruit

Treatment (A x B x C) (Date of application x growth retardant x concentration)	Average length of fruit (cm)	Treatment (A x B x C) (Date of application x growth retardant x concentration)	Average length of fruit (cm)
$D_1G_1C_1$	9.8	$D_2G_2C_3$	9.4
$D_1G_1C_2$	10.1	$D_2G_3C_1$	9.8
$D_1G_1C_3$	9.1	$D_2G_3C_2$	9.6
$D_1G_2C_1$	9.7	$D_2G_3C_3$	9.3
$D_1G_2C_2$	10.2	$D_3G_1C_1$	9.1

$D_1G_2C_3$	9.6	$D_3G_1C_2$	9.3
$D_1G_3C_1$	9.3	$D_3G_1C_3$	9.4
$D_1G_3C_2$	9.5	$D_3G_2C_1$	9.4
$D_1G_3C_3$	9.5	$D_3G_2C_2$	9.2
$D_2G_1C_1$	9.7	$D_3G_2C_3$	9.5
$D_2G_1C_2$	9.0	$D_3G_3C_1$	9.1
$D_2G_1C_3$	9.2	$D_3G_3C_2$	8.8
$D_2G_2C_1$	9.3	$D_3G_3C_3$	9.6
$D_2G_2C_2$	9.7	Treated	9.4
		Control	8.9
S.E. ±	0.1	CD at 5%	0.3

Table 5: Interaction effects of two factors on diameter of fruit

Treatment(A x C)	Average diameter of fruit (cm)	Treatment(B x C)	Average diameter of fruit (cm)
Date of application x concentration		Growth retardant x concentration	
D_1C_1	6.3	G_1C_1	6.3
D_1C_2	6.9	G_1C_2	6.7
D_1C_3	6.3	G_1C_3	6.2
D_2C_1	6.3	G_2C_1	6.2
D_2C_2	6.4	G_2C_2	6.6
D_2C_3	6.4	G_2C_3	6.5
D_3C_1	6.1	G_3C_1	6.3
D_3C_2	6.3	G_3C_2	6.3
D_3C_3	6.2	G_3C_3	6.2
S.E. ±	0.1	S.E. ±	0.1
CD at 5%	0.2	CD at 5%	0.2

Table 6: Mean effect of treatments on number of days required for fruit maturity yield parameters

Treatment	Number of days required for fruit maturity	Number of fruits/ tree	Average weight of fruit (g)	Average length of fruit (cm)	Average diameter of fruit (cm)	Yield/ tree(kg)	Yield/ ha (t)
Treated	107.44	397.6	286.0	9.4	6.4	113.6	11.4
Control	123.50	327.5	247.5	8.9	5.6	93.9	9.4
S.E. ±	0.90	20.9	11.3	0.1	0.1	5.0	0.5
CD at 5%	2.51	64.1	37.4	0.3	0.4	16.8	1.8

Conclusion

Mean of all treatments for fruit maturity, yield and yield contributing characters was higher than control indicating that any of the treatment is superior over control. Based on results obtained from the present investigation foliar application of cycocel @ 3000 ppm during last week of September was more effective in improving fruiting and yield of mango cv. Keshar under western Maharashtra conditions and in minimizing the days require for maturity.

References

1. Anonymous, Indian Horticulture Database- 2015; pub. National Horticulture Board, Ministry of Agriculture, Govt. of India, 2016, 4-296
2. Anonymous. Paclobutrazol, plant growth regulator on fruit. London, Fern Hurst, I.C.I. (Plant Protection Division), 1984, 35.
3. Chaudhari D, Patel NL, Patel NB, Tandel YN, Tulsi Gurjar. Effect of foliar spray of growth retardants on flowering, fruiting and yield of mango (*Mangifera indica* L.) Cv. Kesar. Trends in Biosciences. 2014; **7**(22):3765-3767.
4. Kulkarni VJ. Chemical control of tree vigour and the promotion of flowering and fruiting in mango (*Mangifera indica* L.) using paclobutrazol. J Hort. Sci. 1988; 63:557-566.
5. Singh OP, Phogat KPS. Effect of growth regulators on fruit drop, size and quality of litchi cv. Calcuttia. Punjab Hort. J. 1984; 24(1-4):83-88.
6. Sharma, Kumar SS, Chauhan JK, Kaith NS. Induction of flowering and fruiting in unproductive Chausa mango orchards in Himachal Pradesh. International J Farm Sci. 2011; 1(2):23-29.
7. Thakur S, Kumar R, Brahmachari VS, Sharma RK. Effect of different growth regulators on fruit set, retention and size of Litchi. Indian J Hort. 1990; 47(3):305-308.