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Effect of pruning and potassium nitrate on flowering in mango cv. Kesar

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Abstract
An experiment was conducted to study the effect of pruning and potassium nitrate on flowering and yield in mango cv. Kesar at Fruit Research Station, Sakkarbaug, College of Horticulture, Junagadh Agricultural University, Junagadh during October 2023-May 2024. The experiment was laid out in a Randomized Block Design with a Factorial concept, involving seven pruning levels and three potassium nitrate levels, each replicated thrice. The results due to the pruning were significant and the minimum number of days required for the emergence of reproductive shoots (63.89) and days to flowering (84.67) were found in the removal of 25% length of new vegetative shoots (light green stage). Similarly, the highest number of reproductive shoots per pruned shoot (2.96), number of hermaphrodite flowers per inflorescence (128.67) and total number of flowers per inflorescence (730.42) were recorded in the removal of 100% length of new vegetative shoots (light green stage). Regarding the potassium nitrate, the result was also significant and the least number of days required for the emergence of reproductive shoots (68.57), days to flowering (89.14) and number of male flowers per inflorescence (476.11) were registered in KNO_3 4%. Likewise, the maximum number of reproductive shoots per pruned shoot (2.74) was observed in KNO_3 3%. For the interaction effect, the minimum number of days required for the emergence of reproductive shoots (60.33) and days to flowering (80.33) was noticed in the treatment combination of removal of 25% length of new vegetative shoots (light green stage) with an application of KNO_3 4%. However, the interaction effect was found non-significant for the number of reproductive shoots per pruned shoot and the total number of flowers per inflorescence.

Keywords: *Mangifera indica* L., pruning, potassium nitrate, early flowering, number of flowers

Introduction
Mango (*Mangifera indica* L.) is a fruit originating from the Indo-Burma region, belonging to the Anacardiaceae family. India is the largest producer of mangoes globally, with Gujarat making a significant contribution. The state grows three important commercial mango cultivars: Kesar, Alphonso and Rajapuri. Indian mango farmers face challenges such as erratic flowering patterns, extensive flower drop, inadequate fruit set and retention, increased fruit drop at various growth stages, and reduced yields due to climate change. They also face a seasonal glut that leads to lower market prices. Advancing the flowering period by 2 to 3 weeks could enable farmers to harvest and sell their fruit earlier, potentially at higher prices.

Techniques such as pruning and the application of potassium nitrate are used to induce early flowering in shoots. Pruning, a common practice in deciduous and temperate fruit crops like apples, pears, peaches, plums, grapes, figs, and phalsa, is also considered effective for evergreen fruit trees like mango, according to pomologists (Fivaz and Stassen, 1996) [4]. Potassium nitrate (KNO_3) is a water-soluble nitrate salt that contains 14% nitrogen (N) and 46% potassium (K). Potassium is a crucial element for the development of chlorophyll, which is essential for photosynthesis, translocation of sugar, and starch formation. KNO_3 is commonly used to stimulate flowering in numerous mango cultivars (Barba, 1974) [3]. This can lead to a regular and early crop of mangoes.

Considering the current need and future prospects, it is vital to address the problem of seasonal glut in mango production. Therefore, this experiment was conducted to study the effect of pruning and chemical spray on flowering and fruit yield of mango (*Mangifera indica* L.) cv. Kesar.

Materials and Methods

The present experiment was carried out at Fruit Research Station, Sakkarbaug; College of Horticulture, Junagadh Agricultural University, Junagadh during October-May, 2023-24. The experiment was laid out in a Randomized Block Design with a factorial concept, involving seven levels of pruning and three levels of potassium nitrate, each replicated three times.

Pruning of trees was done in the October month and three sprays of potassium nitrate at fifteen days intervals were given after pruning. The pruning treatments were the removal of 100% length of new vegetative shoots (Coppery stage) (P_1), the removal of 100% length of new vegetative shoots (Light green stage) (P_2), the removal of 50% length of new vegetative shoots (Light green stage) (P_3), the removal of 50% length of old vegetative shoots(P_4), the removal of 25% length of new vegetative shoots (Light green stage) (P_5), the removal of 25% length of old vegetative shoots (P_6) and control (P_7). While the potassium nitrate treatments were KNO_3 2% (C_1), KNO_3 3% (C_2) and KNO_3 4% (C_3).

Observations recorded concerning flowering parameters were manually counted from the cut-off date of November 1st. In the same way, fruiting and yield parameters were recorded.

The standard method of analysis of variance was used for analyzing the data for RBD design with the factorial concept (Panse and Sukhatme, 1985) [8].

Results and Discussion

Days required for emergence of reproductive shoots and days to flowering

Effect of pruning

The minimum number of days required for the emergence of reproductive shoots (63.89) and days to flowering (84.67) were recorded in the removal of 25% length of new vegetative shoots (light green stage) (P_5), which were at par with the removal of 25% length of old vegetative shoots (P_6). Conversely, the maximum number of days required for the emergence of reproductive shoots (77.67) and days to flowering (99.33) were observed in the removal of 50% length of old vegetative shoots (P_4) and the control (P_7), respectively. This might be due to the immediate loss of apical dominance after pruning and as a result of early shoot production, which allowed the shoots to mature earlier than expected and gave rise to earlier panicle emergence. The above results are in agreement with the findings reported by Singh *et al.* (2010) [14], Ghavale *et al.* (2016) [5], Solanki *et al.* (2016) [16], Warang *et al.* (2019) [18], Rani *et al.* (2020) [12], Solanki *et al.* (2021) [15], Aghav *et al.* (2022) [2] in mango and Adhikari and Kandle (2015) [1] in guava.

Effect of potassium nitrate

The lowest number of days required for the emergence of reproductive shoots (68.57) and days to flowering (89.14) was noticed in KNO_3 4% (C_3), which was at par with KNO_3 3% (C_2). Inversely, the greater number of days required for the emergence of reproductive shoots (75.00) and days to flowering (98.43) was obtained in KNO_3 2% (C_1). The earlier flowering could be attributed to KNO_3 active compounds that may be implicated in the inductive process, in which shoots transition from the vegetative to the reproductive phase, develop into panicles and eventually bear flowers by breaking dormancy. The above results are in agreement with findings reported by Sudha *et al.* (2012) [17], Sarker and Rahim (2013) [13] and Nulit *et al.* (2014) [7] in mango.

Interaction effect

The minimum number of days required for the emergence of reproductive shoots (60.33) was recorded in the treatment combination of removal of 25% length of new vegetative shoots (light green stage) with an application of KNO_3 4% (P_5C_3); however, it was at par with treatment combination P_2C_3, P_5C_2, P_6C_2 and P_6C_3. Similarly, the minimum number of days to flowering (80.33) was also noticed in the treatment combination of removal of 25% length of new vegetative shoots (light green stage) with an application of KNO_3 4% (P_5C_3), which was at par with the treatment combination P_1C_2, P_2C_2, P_4C_3, P_5C_1, P_5C_2, P_6C_2 and P_6C_3. Contrarily, the maximum number of days required for the emergence of reproductive shoots (83.67) and days to flowering (105.67) were obtained in the treatment combination of removal of 50% length of old vegetative shoots with an application of KNO_3 2% (P_4C_1). This might be due to the redistribution of endogenous hormonal substances to favour early flowering and better flower production as a result of pruning as well as active compounds of potassium nitrate. The above results are in agreement with the findings reported by Ramirez *et al.* (2010) [11] in mango and Mitali *et al.* (2019) [6] in litchi.

Number of vegetative shoots per pruned shoot

Effect of pruning

The smaller number of vegetative shoots per pruned shoot (1.24) was noticed in the unpruned shoots (P_7), which was at par with the removal of 100% length of new vegetative shoots (coppery stage) (P_1). On the other hand, a greater number of vegetative shoots per pruned shoot (2.83) was obtained in the removal of 50% length of old vegetative shoots (P_4). It may be because severe pruning promotes vegetative growth and moderate to light pruning helps establish optimal balance in endogenous hormonal contents, i.e., growth promoter: inhibitor ratio. The above results are in agreement with findings reported by Singh *et al.* (2010) [14] in mango.

Effect of potassium nitrate

The minimum number of vegetative shoots per pruned shoot (1.78) was recorded in KNO_3 2% (C_1), which was found at par with KNO_3 3% (C_2). Meanwhile, the maximum number of vegetative shoots per pruned shoot (2.08) was noted in KNO_3 4% (C_3). This might be due to the availability of more nutrients to the axillary buds which leads to an increase in the number of vegetative shoots. The above results are in agreement with the findings reported by Sudha *et al.* (2012) [17] and Sarker and Rahim (2013) [13] in mango.

Interaction effect

The minimum number of vegetative shoots per pruned shoot (1.13) was recorded in the treatment combination of control with an application of KNO_3 2% (P_7C_1), which was at par with treatment combination P_1C_1, P_1C_2, P_2C_2, P_7C_2 and P_7C_3. Conversely, the maximum number of vegetative shoots per pruned shoot (2.93) was observed in the treatment combinations of removal of 50% length of old vegetative shoots with an application of KNO_3 2% (P_4C_1) and removal of 50% length of old vegetative shoots with an application of KNO_3 3% (P_4C_2). This might be due to the redistribution of endogenous hormonal substances to favour early flowering and better flower production as a result of pruning as well as active compounds of potassium nitrate. The above results are in agreement with the findings reported by Ramirez *et al.* (2010) [11] in mango and Mitali *et al.* (2019) [6] in litchi.

Number of reproductive shoots per pruned shoot

Effect of pruning

The maximum number of reproductive shoots per pruned shoot (2.96) was registered in the removal of 100% length of new vegetative shoots (light green stage) (P_2), but it was at par with the removal of 25% length of new vegetative shoots (light green stage) (P_5) and the removal of 25% length of old vegetative shoots (P_6). Meanwhile, the lowest number of reproductive shoots per pruned shoot (2.30) was reported in the removal of 50% length of old vegetative shoots (P_4). It seems that the pruning of the axillary buds triggers the accumulation of various plant hormones such as ethylene, ascorbic acid, abscisic acid, and cytokinin, as well as a sudden decrease in gibberellins. All of these factors contribute to maximizing the number of reproductive shoots per shoot, leading to abundant flowering. The above results are in agreement with findings reported by Singh *et al.* (2010) [14], Ghavale *et al.* (2016) [5], Solanki *et al.* (2016) [16], Rani *et al.* (2020) [12] in mango, Adhikari and Kandel (2015) [1] in guava and Parsana *et al.* (2023) [9] in custard apple.

Effect of potassium nitrate

The maximum number of reproductive shoots per pruned shoot (2.74) was reported in KNO_3 3% (C_2) and it was at par with KNO_3 4% (C_3). On the other hand, the lowest number of reproductive shoots per pruned shoot (2.33) was documented in KNO_3 2% (C_1). This might be due to the availability of more nutrients to the axillary buds which leads to an increase in the number of reproductive shoots. The above results are in agreement with the findings reported by Sudha *et al.* (2012) [17] and Sarker and Rahim (2013) [13] in mango.

Interaction effect

The number of reproductive shoots per pruned shoot was found to be non-significant due to the interaction of pruning and potassium nitrate.

Number of flowers per inflorescence

Effect of pruning

A similar trend of the number of reproductive shoots per pruned shoot was also observed for the number of hermaphrodite flowers per inflorescence (128.67) in the removal of 100% length of new vegetative shoots (light green stage) (P_2), which was at par with the removal of 25% length of new vegetative shoots (light green stage) (P_5). Whereas, the minimum number of hermaphrodite flowers per inflorescence (68.01) was observed in the removal of 50% length of old vegetative shoots (P_4). But, the lowest number of male flowers per inflorescence (414.17) was reported in the removal of 50% length of old vegetative shoots (P_4) and it was found at par with the removal of 100% length of new vegetative shoots (coppery stage) (P_1) and control (P_7). Alternately, the highest number of male flowers per inflorescence (601.76) was noted in the removal of 100% length of new vegetative shoots (light green stage) (P_2). However, the maximum number of flowers per inflorescence (730.42) was obtained in the removal of 100% length of new vegetative shoots (light green stage) (P_2), but it was at par with the removal of 25% length of new vegetative shoots (light green stage) (P_5). Meanwhile, the minimum number of flowers per inflorescence (489.96) was documented in the removal of 50% length of old vegetative shoots (P_4). The results might be due to a reduction in vegetative growth caused by light pruning and also panicle developing during December/ January when receiving comparatively low temperatures, generally causing a higher proportion of male flowers. Pruning encouraged new shoot emergence had also increased IAA content, which led to flower induction with a low sex ratio. The above results are in agreement with the findings reported by Singh *et al.* (2010) [14], Solanki *et al.* (2021) [15] in mango and Parsana *et al.* (2023) [9] in custard apple.

Effect of potassium nitrate

The maximum number of hermaphrodite flowers per inflorescence (104.68) was obtained in KNO_3 2% (C_1), which was at par with KNO_3 3% (C_2). On the contrary, the minimum number of hermaphrodite flowers per inflorescence (97.06) was noticed in KNO_3 4% (C_3). However, the minimum number of male flowers per inflorescence (476.11) was registered in KNO_3 4% (C_3) and it was at par with KNO_3 3% (C_2). Alternatively, the maximum number of male flowers per inflorescence (504.93) was noted in KNO_3 2% (C_1). The maximum number of flowers per inflorescence (619.13) was noticed in KNO_3 2% (C_1), but it was found at par with KNO_3 3% (C_2). Whereas, the minimum number of flowers per inflorescence (571.25) was documented in KNO_3 4% (C_3). The results might be due to the floral stimulus being present in stems when buds are forced in response to KNO_3 and that KNO_3 may sensitize buds to the floral stimulus. The above results are in agreement with findings reported by Phyu (2016) [10] in mango and Mitali *et al.* (2019) [6] in litchi.

Interaction effect

For the hermaphrodite flowers, the maximum number per inflorescence (141.47) was registered in the treatment combination of removal of 100% length of new vegetative shoots (light green stage) with an application of KNO_3 3% (P_2C_2) but, it was found at par with treatment combination P_2C_3, P_5C_1 and P_6C_1. On the other hand, the minimum number of hermaphrodite flowers per inflorescence (80.60) was noted in the treatment combination of removal of 50% length of old vegetative shoots with an application of KNO_3 2% (P_4C_1). The lowest number of male flowers per inflorescence (382.90) was obtained in the treatment combination of removal of 100% length of new vegetative shoots (coppery stage) with an application of KNO_3 4% (P_1C_3), which was at par with treatment combination P_3C_2, P_3C_3, P_4C_1, P_4C_2 and P_7C_2. Contrarily, a greater number of male flowers per inflorescence (626.07) was reported in the treatment combination of removal of 100% length of new vegetative shoots (light green stage) with an application of KNO_3 3% (P_2C_2). This might be due to the redistribution of endogenous hormonal substances to favour early flowering and better flower production as a result of pruning as well as active compounds of potassium nitrate. The above results are in agreement with the findings reported by Ramirez *et al.* (2010) [11] in mango and Mitali *et al.* (2019) [6] in litchi.

The total number of flowers per inflorescence was found to be non-significant due to the interaction of pruning and potassium nitrate.

Table 1: Effect of pruning and potassium nitrate on flowering parameters of mango

Treatments	Days required for emergence of reproductive shoots	No. of vegetative shoots/pruned shoot	No. of reproductive shoots/pruned shoot (Initial stage)	Days to flowering
Factor A - Pruning (P)				
P_1	70.44	1.44	2.31	93.11
P_2	70.67	1.83	2.96	94.11
P_3	76.44	2.39	2.67	94.22
P_4	77.67	2.83	2.30	96.11
P_5	63.89	1.67	2.80	84.67
P_6	66.67	2.08	2.77	89.44
P_7	76.44	1.24	2.33	99.33
S.Em.±	1.70	0.07	0.08	2.35
C.D. at 5%	4.87	0.21	0.23	6.70
Factor B - Potassium nitrate spray (C)				
C_1	75.00	1.78	2.33	98.43
C_2	71.67	1.92	2.74	91.43
C_3	68.57	2.08	2.70	89.14
S.Em.±	1.12	0.05	0.05	1.54
C.D. at 5%	3.19	0.14	0.15	4.39
Interaction (P x C)				
S.Em.±	2.95	0.13	0.14	4.06
C.D. at 5%	8.44	0.36	NS	11.61

Table 2: Effect of pruning and potassium nitrate on flowering parameters of mango

Treatments	No. of hermaphrodite flowers per inflorescence	No. of male flowers per inflorescence	Total number of flowers per inflorescence
Factor A - Pruning (P)			
P_1	103.58	444.41	547.99
P_2	128.67	601.76	730.42
P_3	98.22	431.07	529.26
P_4	68.01	414.17	489.96
P_5	117.19	582.28	699.47
P_6	112.50	525.76	638.26
P_7	85.20	436.38	542.69
S.Em.±	3.58	11.58	18.62
C.D. at 5%	10.22	33.11	53.22
Factor B - Potassium nitrate spray (C)			
C_1	104.68	504.93	619.13
C_2	104.00	491.44	600.20
C_3	97.06	476.11	571.25
S.Em.±	2.34	7.58	12.19
C.D. at 5%	6.69	21.67	34.84
Interaction (P x C)			
S.Em.±	6.19	20.06	32.25
C.D. at 5%	17.70	57.35	NS

Table 3: Interaction effect of pruning and potassium nitrate on flowering parameters of mango

Treatment combinations	Days required for emergence of reproductive shoots	Number of vegetative shoots/ pruned shoot	Days to flowering	Number of hermaphrodite flowers per inflorescence	Number of male flowers per inflorescence
P_1C_1	69.00	1.37	94.33	104.53	464
P_1C_2	73.00	1.4	88.33	112.4	486.33
P_1C_3	69.33	1.57	96.67	93.8	382.9
P_2C_1	72.33	1.93	100.33	120.33	580.27
P_2C_2	72.00	1.47	81.67	141.47	626.07
P_2C_3	67.67	2.1	100.33	124.2	598.93
P_3C_1	82.00	1.87	100.33	106.2	499.33
P_3C_2	76.00	2.6	99	92.07	408.33
P_3C_3	71.33	2.7	83.33	96.4	385.53
P_4C_1	83.67	2.93	105.67	63.93	409.13
P_4C_2	79.00	2.93	99	80.6	383.2
P_4C_3	70.33	2.63	83.67	59.5	450.17
P_5C_1	69.67	1.6	89	124.2	587.67
P_5C_2	61.67	1.67	84.67	111.83	589.7
P_5C_3	60.33	1.73	80.33	115.53	569.47
P_6C_1	70.00	1.6	94.67	131.53	552.2
P_6C_2	66.00	2	89.33	103.87	523
P_6C_3	64.00	2.63	84.33	102.1	502.07
P_7C_1	78.33	1.13	104.67	82	441.93
P_7C_2	74.00	1.4	98	85.73	423.47
P_7C_3	77.00	1.2	95.33	87.87	443.73
S.Em.±	2.95	0.13	4.06	6.19	20.06
C.D. at 5%	8.44	0.36	11.61	17.70	57.35

Conclusion

Based on the experiment and the preceding discussion, there were significant variations among the different treatments in terms of flowering parameters. The study discovered that tip pruning of 25% of new vegetative shoots at the light green stage resulted in early flowering as compared to other treatments. Additionally, the use of KNO_3 at 3% led to improved flowering. Notably, the combination of tip pruning of new vegetative shoots by 25% at the light green stage during October with three sprays of KNO_3 at 3%, at the interval of 15 days led to the best results for early and profuse flowering.

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