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Influence of pruning intensity on flowering, fruit yields and floral malformation in three mango cultivars planted under high density

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ABSTRACT

An experiment was conducted during 2005-07 on influence of pruning intensity on flowering, fruit yield and floral malformation in three mango cultivars ('Amrapali', 'Mallika' and 'Dashehari') planted under high density. The pruning intensity at moderate level took least days to 50% flowering, had highest number of panicles per branch (5.13, 5.66), longest blooming period (22.00, 22.66 days) and lowest sex ratio (7.41, 6.85) while no-pruning (control) had delayed flowering with lowest number of panicles per branch, shortest bloom period but then highest sex ratio. Moderate pruning drastically reduced the floral malformed panicles (9.40, 11.21) than the control (51.23, 41.39). The control (un-pruned) trees in all cultivars showed the higher malformation incidence, while lower was registered after pruning. Fruit drop and yield were also significantly affected by pruning intensity. The fruit drop reduced significantly with severe pruning (77.19, 78.43%), which was lower than the control (86.53, 87.76%). Moderately pruned trees had the highest fruit yield (6.55, 8.59 kg tree^{-1}) than un-pruned ones (5.10, 6.45 kg tree^{-1}) and they also had maximum number of fruits per panicle. Conclusively, the light pruning for 'Amrapali', moderate for 'Mallika' and severe pruning for 'Dashehari' can be recommended for restoring the production and productivity in high density orchards.

Key words: Mango, Pruning, flowering, fruit drop, malformation, yield.

INTRODUCTION

Mango (*Mangifera indica* L.), is the most important fruit crop in the sub-tropical and tropical regions of the world normally planted at 10-12 m distance. The high density orcharding in mango is suggested to make the maximum use of land to achieve higher yields in the early years of the orchard life. Pruning is an operation familiar to all arborists and horticulturists managing growth and reproductive habits of fruit trees especially under close spaced orchards/plantations. The pruning strategies in mango have been developed to 1) prevent trees from getting large through annual pruning as part of a production management programme; 2) reshape intermediate size trees to smaller or more manageable sizes; and/or 3) completely rejuvenate large trees that are no longer productive due to their size and height (Davenport, 3). Furthermore, the architecture and form of a tree is keeping changing with the tree age, climate, cultural practices, training and pruning etc. Large tree size can lead to more harvest bruising, as well as increasing harvesting, pruning and maintenance costs, compared to smaller trees. The technique of high-density orcharding (HDO) in mango has been successful in some Indian cultivars *viz*., Amrapali (2.5 m x 2.5 m), Mallika (6 m x 6 m) and Dashehari (3.0 m x 2.5 m) with the help of pruning and also with the application of paclobutrazol (Majumder *et al*., 9; Ram and Sirohi, 14; Ram *et al*., 15).

Pruning is resorted as a tool not only to control size but also maximize yields, however practice such as severe pruning and drastic orchard thinning seriously affect bearing surface, reducing productivity for at least the following year (Sauco, 19). Pruning not only helps to induce axillary panicles (to control biennial bearing and removal of malformed panicles) but has also been adopted for rejuvenation of orchards along with crop regulation (Shinde *et al*., 21). However, the main advantage of annual tip pruning is that it provides reliable synchronized flowering in selected rows year after year in trees thus making them remaining in the same size for many years (Davenport, 3). The combined application of biennial mechanical topping and hedging appeared to be the most appropriate method to manipulate tree

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growth with satisfactory annual yields (205 kg/tree), which are slightly lower than those of control trees (255 kg/ tree). Hence, keeping above facts in view, the present investigation was undertaken to study the effect of pruning on flowering, fruiting and floral malformation incidence in three mango cultivars ('Amrapali', 'Mallika' and 'Dashehari') growing at high-density.

MATERIALS AND METHODS

A field experiments were conducted at the Main Orchard, Division of Fruits and Horticultural Technology, IARI, New Delhi, during 2005 to 2007. Three mango cultivars *viz*., 'Amrapali' (V_1) (23-year-old), 'Mallika' (V_2) (24-year-old) and 'Dashehari' (V_3) (25-year-old) were selected for present study. Above-mentioned cultivars were planted at high density, *viz*. 2.5 m x 2.5 m, 4.0 m x 3.0 m and 3.0 m x 2.0 m, respectively. All the trees were maintained under uniform cultural practices during the entire course of investigation. Pruning was done in mid August, 2005 and the pruning intensities were as follows: I_0 (Control): un-pruned, I_1 (Light): 30 cm from the apex, I_2 (Moderate): 60 cm from the apex and I_3 (Severe): 90 cm from the apex. Each cultivar had three replications per treatment. Thus, the total numbers of treatment combinations were 12 with three trees per replication. The experiment was conducted under factorial randomized block design. The balanced pruning was performed in all directions by removing both inner and few peripheral branches of the canopy, which were dense and overcrowded. The control trees were left as such without pruning. As a result of pruning, trees did show mild flowering and fruiting during 2005-06, i.e. first year called as 'off' year and second year (2006-07) as 'on' year.

Floral measurements comprised of all parameters recorded under flowering activities. The time of panicle emergence was recorded (as date of appearance of first panicle) on the tagged branches after pruning. The number of panicles formed per tagged shoots was counted. The length of panicle at anthesis was measured from the shoot apex to that of panicle apex and an average of five observations was taken for computing the mean value. The time to 50 per cent flowering was recorded by visiting the experimental orchard every day after panicle emergence and the number of days was counted from the date of pruning to the day when 50 per cent opening of flowers on a panicle. The full bloom period (in days) was recorded by counting the days taken from emergence of first panicle to the termination of the same on individual tree. The sex ratio (number of male: hermaphrodite flowers) was calculated by daily counting and removal of flowers up to opening of last flower right from the opening of the first flower. The total numbers of panicles (healthy and malformed) was counted on the individual trees and then floral malformation was calculated and expressed in percentage. Total number of flowers was counted on each panicle and fruit set was calculated on the basis of the initial set at pea stage in percentage. The fruit drop was recorded at weekly intervals up to the harvest by counting the number of fruits retained per panicle. The percentage fruit drop was calculated on the basis of initial fruit set (10 days post fruit set). The number of fruits per panicle at maturity was counted at the time of harvesting. For yield estimation, the number of fruits on each tree was counted and their means were calculated. The fruit yield (kg/ tree) was recorded by weighing the samples on a physical balance. Average fruit yield of five trees was calculated.

The experimental data were subjected to statistical analysis in Randomized Block Design (Gomez and Gomez, 6) and the interpretation of results was based on 'F' test. The critical difference (CD) at P=0.05 was worked out for comparing the means. The percentage data were subjected to Arc Sin square root transformation before analysis.

RESULTS AND DISCUSSIONS

Evergreens, unlike deciduous trees, do not normally stores large reserves of manufactured food and growth are more closely related to currently available leaf surface obtained after pruning. Though, very early panicle emergence in mango is not desirable in north India because it may lead to high degree of malformation but marginal earliness in flowering is desirable. In this investigation the light pruning (I_1) led to earliest (189.18, 182.65 DAP) panicle emergence while it was delayed (194.26, 192.47 DAP) in un-pruned trees (I_0) with time lag of about 5 to 10 days (Table 1). Thus, the shoot sprouts appear little early after pruning which may be due to immediate loss of apical dominance and due to early shoot production, these shoots attained the desired maturity to give rise to early panicle emergence. During 'on' year the time of panicle emergence was lesser than 'off' year because shoot maturity was advanced when time lag after pruning if increased.

The pruning intensities significantly improved the number of panicle per branch (Table 1). The moderately pruned (I_2) mango trees showed maximum number of panicles per branch (5.13 ('off' year); 5.66 ('on' year)], while least (3.24, 3.85) was recorded in un-pruned trees (I_0), which reflects that pruning restores floriferousness. The severely pruned trees showed less number of panicles due to heavy vegetative growth. It is suggested that moderate pruning helped in establishing optimal balance in root: shoot ratio and endogenous hormonal

Table 1. Effect of pruning intensity on time of panicle emergence, number of panicles, panicle length and days taken to flowering in three mango cultivars planted under high density.

Treatment†	Days to panicle emergence (Days after pruning)		No. of panicles per branch		Panicle length (cm) at anthesis		Days taken to 50% flowering	
	2006*	2007**	2006*	2007**	2006*	2007**	2006*	2007**
V_1	193.87	190.93	6.25	6.61	13.31	12.79	220.71	219.80
V_2	190.85	190.36	5.25	5.67	15.49	18.82	214.95	214.49
V_3	188.49	186.87	1.18	2.25	15.94	17.15	211.89	211.08
$CD_{0.05}$	02.71	02.44	0.428	0.450	0.753	0.725	1.51	1.29
I_0	194.26	192.47	3.24	3.85	13.40	13.83	220.34	220.66
I_1	189.18	182.65	5.15	5.40	14.41	14.22	216.30	214.92
I_2	191.21	189.32	5.13	5.66	15.77	15.60	213.18	212.12
I_3	189.63	188.11	3.38	4.37	16.08	15.95	213.57	212.78
$CD_{0.05}$	3.13	2.81	0.49	0.32	0.86	0.83	1.74	1.48

*'off' year, †the details of treatment are given in the text; ** 'on' year.

contents, i.e. growth promoter: inhibitor ratio. Data (Table 1) also revealed that 'on' year had more number of panicles than 'off' year in all three cultivars This may be due to lack of maturity in shoots (7 to 8 month-old), which were formed during 'off' year (than 'on' year) required for flower bud differentiation (FBD). Severe pruning (I_3) led to formation of longer panicles [(16.08 cm in 'off' year) and 15.95 cm ('on' year)], while smallest panicle (13.40, 13.83 cm) was found in un-pruned treatment (I_0), which may be due to gross changes in endogenous hormonal levels. It was observed that severity of pruning increased panicle length up to certain extent. Thus, thinning of terminal shoot clusters and young growth flushes would bring an optimum cytokinin/ gibberellin balance required for flowering (Rao and Khader, 17). Therefore, lateral buds are stimulated to grow (due to better dry matter partitioning) after pruning than no-pruning due to higher activity of GA-like substances during floral bud induction (Mika, 10; Shinde *et al.*, 21; Bhanu Pratap, 1).

In general, there was uniform flushing and flowering after pruning. However, flushing in un-pruned trees was though prolific but less uniform and more protracted. Flowering (time to 50% flowering) was advanced (213.18, 212.12 days after pruning) after moderate pruning than the no pruning (control tree) (I_0) (220.34, 220.66 days after pruning) (Burondkar *et al.*, 2). Higher percentage of flowering due to pruning treatments was attributed mainly due to new growth and better availability of photosynthetic solar radiation to the leaves (Lal and Misra, 8), thus causing alteration in the IAA activities, which enhanced flowering. The data also revealed that during 'on' year, less time for 50% flowering was registered than during 'off' year (Table 1).

The full bloom period in mango in north India is about 20 to 25 days. However, different cultivars show differential blooming period. Data (Table 2) clearly showed that severe pruning, trees generally registered a longer bloom period (20.66, 22.66 days), while shortest was in un-pruned trees (18.34, 20.26 days). Thus, severity of pruning increased the blooming period and in 'on' year, it was rather longer than in 'off' year. This may be due to the fact that pruning increased the production of new shoots, which are the source of auxin(s), required for induction of flowering. The late physiological maturity of new shoots enhances the duration of blooming period with uniformity in 'on' year (Oosthuyse, 13). Sex ratio (male: hermaphrodite flowers) has direct relationship with fruit set and yield. The pruning intensities significantly improved sex ratio and the lowest sex ratio was found in moderately pruned trees (I_2) (7.41, 6.85) followed by severely pruned trees, which attributed to the development of lower temperature regime in denser canopies (Waghmare and Joshi, 24). The highest sex ratio was found in un-pruned trees (I_0) (8.82, 8.39) (Table 2). The 'on' year had low sex ratio than 'off' year. Thus, it was noted that with pruning reduced sex ratio. In northern India panicle developing during December/ January when received comparatively low temperature, generally causes higher proportion of male flowers (Singh *et al*. 1974). Pruning encouraged new shoot emergence had also resulted in increase of IAA content, which led to flower induction with low sex ratio (Burondkar *et al.*, 2; Sharma and Singh, 20).

Table 2. Effect of pruning intensity on the period of full bloom, sex ratio, floral malformation incidence and fruit drop in three mango cultivars planted under high density.

Treatment†	Full bloom period (Days)		Sex ratio (male: (Hermaphrodite flower)		Floral malformation (%)		Fruit drop (%)	
	2006*	2007**	2006*	2007*	2006*	2007**	2006*	2007*
V_1	20.50	21.75	4.2	4.11	22.35 (28.18)	25.02 (30.00)	77.69 (61.75)	79.24 (62.87)
V_2	21.66	22.33	10.17	9.12	18.54 (25.48)	17.10 (24.43)	84.76 (66.97)	85.98 (67.94)
V_3	21.09	21.70	9.14	8.76	17.24 (24.50)	14.50 (22.38)	80.30 (63.65)	81.64 (64.60)
$CD_{0.05}$	NS	NS	0.635	0.449	3.55	3.00	5.37	5.26
I_0	18.34	20.26	8.82	8.39	51.23 (45.69)	41.39 (39.99)	86.53 (68.44)	87.76 (69.47)
I_1	21.33	20.11	7.65	7.10	7.50 (15.89)	11.38 (19.64)	81.95 (64.82)	83.33 (65.88)
I_2	22.00	22.66	7.41	6.85	9.40 (17.89)	11.21 (19.53)	77.99 (61.96)	79.63 (63.15)
I_3	22.66	22.66	7.49	6.90	9.38 (17.76)	11.52 (19.82)	77.19 (61.41)	78.43 (62.31)
$CD_{0.05}$	1.34	1.35	0.733	0.318	4.10	3.47	6.20	6.08

*'off' year, †the details of treatment are given in the text; ** 'on' year; Figures in parentheses represent the transformed value.

Among the known cultivation problems in mango, malformation is undoubtedly the most serious one and the pruning intensities, irrespective of cultivars also had significant effect on floral malformation (Table 2). The highest number of floral malformed panicles (51.23, 41.39 %) was observed in un-pruned (I_0) trees, whereas, minimum (7.50, 11.38 %) in light pruned trees (I_1). The pruning operation significantly reduced the incidence of malformation and pruned trees produced lesser number of malformed panicles than un-pruned trees (Sirohi *et al.*, 22). Early removal of malformed panicles along with pruning helped to promote healthy vegetative growth followed by emergence of normal inflorescence (Muhammad *et al*., 11). During 'on' year, the malformation incidence increased due to time lag between pruning and onset of flowering and also due to increase in canopy volume. The data also depict that malformation incidence increased with the time, as in 'on' year incidence was higher than the preceding ('off') year.

The pruning intensities irrespective of the cultivars significantly reduced the fruit drop. The lowest fruit drop was noted in severely pruned trees (I_3) (77.19, 78.43 %) and the highest (86.53, 87.76 %) in un-pruned trees (I_0) (Table 2), because of the supply of available reserves to remaining blossoms (after pruning) is increased (Ferree and Schupp, 5) and subsequently fruit drop decreased with the pruning intensity. Pruning creates vigour, which had favourable effect on fruit set to counteract fruit drop. Un-pruned tree (control) recorded lower fruit set due to misbalanced ratio of growth promoters and inhibitors, low sugar reserve in older shoots (dead, decayed and infected) and more malformed shoots (Rao and Shanmugavelu, 18; Davie and Stassan, 4). The number of fruits per panicle at harvest stage is very speculative for yield estimation but it varies with the bearing behaviour of cultivar and fruit set per panicle. The pruning intensities significantly affected the number of fruits panicle^{-1} and the highest (4.01) was found in moderately pruned trees (I_2), in 'on' year but in 'off' year the maximum fruits were recorded in light pruned (I_1) trees while the number of fruits panicle^{-1} was drastically reduced (2.86, 3.06) in un-pruned trees in both the years of experiment. This was primarily due to availability of adequate light and low sex-ratio. Less malformed panicles in moderately pruned trees lead to realization of higher yield compared to un-pruned trees because later had slow growth and higher floral malformation (Swaroop *et al.*, 23). The data (Table 3) also revealed that during 'on' year there was less number of fruits per panicle than 'off' year.

The yield which is the most important aspect for fruit growers was found to be significantly influenced by genotype and also cultural practices like pruning. Pruning and thinning operations lead to increase in yield (Rao,

Table 3. Effect of pruning intensity on fruit bearing behaviour and fruit yield in three mango cultivars planted under high density.

Treatment†	No. of fruits per panicle		Fruit yield			
			No. of fruits per tree		Fruit yield (kg/ tree)	
	2006*	2007**	2006*	2007**	2006*	2007**
V_1	4.86	4.39	83.33	90.83	11.00	11.85
V_2	4.00	3.82	22.83	31.33	6.56	8.14
V_3	0.933	2.76	3.33	26.08	0.526	4.01
$CD_{0.05}$	0.24	0.13	2.77	2.69	0.39	0.32
I_0	2.86	3.06	31.66	39.44	5.10	6.45
I_1	3.52	3.76	40.66	53.22	6.55	8.59
I_2	3.45	4.01	38.88	53.22	6.41	8.53
I_3	3.22	3.80	34.77	51.77	6.04	8.43
$CD_{0.05}$	0.28	0.24	3.20	3.11	0.45	0.37

16; Moss, 12; Rao and Shanmugavelu, 18; Rao and Khader, 17; Gross, 7; Swaroop *et al.,* 23; Shinde *et al*, 21; Bhanu Pratap *et al.*, 1; Yeshitela *et al.,* 25; Sharma and Singh, 20; Waghmare and Joshi, 24), because they are effective in diverting nutrients and water taken up by the tree to productive branches in mango. The highest number of fruits tree^{-1} at harvest stage [40.66 ('off' year); 53.22 ('on' year)] and fruit yield [6.55 ('off' year); 8.59 kg tree^{-1} ('on' year)] was recorded in light pruned trees (I_1) followed by moderately pruned trees (I_1), whereas lowest number of fruits tree^{-1} (31.66, 39.44) and fruit yield (5.10, 6.45 kg tree^{-1}) was in un-pruned trees (I_0) (Table 3). If severe pruning is followed then it is expected to lead to a substantial drop in yield for at least the succeeding one or more years. Irrespective of intensity and severity, pruning helps in balanced vegetative growth, better nutrition depending upon shoot: root ratio and better availability of the sunlight to the leaves, which lead to the production of more hermaphrodite flowers. Naturally, in the 'on' year the trees had higher yield in terms of number of fruits and weight (in kg basis) per tree than the 'off' year. The study indicates that mild pruning is a beneficial practice to maintain high density orchards in mango for sustainable production and yield of better quality fruits.

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