Synergistic Effect of Leaf Count for Flower Induction in Mango cv. 'Himampasand'

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Summary

The synergistic effect of leaf count for flower induction was investigated in mango cv. 'Himampasand' under Ultra High Density Plantation. The trees are grown in tropical conditions in Tamil Nadu, India, and the trial was conducted by adopting a Factorial Randomized Block Design (FRBD) with three replications and two factors: leaf pruning and month. The experiment was set up in a five-year old orchard with uniform-sized 'Himampasand' trees planted at 3 x 2 m spacing. The treatments were imposed during the middle of October, November and December. Treatments consisted of 0 (no leaves), 1/8, 1/4, 1/2, 1, 2, 3, 4, 5, 6, and control (without leaf removal) leaves remaining on each stem of every treated branch. Under tropical, warm weather, the fractions of leaves / stem are able to induce minimal quantity of flowering without leaves in the shoot. Leaf pruning in different months from October to December had varied effects. However, in a tropical climate, six leaves per shoot and December pruning resulted in 100 per cent flowering in mango cv. 'Himampasand'.

Key words

mango, florigen, leaf count, tropical climate, ultra high density plantation

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Introduction

Mango is renowned as the "King of Fruit" because of its appealing colour, delicious taste and mouth-watering flavour (Gopu et al., 2017). It is the most economically important tropical fruit crop in India exhibiting several interesting features in its growth and development (Gopu, 2014). The mechanism of vegetative growth and reproductive development control in tropical evergreen fruit trees, such as mango, is complex and not fully understood (Nunez-Elisea et al., 1993). The mechanism of mango flowering is still not fully comprehended, even though it undoubtedly relies on environmental influences to initiate the shift from vegetative to reproductive growth, after inhibiting or checking vegetative growth (Davenport and Nunez-Elisea, 1997). Bernier et al. (1981) reported that the photoperiod, plant hormones, nitrogen status, carbohydrates and other as-yet unidentified factors might also be inducing flowering. It is known that the transition is caused by cold weather, or cold weather combined with water stress (Whiley, 1993).

According to Singh et al. (2019), the mechanism of regulating the balance between the vegetative and reproductive stages and the climatic conditions that have a significant influence on mango growth and flowering, make mango flower production an extremely complex phenomenon. Mango flowering is a complex phenomenon, making it a difficult task for breeders, physiologists, and growers (Rani, 2018 and Jameel et al., 2018). A quick-acting, temperature-controlled florigenic promoter is hypothesised to control mango flowering. The florigenic promoter is synthesised in mango leaves and transferred to buds through phloem based on the observed leaf requirements for flowering (Davenport et al., 2006; Davenport, 2009; and Jameel et al., 2018).

Nunez-Elisea and Davenport (1995) report that under warm tropical conditions, the synthesis and transfer of florigenic promoter have not been evaluated, and the leaf count number to supply florigenic promoter to allow flowering is unclear. Floral induction of mango shoots occurs only on terminal stems that have rested for a sufficient period, at least four months in the tropical regions (Davenport, 2003). According to Davenport et al. (2006) the hormonal regulation paradigm, the interaction between the florigenic promoter and the vegetative promoter causes the induction of floral or vegetative new shoots. Davenport (2000) proposes that under cool temperature circumstances, in leaves, more florigenic promoter is synthesised than under warm tropical temperatures.

During cool, sub-tropical flowering circumstances, all the leaf treatments containing half to six leaves of 'Keitt' and one to six leaves of 'Tommy Atkins' produced 100 per cent reproductive shoots (Davenport et al., 2006). In mango cultivars including Banganapalli, Alampur Baneshan, and Royal Special, for floral induction, one or more leaves were necessary when they were cultivated in India under unreported temperature circumstances (Davenport et al., 2006). Ramirez et al. (2010) report that under warm, tropical circumstances, four or more leaves are essential to complete a 100 per cent flowering. In 'Keitt' mango trees exposed to cool temperatures, ¼ leaf per stem recorded 95 per cent flowering in lateral shoots, while ½ leaf per stem recorded 100 per cent reproductive shoots (Davenport et al. 2006). Assuming that the quantity of florigenic promoter required to induce 100 per cent flowering in the reproductive shoots is near half the leaf, one can therefore determine that one leaf per stem delivers nearly two times the amount of florigenic promoter required to produce 100 per cent flowering response in the initiated shoots. In contrast, the 'Keitt' mango trees with four leaves per stem produced only 22 per cent of flowering under warm temperature in the Colombian tropics (Davenport, 2007).

Ramirez et al. (2010a) report that in the tropical warm circumstances, fractions of leaves per stem are able to triggering a minimum quantity of flowering. Increased leaf number is associated with increased flowering responses, but in comparison to leaves exposed to subtropical, cool conditions, significantly it requires more leaves for a 100 per cent flowering. As a result, understanding mango flowering mechanisms in the tropics is critical. The aim of this research is to understand the synergistic effect of leaf count on flowering mechanisms in mango cv. 'Himampasand' under tropical climate conditions.

Materials and Methods

Research Area

The experimental study plots were located at Jain Irrigation Systems Limited (JISL), Udumalpettai near the Elayamuthur village, Tamil Nadu, India, which has a warm tropical climate with latitude (10° 34´ 48" N), longitude (77° 14´ 24" E), altitude (1208 feet above MSL), and average annual rainfall of (501.40 mm). The monthly average max-min temperature and rainfall during the experimental period were monitored (Fig. 1). The mean daily maximum and minimum RH were 74 % and 49 % respectively.

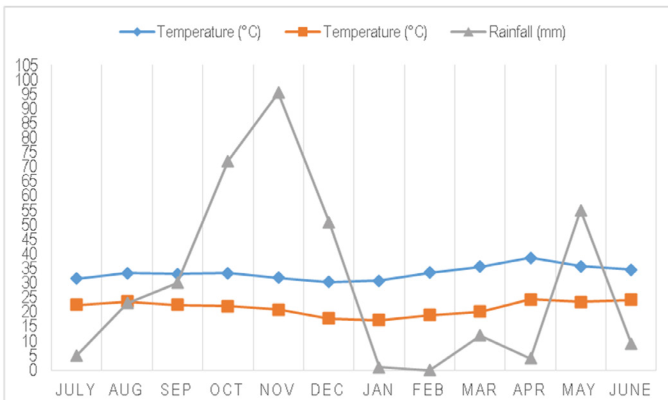

Figure 1. Mean monthly temperature and rainfall averages for the research locations

Experimental Design and Statistical Data Analysis

The study area was set up in a Factorial Randomized Block Design (FRBD) having three replications with two factors: leaf pruning and month. Ten trees per replication were used in each treatmental unit. The number of panicles/branch, the length and breadth of panicle, the number of pure and mixed panicles/branch, and the percentage of shoots with panicle were all recorded and statistically analysed. Web Agri Stat Package (WASP) 2.0, developed by ICAR - Central Coastal Agricultural Research Institute (CCARI), Goa (http://icargoares.in/wasp2.0/index.php), was used to compare mean using Analysis of Variance (ANOVA) at a $P \leq 0.05$ significance level.

Biological Material

The research was conducted at Jain Irrigation Systems Limited (JISL), Udumalpet, Tamil Nadu, India. The research work was a collaboration between Horticulture College and Research Institute, TNAU, Coimbatore and Jain Irrigation Systems Ltd. Udumalpet. The field study was set up in a five-year old mango orchard evenly planted at 3 × 2 m. During the research period, the trees were maintained uniformly and the same cultural practices were followed. **Factor 1** (Leaf pruning levels) *viz*., T_1: Total removal of leaves from the shoot, T_2: Retention of 1/8th leaf lamina, T_3: Retention of 1/4th leaf lamina, T_4: Retention of half the leaf lamina, T_5: Retention of 1 leaf per shoot, T_6: Retention of 2 leaves per shoot, T_7: Retention of 3 leaves per shoot, T_8: Retention of 4 leaves per shoot, T_9: Retention of 5 leaves per shoot, T_{10}: Retention of 6 leaves per shoot, T_{11}: Control (without leaf removal). **Factor 2** (Months) *viz*., M_1: October M_2: November and M3: December.

Procedure for Leaf Pruning

As per the treatments, all the leaves were removed, except the required number of leaves per stem which were retained. The replicating branch was separated from the rest of the tree by girdling at the same time as leaf pruning. Girdling (wide ring of a 0.5 cm) was made in the bark wide ring. Girdling was given just above the treatment imposed branch point with twenty shoots on the same branch (remaining was removed). Treatments consisted of 0 (no leaves), 1/8, 1/4, 1/2, 1, 2, 3, 4, 5, 6, and control (without leaf removal) leaves remaining on each selected stem of each treated branch. Leaves were removed by hand (manually) from all stems on every treated branch according to Davenport et al. (2006).

In the treatments with leaf fraction, the leaf lamina close to the petiole was retained after cross cutting at mid-lamina (1/2 leaf treatment), one by four lamina length (1/4 leaf treatment) and at one by eight lamina length (1/8 leaf treatment). All selected branches were tagged before imposing the treatments at different months. The treatments were imposed during the middle of October, November and December. The average number of leaves was observed in control (T11) at the time of leaf pruning during October (23.00), November (23.76) and December (24.00).

Results and Discussion

Effect of Leaf Pruning on Number of Panicles/Branch and Highest Percentage of Shoots with Panicle in Mango

Florigen is a putative signal produced by the leaves that induces floral ignition at the apex of the shoot (Zeevaart, 2008). Among the leaf pruning treatments, control (T_{11}) and retention of 6 leaves / shoot (T_{10}) registered the maximum number of panicles / branch and the highest percentage of shoots with panicle (Table 1). However, the least number was observed in the total removal of leaves from the shoot (T_1). The quantitative rise in the proportion of reproductive shoots growth with an increasing number of leaves was noticed. It might be due to florigen (flower-former) signals that move via the phloem to the shoot apex from an induced leaf that will contribute to more flowering than total removal of the leaf from the shoot. Leaf removal from branches, which is the source of florigenic promoter, has been known to induce only vegetative shoots in tropical (Ramirez et al., 2010b). Reece et al. (1946 and 1949) state that early and contemporary research has established the existence of a mango florigenic promoter, a chemical substance that is hypothesised to be synthesised in leaves and transmitted to buds via phloem (Singh, 1962 and 1977; Davenport et al., 2006; Ramirez et al., 2010a). Leaf fractions per stem are proficient of producing a minimum quantity of flowering (Ramirez and Davenport, 2010). Although more leaves are needed for a 100 per cent flowering response, an increase in leaf quantity is correlated with an increase in flowering responses. Similar findings were also obtained by Davenport et al. (2006). Depending on the cultivar, the number of mango leaves more crucial to initiate flowering in mango may vary. Davenport et al. (2006) found that the Alphonso and Langra varieties of mango required at least six leaves to enable flowering.

Among the months, the maximum number of panicles/branch and the maximum percentage of shoots with panicle occurred in the month of December, while the least was observed in the month of November (Table 1). The December month leaf pruning was observed to have high flowering, when compared to other months. It might be due to the age of the shoot and the number of leaf count per shoot (Ramirez and Davenport, 2012). However, early removal in November had very little flowering compared to October, meaning that November removal might have disturbed the plant, leaving a few days for synthesising florigen sufficient to produce flowers. The maximum number of panicles / branch and the highest percentage of shoots with panicle were observed in $T_7 M_3$, $T_8 M_3$, $T_9 M_1$, $T_9 M_3$, $T_{10} M_1$, $T_{10} M_2$, $T_{10} M_3$, $T_{11} M_1$, $T_{11} M_2$ and $T_{11} M_3$. However, the least was observed in $T_1 M_1$ and was on par with $T_1 M_2$. These results clearly indicate that the age of the leaves and shoots and the number of leaf count per stem are crucial for obtaining a better flowering response. Ramirez et al. (2010b) also reported similar findings in mango.

Effect of Leaf Pruning on Length and Breadth of Panicle/ Branch in Mango

In different leaf pruning treatments, control (T_{11}) registered the longest and widest panicles, followed by the retention of 6 leaves per shoot (T_{10}). However, the least was observed in the total removal of leaves from the shoot (T_1). Among the months, the longest and widest panicles were observed in the month of December, while the least was observed in the month of November (Table 2). The longest and widest panicles were observed in the $T_{11} M_3$ combination. However, the least were observed in the $T_1 M_3$ combination. This study supports the evidence for the view that the florigen promoter plays a fundamental role in flowering (Zeevaart, 2008). Increases in length and width of panicles are correlated with increasing leaf numbers and the age of shoots and leaves. The interaction effect (total removal of leaves from the shoot x December) had the lowest length and width of panicles when compared to October and November.

Effect of Leaf Pruning on Number of Pure and Mixed Panicles / Branch in Mango

Retention of 6 leaves per shoot (T_{10}) and control (T_11) registered the highest number of pure panicles/branch. However, the lowest number of pure panicles per branch and the highest number of mixed panicles per branch were observed in total removal of leaves from the shoot (T_1).

Table 1. Effect of leaf pruning on number of panicles/branch and percentage of shoots with panicle in mango

Treatments	Number of panicles/branch				Percentage of shoots with panicle			
	October (M_1)	November (M_2)	December (M_3)	Mean	October (M_1)	November (M_2)	December (M_3)	Mean
T_1	3.34	4.00	11.00	6.11	16.70	20.00	55.00	30.57
T_2	7.00	5.50	16.66	9.72	35.00	27.50	83.33	48.61
T_3	11.25	8.66	16.30	12.07	56.25	43.33	81.05	60.21
T_4	12.00	10.00	17.00	13.00	60.00	50.00	85.00	65.00
T_5	14.50	13.00	18.50	15.33	72.50	65.00	92.50	76.67
T_6	16.00	13.20	19.00	16.07	80.00	66.00	95.00	80.33
T_7	17.65	16.00	20.00	17.88	88.25	80.00	100	89.42
T_8	19.00	15.80	20.00	18.27	95.00	79.00	100	91.33
T_9	20.00	18.50	20.00	19.50	100	92.50	100	97.50
T_{10}	20.00	20.00	20.00	20.00	100	100	100	100.00
T_{11}	20.00	20.00	20.00	20.00	100	100	100	100.00
Mean	14.61	13.15	18.04		73.06	65.76	90.17	

	T	M	T x M	T	M	T x M
SEd	0.22	0.18	0.39	0.78	0.41	1.36
CD (0.05)	0.48	0.23	0.77	1.57	0.82	2.72

Table 2. Effect of leaf pruning on length and breadth of panicles/branch in mango (cm)

Treatments	Length of panicle				Breadth of panicle			
	October (M_1)	November (M_2)	December (M_3)	Mean	October (M_1)	November (M_2)	December (M_3)	Mean
T_1	7.50	4.67	3.25	5.14	2.22	1.75	1.00	1.66
T_2	7.66	4.90	6.00	6.19	2.50	2.00	2.90	2.47
T_3	7.91	4.50	6.72	6.38	3.33	2.25	3.05	2.88
T_4	7.83	5.68	8.00	7.17	4.00	2.33	3.75	3.36
T_5	8.00	5.00	8.80	7.27	4.05	2.50	4.00	3.52
T_6	8.20	6.65	10.83	8.56	3.95	2.75	5.17	3.96
T_7	11.70	8.57	13.80	11.36	5.33	3.88	6.67	5.29
T_8	13.05	11.00	14.30	12.78	6.00	4.69	7.92	6.20
T_9	18.00	14.25	15.33	15.86	6.00	5.40	9.00	6.80
T_{10}	18.20	18.30	20.60	19.03	6.30	7.50	7.00	6.93
T_{11}	20.34	20.00	27.37	22.57	12.96	13.00	15.79	13.92
Mean	11.67	9.41	12.27		5.15	4.37	6.02	

	T	M	T x M	T	M	T x M
SEd	0.15	0.08	0.26	0.08	0.04	0.14
CD (0.05)	0.30	0.16	0.53	0.16	0.09	0.29

Table 3. Effect of leaf pruning on number of pure and mixed panicles per branch in mango

Treatments	Number of pure panicles per branch				Number of mixed panicles per branch			
	October (M_1)	November (M_2)	December (M_3)	Mean	October (M_1)	November (M_2)	December (M_3)	Mean
T_1	1.19	0.00	11.00	4.06	2.15	4.00	0.00	2.05
T_2	5.75	5.50	16.66	9.30	1.25	0.00	0.00	0.42
T_3	11.25	7.66	16.00	11.64	0.00	1.00	0.00	0.33
T_4	11.00	10.00	15.00	12.00	1.00	0.00	2.00	1.00
T_5	14.50	13.00	17.50	15.00	0.00	0.00	1.00	0.33
T_6	16.00	11.45	18.00	15.15	0.00	1.75	1.00	0.92
T_7	17.65	12.00	20.00	16.55	0.00	4.00	0.00	1.33
T_8	19.00	11.80	20.00	16.93	0.00	4.00	0.00	1.33
T_9	20.00	18.50	20.00	19.50	0.00	0.00	0.00	0.00
T_{10}	20.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00
T_{11}	20.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00
Mean	14.21	11.81	17.65		0.40	1.34	0.36	

	T	M	T x M	T	M	T x M
SEd	0.21	0.11	0.37	0.02	0.01	0.03
CD (0.05)	0.43	0.22	0.74	0.04	0.02	0.07

Among the months, the highest number of pure panicles and the lowest number of mixed panicles/branch were observed in the month of December. However, the highest number of mixed panicles and the lowest number of pure panicles per branch were observed also in the month of December. Greater number of leaf counts per shoot and late leaf pruning resulted in maximum number of pure panicles per branch with less number of mixed panicles per branch. It is thought that the ratio of florigenic to vegetative promoter induces the development of vegetative, mixed and generative shoots. The production of generative shoots is induced by a high florigenic promoter to vegetative promoter ratio, whereas the development of vegetative shoots is induced by a low ratio. The development of mixed shoots may be induced by an intermediate florigenic promoter to vegetative promoter ratio (Davenport, 2000, 2003, and 2009). The putative vegetative promoter appears to be the most active in the leaves of young stems, i.e., in the first month (October) of leaf pruning, and gradually dissipates over time, allowing the expression of the ever present florigenic promoter, i.e., the later month (December), when shoots are initiated fully to grow in warm tropical conditions (Davenport, 2009).

Conclusion

Based on this experiment, it is concluded that under warm, tropical circumstances, fractions of leaves / stem are able to induce minimum quantity of flowering. Generally, an increase in flowering response is associated with a greater number of leaves. From the study, it is concluded that 6 leaves per shoot (T_{10}) are essential for a 100 per cent flowering. Leaf pruning in different months from October to December had varied effects. However, in a tropical climate, 6 leaves per shoot and December pruning resulted in 100% flowering in mango cv. 'Himampasand'. Therefore, the florigen (flower-former) is universal in flowering plants.

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References

Bernier G., Kinet, J. M., Sachs, R. M. (1981). The Physiology of Flowering. Vol. 1. Boca Raton, CRC Press, Florida. pp. 78-102

Davenport T. L., Nunez-Elisea, R. (1997). Reproductive Physiology. In: The Mango Botany: Production and Uses (ed. Litz, R.E.), CAB International, Wallingford, UK. pp. 69-146

Davenport T. L. (2003). Management of Flowering in Three Tropical and Subtropical Fruit Tree Species. Hort Sci 38: 1331-1335

Davenport, T. L. (2000). Processes Influencing Floral Initiation and Bloom the Role of Phytohormones in a Conceptual Flowering Model. Hort Technol 10: 733-739

Davenport T. L. (2007). Reproductive Physiology of Mango. Braz J Plant Physiol 19 (4): 363-376

Davenport T. L. (2009). Reproductive Physiology. In The Mango: Botany, Production and Uses, 2nd edition, (ed. Litz, R.E.), CAB International, Wallingford, UK. pp. 98-169

Davenport T. L. Ying Z., Kulkarni V. and White T. L. (2006). Evidence for a Translocatable Florigenic Promoter in Mango. Sci Hort 110: 150-159

Gopu B., Balamohan T. N., Soman P. and Jeyakumar P. (2014). Canopy Management in Mango (*Mangifera indica* L.) cv. Alphonso with Reference to Flowering, Yield and Quality Characters under Ultra High Density Planting. J Appl Hort. 16 (1): 50-53

Gopu B., Balamohan T. N., Swaminathan V., Jeyakumar P. and Soman, P. (2017). Effect of Growth Retardants on Yield and Yield Contributing Characters in Mango (*Mangifera indica* L.) cv. Alphonso under Ultra High Density Plantation. Int J Curr Microbiol App Sci 6 (11): 3865-3873

Jameel M.A., Rajesh Naik S. M., Madhumathi C., Srinivasa Reddy D. and Venkataramana K.T. (2018). Physiology of Flowering in Mango. Journal of Pharmacognosy and Phytochemistry. 7 (6): 2375-2382

Nunez-Elisea R. and Davenport T. L. (1995). Effect of Leaf Age, Duration of Cool Temperature Treatment and Photoperiod on Bud Dormancy Release and Floral Initiation in Mango. Sci Hort 62: 63-73

Nunez-Elisea R. and Davenport T. L. (1994). Flowering of Mango Trees in Containers as Influenced by Seasonal Temperature and Water Stress. Sci Hort 58: 57-66

Nunez-Elisea R., Davenport T. L. and Caldeira M. L. (1993). Bud Initiation and Morphogenesis in 'Tommy Atkins' Mango as Affected by Temperature and Triazole Growth Retardants. Acta Hort 341: 192-198

Ramírez F. and Davenport T. L. (2010). Mango (*Mangifera indica* L.) Flowering Physiology. Sci Hort 126 (2): 65–72

Ramirez F. and Davenport T. L. (2012). Reproduction Biology (Physiology) the Case of Mango. In Mango, Vol. 1, Production and Processing Technology, Studium Press LLC, USA. pp. 56-81

Ramirez F., Davenport T. L. and Fischer G. (2010a). The Number of Leaves Required for Floral Induction and Translocation of the Florigenic Promoter in Mango (*Mangifera indica* L.) in a Tropical Climate. Sci Hort 123: 443-453

Ramirez F., Davenport T. L., Fischer G. and Pinzon J. C. A. (2010b). The Stem Age Required for Floral Induction of Synchronized Mango Trees in the Tropics. Hort Sci 45 (10): 1453-1458

Rani K.U. (2018). Advances in Crop Regulation in Mango (*Mangifera indica* L.). Int J Curr Microbiol App Sci 7 (9): 35-42

Reece P. C., Furr J. R. and Cooper W. C. (1949). Further Studies of Floral Induction in the Haden Mango (*Mangifera indica* L.). American J Botany. 36 (10): 734-740

Reece P. C., Furr J. R. and Cooper W. C. (1946). The Inhibiting Effect of the Terminal Bud on Flower Formation in the Axillary Buds of the 'Haden' Mango. American J. Botany. 33 (3): 209-210

Singh L. B. (1962). A New Technique for Inducing Early Fruiting in Mango Hybrids Based on the Movement of Hormones. *Proc Hort Soci* 75: 410-412

Singh L. B. (1977). Mango. In Ecophysiology of Tropical Crops (eds. Alvim, P., de, T. and Kozlowski, T. T.). Academic Press, New York. pp. 479-485

Singh M. K., Singh V. B. Singh S. S. and Singh A. K. (2019). Floral Biology and Fruit Set of Mango (*Mangifera indica* L.) as Influenced by Different Chemicals. Int J Curr Microbiol App Sci 8 (01): 1106-1117

Whiley, A. W. (1993). Environmental Effects on Phenology and Physiology of Mango - A Review. Acta Hort 341: 168-176

Zeevaart, J. A. D. (2008). Leaf-Produced Floral Signals. Current Opinion Plant Bio. 11: 541-545

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