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INFLUENCE OF CROP LOAD ON PHYSICO-CHEMICAL ATTRIBUTES OF MANGO FRUIT CV. AMRAPALI

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ABSTRACT

Crop load is the key cultural component for efficient and effective management of fruit crops which influences the fruit quality. The present investigation was conducted in the Department of Horticulture (Fruit and Fruit Technology), BAU, Sabour during 2022-23 to evaluate the response of crop load on physico-chemical composition of mango cv. Amrapali. Studies were conducted with the objective to evaluate the effect of crop load levels i.e. retaining of 20, 30, 40, 50, 60 and 70 fruits per plant and control (no thinning) on physical and biochemical parameters of mango cv. Amrapali under high density planting. The experimental observations revealed that the physical attributes such as fruit weight (290.79 g), fruit length (114.82 mm), fruit breadth (76.03 mm), fruit volume (256.60 cc), pulp weight (229.54 g), pulp: stone ratio (6.65) and pulp percent (78.71) were found to be highest in (T_1) *i.e.* crop load with 20 fruits per tree retained at marble stage . Further, fruit quality attributes in terms of TSS (23.69 °Brix) and total carotenoids (5.71 mg 100 g^{-1} FW) was recorded maximum by the crop load 20 fruits per tree retained at marble stage (T_1). Similarly, minimum titratable acidity of 0.22%, was recorded in the crop load 20 fruits per tree retained at marble stage (T_1). All the above attributes were found statistically at par with the crop load 30 (T_2), 40 (T_3) and 50 (T_4). From the results, it can be concluded that thinning of fruits (i.e. retaining of 20, 30, 40, 50, 60 and 70 fruits per plant) significantly improved the physical and biochemical character of fruits. Retaining of 20 fruits per plant was recorded significantly higher for both physical and biochemical attributes. Therefore, from this experiment, it may be concluded that for quality and fruit size, retaining 20 to 50 fruits per tree (T_4) is advisable.

Keywords: Mango, crop load**,** marble stage, thinning, carotenoids

Introduction

Mango (*Mangifera indica* L.), a prominent tropical fruit crop from the family Anacardiaceae, is grown commercially in tropical and subtropical regions and is frequently referred to as the "King of Fruits" in India. It is one of the most appreciated fruits in significant supermarkets nationwide and worldwide due to its delicious taste, alluring fragrance, outstanding hues, and nutritious value. India is considered to be one of the foremost mango-producing countries globally. The cultivation of mangoes in India encompasses approximately 22.91 lakh hectares of land, resulting in a production of 20.44 metric tonnes. This equates to an average productivity of 8.9 metric tonnes per hectare, which is considered relatively poor (Anonymous, 2019).

Fruit trees frequently exhibit vulnerability towards biannual bearing. Biennial bearing refers to a cultivar's tendency to alternate between a full ("on") crop year and a minimal ("off") crop year, resulting in variable fruit quality and quantity (Monselise and Goldschmidt, 1982). Biennial bearing can be influenced to some amount by regulating crop load in the "on" year, but the effects vary by cultivar (Schwallier *et al*., 2006; Singh, 1948). Effective crop load management can eliminate biennial bearing, ensuring adequate return bloom each year with regular, predictable yields. Crop load management is usually achieved by removing excess or unwanted flowers/ fruits from the tree (crop regulation or thinning) or preventing flower initiation. There are several methods by which a reduction in flowers/fruits can be accomplished: (1) hand thinning; (2) application of plant bioregulators (PBRs) that either prevent fertilisation at flowering or result in abscission of flowers/fruits; (3) through shading (photosynthetic inhibition) of the tree; (4) physical removal by use of mechanical devices; or (5) through cultural practices such as pruning (Bound *et al.*, 2001; Webster 2002). Hand thinning, which involves manually removing excessive flower or fruit loads, is the most accurate and reliable way of thinning (Costa *et al.*, 2013; Bound 2021).

Crop load is a significant factor in maximizing fruit colour and size. A high fruit-to-leaf ratio may mean that the leaves cannot produce enough carbohydrates to colour or size all of the fruit to their full potential (Tahir and Hamid, 2002). Fruit thinning is therefore needed to ensure the fruit-to-leaf ratio is within the desired range to reach an adequate size and good quality fruits. Increasing the size and producing fruits of desired quality attributes balance crop load because, due to limited carbohydrate and nutrient supply, the size of fruits still needs to be more significant. Crop load can be reduced mechanically by hand at the fully swollen bud or fruitlet stage.

Fruit thinning is effective in managing the relationship between vegetative and reproductive growth, which ensures high quality and yield in fruit trees by adjusting the relationship between "sink" and "source" and changing the transportation and distribution of photosynthates (Morandi and Grappadelli, 2009; Seehuber, 2011). Fruit thinning has successfully overcome alternate bearing, increase nutrient accumulation, and prevent premature ageing (Hehnen, 2012). Numerous researches have demonstrated that proper fruit thinning can improve the fruit'saverage weight and the fruit's quality and commodity rate (Bussi *et al.*,2005; Serra *et al.*, 2016). Meanwhile, the proper crop load can improve leaf photosynthesis (Syvertsen, 2003; Kasai, 2008).

Consequently, considering the importance of crop load on the growth and quality parametersthe present investigation was undertaken to study the effect of crop load on physico-chemical composition of mango cv. Amrapali.

Materials and Methods

The present experiment was conducted under All India Coordinated Research Project on Fruits, Bihar Agricultural College, Sabour, during 2022-23. Thirty five years old Mango cv. Amrapali was selected as the experimental plant which was headed back to height of 110 cm from ground level. After the fruit set, fruits were hand thinned at marble stage and desired number of fruits per tree according to the determined treatments fruits were retained per tree. T_1-crop load with 20 fruits per tree retained at marble stage, T_2-crop load with 30 fruits per tree retained at marble stage, T_3-crop load with 40 fruits per tree retained at marble stage, T_4-crop load with 50 fruits per tree retained at marble stage , T_5-crop load with 60 fruits per tree retained at marble stage , T_6-crop load with 70 fruits per tree retained at marble stage and T_7-control(no thinning).

For each experiment ten fruits were selected randomly and weighed on digital weighing balance and expressed in gram. Fruit length and breadth wastaken with the help of digital vernier calliperand expressed in millimetre (mm).Fruit volume was calculated by water displacement method and was expressed in terms of cubic centimetre (cc). Peel, stone and pulp percentage was calculated by using following formula:

$$Peel/Stone/Pulp(\%) = \frac{Weight\ of\ Peel\ or\ Stone\ or\ Pulp}{Total\ weight\ of\ fruit} X100$$

The pulp stone ratio of fruits was calculated as pulp weight dividing by stone weight. Ascorbic acid content of the fruit was determined by 2, 6-dichlorophenol indophenol dye method (Jones *et al.*, 1983).TSS of the fruits were recorded by hand refractometer according to the method described by Rangana (2010) and were expressed in (°Brix). Titratable acidity was calculated by using titration method (Rangana, 2010) and the assessment was done with following formula:

$$TA(\%) = \frac{Titre\ value \times Normality\ of\ Alkali \times Vol.made\ up \times Equiv.wt.of\ acid \times 100}{Vol.of\ sample\ taken\ for\ estimation \times Wt.or\ Vol.of\ sample\ taken \times 1000}$$

Total sugar present in the sample was calculated by Lane and Eynon (1934) method by using following formula:

$$Total\ sugar\ \% = \frac{Factor \times Dilution \times 100}{50 \times Titrate\ Value \times Weight\ of\ sample} \times 100$$

The total carotenoid content of the fruit juice was determined using Roy (1973) method. Cupric reducing antioxidant capacity (CUPRAC) assay was estimated as the method of Apak *et al.* (2008). The results were expressed as μ mol Trolox equivalent g^{-1} FW by using the formula as mentioned below:

$$Total\ Antioxidant\ Activity = \frac{O.D. \times 4.1 \times time\ prior\ to\ analysis \times total\ volume}{Weight\ of\ sample \times 1.67 \times 10000 \times 0.1}$$

Results and Discussion

Physical parameters

Data represented in Table 1, shows that among the treatments the maximum fruit weight and volume290.79 g and 256.60 cc respectively was recorded in T_1, which was statistically at par with the crop load T_2, (T_3) and (T_4) fruits per tree retained at marble stage. However, minimum fruit weight and volume 215.68 g and 208.70 cc, respectively was recorded in control (T_7).A high leaf-to-fruit ratio promotes faster fruit growth by ensuring an adequate supply of starch for storage (Kousar *et al.*, 2016). These findings have been confirmed by the study conducted by Casierra *et al.* (2007). Fruits show a strong demand for photosynthetic products if the amount of fruit rises (Kozlowski and Pallardy, 1997). The maximum fruit length (114.82 mm) and breadth (76.03mm) were obtained in T_1. However, minimum fruit length of 92.35 mm and breadth (61.46 mm) was observed in control (T_7). According to Davarynejad *et al.* (2008), there is a linear relationship between the severity of thinning and an increase in diameter. Gurudarshan Singh and Dhaliwal (2004) also reported similar findings on guava, Arora and Chanana (2001) on peach, and Rascko (2006) on apple.

Table 1: Influence of crop load on weight, length, breadth and volume of fruit mango cv. Amrapali.

Treatments	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Fruit volume (cc)
T_1	290.79	114.82	76.03	256.60
T_2	284.05	112.67	74.58	250.30
T_3	272.28	110.01	70.96	243.65
T_4	263.47	107.80	68.93	236.05
T_5	244.28	97.62	64.19	222.95
T_6	236.33	95.66	63.22	209.35
T_7	215.68	92.35	61.46	208.70
Sem(±)	14.51	5.51	3.77	12.95
CD (P=0.05)	43.11	16.35	11.19	24.67
CV (%)	9.74	9.13	9.53	9.65

According to the data presented in the Table-2, maximum pulp: stone was observed in T_1(6.65), which was statistically at par with the crop load 30 (T_2),40 (T_3) and 50 (T_4) fruits per tree retained at marble stage. However, minimum was recorded in control T_7(4.53).This redistribution may lead to the production of larger cells, hence enhancing the overall weight and size of the fruits. The current results align closely with the findings reported by Wiggans (1959) as well as Casierra *et al.* (2007). Peel and stone per cent was found to be non-significant (table-2). The data reflected that peel percent was varied from 9.19 per cent in T_1 to 11.20 per cent in T_7 and stone percent was also varied from 12.09 per cent in T_1 to 17.88 per cent in T_7. The current results are consistent with the findings of Casierra *et al.* (2007).The data with regarding pulp per cent indicates significant variation among the treatments. Maximum pulp per cent was found 78.71 in T_1 .However, minimum pulp per cent was computed in control T_7 i.e.70.92.The results were consistent with the findings reported by Patel *et al.* (2015) in peach that the increase in pulp weight, stone weight, stone size and pulp: stone ratio could be attributed to increase in fruit size which resulted in higher proportionate pulp weight and increased marginal stone weight.

Table 2: Influence of crop load on Pulp: stone, Peel, stone, pulp percent of mango c.v. Amrapali.

Treatments	Pulp: stone (g)	Peel (%)	Stone (%)	Pulp (%)
T_1	6.65	9.19	12.09	78.71
T_2	6.43	9.24	12.45	78.31
T_3	6.07	9.61	12.95	77.44
T_4	5.60	9.90	13.83	76.27
T_5	5.00	10.45	15.14	74.40
T_6	4.83	10.57	15.62	73.80
T_7	4.53	11.20	17.88	70.92
Sem(±)	0.47	2.07	1.20	2.26
CD (P=0.05)	1.40	N.S.	N.S.	4.21
CV (%)	14.57	12.03	14.56	5.17

Biochemical parameters

Among the treatment there was significant difference with respect to Total soluble solids, Total carotenoid and Titratable acidity content (table-3).Maximum total soluble solid and total carotenoid content was recorded 23.69 °Brix and 5.71 mg 100 g^{-1} FW respectively, whereas minimum titratable acidity of 0.22% was noted in T_1.However, the minimum TSS and total carotenoid content, whereas maximum titratable acidity was observed in control (T_7).Thinning process leads to increased synthesis, transport and accumulation of sugars in the remaining fruits. The findings coincide with the study conducted by (Casierra *et al*., 2007; Dhillon *et al*., 1987; Bashir *et al*., 2003; Hegde and Chharia, 2004 and Singh and Jain, 2007). Increase in total carotenoid might be due to the fact that fruit thinning resulted in reducing the inter-fruit competition for minerals, metabolites and precursors, which increased the faster accumulation of colouring pigments (Meitei *et al*., 2013). The research findings align with those of Jafari *et al*. (2014). The reduction in acidity might be due to the conversion of organic acid to sugar. These findings are supported by the studies conducted by Fanasca *et al*. (2007) and Saini *et al*. (2003).

There were no significant modifications observed in the overall ascorbic acid content, total sugar content and antioxidant capability of the fruits in relation to crop load. The data reflected that ascorbic acid content was varied from 25.91 mg100 g^{-1} FW in T_7 to 26.78 mg 100 g^{-1} FW in T_1.Total sugar content varied from16.80 per cent in T_7 to 17.10 per cent in T_1 and total antioxidant capacity was found varied from555.95 µ mol Trolox/ 100 g FW in T_7 to 559.48 µ mol Trolox/ 100 g FW in T_1. Mustafa *et al*. (2023) observed that thinning led to early maturity, which helped in higher accumulation of ascorbic acid in fruits. Fattahi *et al*. (2020) and Bunendia *et al*. (2008) also observed similar results. Increase in sugars might be due to the degradation of polysaccharides into simple sugars as reported by Naik (1985) in mango. The results are in close conformity with Casierra *et al*. (2007), Soliman *et al*. (2011). Nevertheless, Hegedus *et al*. (2010) and Mustafa *et al*. (2023) have both confirmed the beneficial impact of crop load on antioxidant activity in apricot and pomegranate, respectively.

Table 3 : Influence of crop load on total soluble solids, titratable acidity, total sugar of mango cv. Amrapali.

Treatments	Ascorbic acid (mg/100 g FW)	TSS (° Brix)	Titratable acidity (%)	Total sugar (%)	Total carotenoids (mg/100g FW)	Antioxidants (mol Trolox/ 100g FW)
T_1	26.78	23.69	0.22	17.10	5.71	559.48
T_2	26.56	23.65	0.23	17.20	5.66	558.92
T_3	26.33	23.59	0.25	17.16	5.54	557.44
T_4	26.17	23.36	0.26	17.03	5.44	556.95
T_5	26.03	22.90	0.26	16.94	5.42	556.46
T_6	25.96	22.59	0.27	16.88	5.35	556.17
T_7	25.91	22.24	0.27	16.80	5.32	555.95
Sem(±)	0.52	0.41	0.01	0.40	0.10	10.52
CD (P=0.05)	N.S.	1.01	0.02	N.S.	0.26	N.S.
CV (%)	3.45	3.05	3.68	4.11	3.21	3.27

Conclusion

Based on obtained findings it could be concluded that crop load significantly improved the fruit growth parameter i.e. fruit weight, fruit size and fruit volume without imparting the fruit quality parameters. The experimental observations revealed that the physical attributes such as fruit weight (290.79 g), fruit length (114.82 mm), fruit breadth (76.03 mm), fruit volume (256.60 cc), pulp: stone ratio (6.65) and pulp percent (78.71) were found to be highest in (T_1) *i.e.* crop load with 20 fruits per tree retained at marble stage . Further, fruit quality attributes in terms of TSS (23.69 °Brix) and total carotenoids (5.71 mg 100 g^{-1} FW) was recorded maximum by the crop load 20 fruit per tree retained at marbles stage (T_1). Similarly, minimum titratable acidity of 0.22 %, was recorded in the crop load 20 fruit per tree retained at marbles stage (T_1). All the above attributes were found to be statistically at par with the crop load 30 (T_2), 40 (T_3) and 50 (T_4). From the results, it can be concluded that thinning of fruits (i.e. retaining of 20, 30, 40, 50, 60 and 70 fruits per plant) significantly improved the physical and biochemical character of fruits. Retaining of 50 fruits per tree (T4) was recorded significant with (T1) retaining of 20 fruits per tree, could be recommended for better fruit quality and size.

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