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Effect of hand defoliation on advancing fruiting in sugar apple (*Annona squamosa* L.) cv. Balanagar

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ABSTRACT

Sugar apple cultivar 'Balanagar' comes to harvest during August-September under mild tropical climate, which coincides with monsoon rains resulting in poor fruit quality and high susceptibility to anthracnose and fruit fly. An attempt was made to advance the fruiting in this cultivar through hand defoliation in 2017-18 at ICAR-IIHR, Bengaluru. The effects of defoliation on flowering and fruiting were compared. Early sprouting, flowering and fruit harvest were recorded in the defoliated trees. Earliest fruits were harvested during 3rd week of April (216 days) from the defoliated trees while the un-defoliated trees come to harvest during the 1st week of August (313 days) (P=0.01). Fruits with higher pulp per cent (61.6) and lesser seeds (31) were harvested from the defoliated trees (P=0.05). Defoliation did not affect the fruit weight and acidity significantly. Comparatively, higher yield per tree and fruit TSS (7.2 kg; 24.7°B) were recorded for the un-defoliated trees over the defoliated trees (6.8 kg; 23.1°B) (P=0.05). Results revealed that fruiting could be advanced by three months to April from the normal season of August-September with comparable fruit quality by defoliating the trees during 3rd week of September.

Introduction

Sugar apple (*Annona squamosa* L.) is predominantly cultivated in the arid and semi-arid regions of India, notably in the states of Andhra Pradesh, Maharashtra, Karnataka, Bihar, Odisha, Assam, Tamil Nadu, and Rajasthan. The fruit is primarily consumed fresh, although products like custard powders and ice creams are also made from its pulp. It is a high-energy fruit, an excellent source of vitamin C and manganese, and is rich in thiamine, vitamin B6, iron, magnesium, phosphorus, and potassium in moderate amounts. Among the various sugar apple cultivars grown across India, such as Balanagar, Mammoth, Mahaboobnagar, Washington, Red Sitaphal, British Guinea, and Kakarlapahad, Balanagar is the most commonly cultivated. Under natural conditions, the fruits mature and are harvested during September-October, coinciding with the monsoon season. This often results in poor fruit quality and a high incidence of anthracnose disease and fruit fly infestations. As a deciduous fruit crop, sugar apple flowers on the current season's growth in March-April after leaf fall in the preceding winter. Advancing the fruiting season through crop regulation practices could enhance fruit quality during summer.

In sugar apple, flower buds are formed extra-axillary, opposite

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the leaves, and are limited to early shoot development (George and Nissen, 1987; Chander *et al.*, 2022). The cultivar Balanagar, with its short branches and sub-petiolar lateral buds, offers an opportunity to induce flowering through defoliation or bud break promotion, which could be more practical than pruning (Chander *et al.*, 2019). While various chemicals like urea, dormex, ethrel, potassium iodide (KI), and naphthalene acetic acid (NAA) have been used to defoliate trees effectively, the physical removal of leaves through hand defoliation is an alternative that avoids chemical applications. Several studies on different fruit crops, including guava (Sahay & Singh, 2001; Atawia *et al.*, 2017), lasora (Kumar *et al.*, 2018), peach (Lloyd and Firth, 1990), and vine (Sabbatini and Howell, 2010), have demonstrated the potential of hand defoliation to induce flowering. Watson and Casper (1984) and Watson (1986) noted that defoliation interrupts flowering responses by altering the partitioning of assimilates within the tree.

Defoliation of leaves in lasura in the month of December-January produces early flowering and fruiting in arid region (Sharma *et al.*, 2013). The competition for assimilates depends on branch autonomy, balancing reproductive and vegetative growth. In sugar apple, axillary buds are concealed at the leaf petiole base, which acts as a physical barrier to sprouting. Manipulating the timing of defoliation could thus influence flowering and fruiting periods (Chander *et al.*, 2022). Given the limited information on crop regulation in sugar apple, this study aims to explore the potential of hand defoliation as a sustainable, small-scale method to induce early flowering and fruiting and enhance the fruit's marketability. Although challenging and not economical on a large scale, this approach offers valuable insights into targeted and environmentally friendly crop management practices.

Material and Methods

The investigation was carried out on 8-year-old healthy trees of sugar apple cv. Balanagar maintained at orchard of ICAR-IIHR, Bengaluru (India) during 2017-18. Thirty-two uniform and healthy trees were selected for the present study. Hand defoliation (T_1) (Picture 1) was undertaken during third week of September while control trees kept un-defoliated (T_2). Standard package of practices were adopted for maintenance of trees during the experimentation. The number of days required for sprouting and flowering was assessed by recording the days taken for the emergence of first sprout and flower respectively after the treatment imposition. The duration of the harvest was calculated from the date of imposing the treatments to the first fruit harvest. The total fruit yield per tree was recorded at harvest by measuring weight of fruit harvested and values were expressed in kilogram. Fruit weight (g) and peel weight (g) was recorded using electronic balance. The number of seeds per fruit was calculated by counting the number of seeds. The total soluble solids (TSS) were measured using digital refractometer and expressed as degree Brix. The titrable acidity was estimated by adopting the titrimetric method of AOAC (1975) using phenolphthalein indicators and values were expressed in terms of percentage tartaric acid equivalent. Pulp per cent was calculated by using the following formula: Pulp (%) = (Pulp weight / Fruit weight) × 100.

The experiment was laid out in a randomized block design (RBD) with two treatments (T_1 and T_2), each comprising 16 trees. Statistical analysis was performed using the t-test at a significance level of P = 0.05 as well as P = 0.01 to compare the means of the treatments. The critical difference (CD) at 5% & 1% was calculated to determine significant differences between the treatments. Data analysis was conducted using WASP (2.0) software (Jangam and Thali, 2004).

Results and Discussion

Sprouting and flowering

Hand defoliation significantly influenced the timing of sprouting and flowering in sugar apple. Early sprouting was observed in defoliated trees compared to the control. This early sprouting led to the initiation of flowering earlier than usual, with flowers emerging approximately 216 days after defoliation. In contrast, flowering in the un-defoliated trees began much later, with fruit development taking 313 days. The advancement of sprouting and flowering in defoliated trees could be attributed to the removal of physical and hormonal barriers posed by the leaf petioles (Chander *et al.*, 2019). This manipulation allowed better exposure of the dormant buds, stimulating early bud break. Manual defoliation resulted in the earliest sprouting as well as flowering in lasora (Kumar *et al.*, 2018). Similar findings have been reported in other fruit crops, where defoliation induced early flowering by redistributing assimilates and activating dormant meristems (Nanra *et al.*, 2001; Olesen and Muldoon, 2012; Sharma *et al.*, 2013; Boora *et al.*, 2016). Advancing the flowering period can provide significant advantages, as it shifts the fruiting period to a more favourable season, reducing susceptibility to monsoon-related fruit quality issues such as anthracnose and fruit fly infestation.

Fruit weight

The average fruit weight was marginally lower in the defoliated trees (237.7 g) compared to the control (246.1 g). However, this difference was statistically non-significant, indicating that hand defoliation did not have a measurable impact on fruit size. However, Sahay *et al.* (2001) found that application of urea at 15% + hand de-blossoming in guava,

and Chander *et al*. (2019) in Annona cv. Balanagar (urea @ 15%) increased the fruit size over control. The present study achieved an earlier harvest of fruits which was an notable advancement, nevertheless the fruit size remained non-significant which may be due to the weather conditions particularly lower temperature during the growth period of fruit.

Peel weight

Peel weight was significantly lower in the defoliated trees (79.7 g) compared to the control (84.4 g) (P=0.05). This reduction could be attributed to the early development of fruits under defoliated conditions, which potentially influenced fruit composition and peel thickness. Lower peel weight was advantageous as it increases the proportion of edible pulp, improving overall fruit quality (Chander *et al.*, 2019).

Pulp content (%)

Hand defoliation significantly increased pulp content to 61.6%, compared to 59.9% in the control (P=0.05). The higher pulp percentage in defoliated trees could be due to better resource allocation during fruit development under induced flowering conditions. This improvement in edible yield is a critical quality parameter for commercial production, as higher pulp content enhances consumer preference. Chander *et al.* (2019) stated that lower peel weight was advantageous as it increases the proportion of edible pulp, improving overall fruit quality of sugar apple cv. Balanagar.

Number of seeds

Defoliated trees produced fruits with significantly fewer seeds (31.3) compared to the control (41.8) (P=0.05). Reduced seed numbers are desirable in fruits, as it enhances the fruit's marketability and consumer acceptance. The reduction may result from altered assimilate partitioning caused by defoliation, as well as prevailing weather conditions during fruit set and development period which prioritizes pulp development over seed formation. Similar, result was observed by Gonzalez *et al.* (2013) in defoliated cherimoya and Chander *et al*. (2019) in sugar apple cv. Balanagar.

Fruit yield per tree

The yield per tree was slightly lower in the defoliated trees (6.8 kg) compared to the control (7.2 kg) (P=0.05). While the reduction in yield may be attributed to the physiological stress caused by defoliation, it is noteworthy that the quality parameters of the fruits from defoliated trees were superior. This trade-off between yield and quality warrants further investigation to optimize defoliation practices. The findings of Khan *et al.* (2013) in guava and Chander *et al.* (2019) in sugar apple, where no significant effect of defoliation treatments was seen on fruit yield.

Total soluble solids (TSS) and acidity

The TSS of fruits from defoliated trees was slightly lower (23.1°B) than that of the control (24.7°B) (P=0.05). Despite this reduction, the TSS remained within acceptable ranges for high-quality sugar apple fruits. Acidity levels were not significantly affected by defoliation, suggesting that the manipulation did not compromise the fruit's flavour profile. Similar result was reported by Chander *et al*. (2019) in sugar apple cv. Balanagar.

Harvest time

Defoliation advanced fruit harvest by approximately three months, with fruits from defoliated trees maturing in the third week of April (216 days), compared to the first week of August (313 days) for the control (P=0.01) (Picture 2a and 2b). This advancement aligns with the goal of shifting fruiting to a period with reduced rainfall, thereby improving fruit quality by minimizing the incidence of anthracnose and fruit fly infestation. Similar results were recorded in guava (Amador *et al.*, 1992; Khan *et al.*, 2013), lasora (Sharma *et al.*, 2013; Kumar *et al.*, 2018) and annona (Gonzalez *et al.*, 2013; Chander *et al.*, 2019).

Table 1. Effect of defoliation on fruit and yield characteristics

Treatments	Fruit weight (g)	Peel weight (g)	Pulp content (%)	Number of seeds	Fruit yield/ tree (kg)	TSS (°B)	Acidity (%)
Hand defoliation (T_1)	237.7	79.7	61.6	31.3	6.8	23.1	0.18
Control (Un-defoliated) T_2	246.1	84.4	59.9	41.8	7.2	24.7	0.19
CD @ 5%	-	2.0	2.0	2.1	2.0	2.1	-
T-test (P=0.05)	NS	S	S	S	S	S	NS

NS=Non-significant; S=Significant

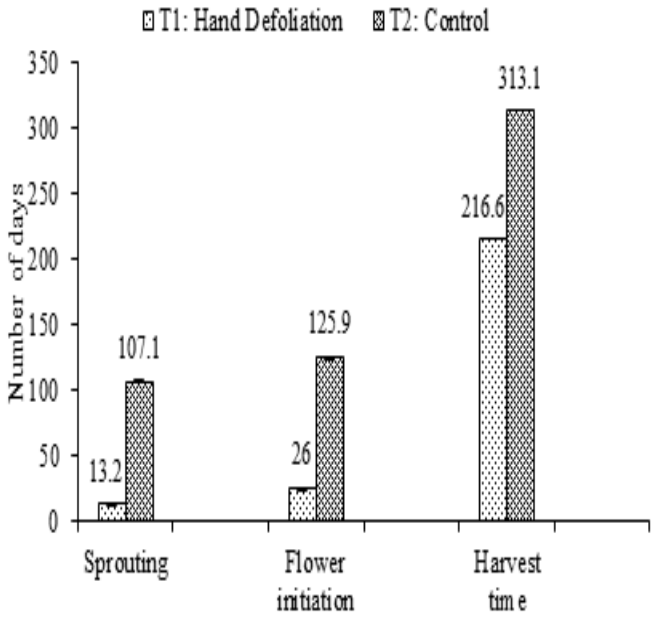

Figure 1. Effect of defoliation on sprouting, flower initiation and harvest time

Picture 1. Defoliated tree

Picture 2a. Harvested fruits (April, 2018)

Picture 2b. Harvested fruits (August, 2018)

Conclusion

The study demonstrated that hand defoliation during the third week of September effectively advanced the harvest season of sugar apple cultivar 'Balanagar' by three months, yielding fruits of comparable or improved quality. Although yield and TSS were slightly lower in defoliated trees, the higher pulp percentage, fewer seeds, and reduced peel weight highlight the potential of this practice for enhancing fruit quality of sugar apple cv. Balanagar. Further studies are recommended to refine defoliation techniques and evaluate their long-term impacts on productivity and profitability.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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