EFFECT OF CROP REGULATION ON YIELD AND QUALITY OF MANGO (*Mangifera indica* L.) UNDER HIGH DENSITY PLANTING SYSTEM

by

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(2017-12-005)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system"** is a bonafide record of research work done by me during the course of research and thethesishas not previously formed the basis for the award to me of any degree, associate ship, diploma, fellowship or other similar title, of any other University or Society.

25/07/2019

Vellanikkara
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CERTIFICATE

Certified that this thesis entitled **"Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system"** is a record of research work done independently by **Ms. Amrita Manohar (2017-12-005)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to her.

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We, the under signed members of advisory committee of **Ms. Amrita Manohar (2017-12-005),** a candidate for the degree of **Master of Science in Horticulture** with major in **Fruit Science**, agree that the thesis entitled **"Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system"** may be submitted by **Ms. Amrita Manohar (2017-12-005),** in partial fulfilment of the requirement for the degree.

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Amrita Manohar

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Dedicated to my teachers, family and Horticoz

Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.) which is known as the 'King of fruits' is grown in the tropics and subtropics of the world. The fruit has highest potentiality with its nutritional value, ravishing appearance, charming taste and flavour. It is the choicest fruit crop of India grown on commercial scale in the mango tracts of the country. It is entitled as the National fruit of the country owing to its popularity among the people. Mango is occupying an area of 22.09 lakh ha with an annual production of 18642.53 MT and an average productivity of 8.44 MT/ lakh ha (NHB, 2015-16). India is the largest producer of mango in the world.

Although mango has attained commercial status in certain tracts of Kerala, it is one among the main crop grown in the homesteads. Kerala mangoes are the first to reach the Indian market every year. Muthalamada panchayath in the Palakkad district known to be the 'Mango city' is now becoming the mango growing tract of Kerala with the cultivation of different varieties on a commercial scale. In Kerala mango occupies an area of 79.99 thousand ha with an annual production of 414.54 T and productivity of 5182 kg/ha (NHB, 2015-16). Low productivity of mango in the state is attributed to the homestead system of cultivation, small land holdings, shortage of space, biennial and erratic bearing, high humidity, high rainfall coinciding with the flowering, excessive fruit drop, pest and disease attack, unscientific management of orchards and lack of awareness about the good varieties grown in other regions of the country.

Flowering is the most important process that ensures high productivity in mango like any other crops. The complex phenomenon of flowering of mango is still a major concern for the researchers. Mango growers face a multitude of problems such as alternate bearing, sparse flowering, erratic flowering, fruit drop and so on which in turn lead to lesser yield from the orchard. Each tree differs in their bearing capacity from year

to year depending on their varietal characters, climatic conditions, prevailing weather during flowering and fruiting, environmental conditions, water availability, pest and disease attack. Biennial and erratic bearing can be attributed to the hereditary characters and changes in the physiology of the tree due to the prevailing weather conditions and management practices followed. The exhaustion of the carbohydrate reserve in the previously fruited shoots may also lead to alternate bearing.

In mango, vegetative flushes occur 3-4 times a year depending on the variety and environmental conditions. As mango flowers are produced on past season growth, about 8-10 months are required for a new shoot to attain the maturity required to produce the inflorescence (Pandey, 1989).

Adoption of high density planting (HDP) system along with crop regulation are of utmost importance for boosting the productivity of mango orchards. HDP helps to make the best use of vertical and horizontal space by accommodating more number of plants per unit area facilitating easy cultural practices leading to higher productivity by the maintenance of tree size. Crop regulation using plant growth regulators combined with pruning were found to be effective in regulating the vegetative and reproductive phases in mango, which in turn lead to high productivity and production of good quality fruits.

Paclobutrazol which has anti-gibberellic activity is widely used as a growth regulator in India to retard the vegetative growth of new shoots and to promote flowering in mango. Besides floral induction it enhances the production of inflorescence leading to higher yield that prevents alternate bearing habit in mango. Off season flowering can also be induced through the use of paclobutrazol by regulating the gibberellin synthesis that advances the harvesting of fruits by about one month. Pruning the shoots immediately after the harvest followed by paclobutrazol application is found to put forth new shoots which bears fruits in the coming season. Preponing

the harvesting of the fruits by even one month helps the mango farmers to fetch premium price in the market making mango cultivation highly remunerative.

Due to the climatic conditions prevalent in Kerala, crop regulation techniques standardized in HDP in mango for a particular variety elsewhere cannot be blindly adopted here since the growth pattern and flowering behaviour of mango tree grown under our climatic condition are entirely different, from other regions of our country.

However, only few works have been reported on chemical crop regulation in mango and no work has so far been conducted on mango under high density planting system in Kerala. In this context, the present study was undertaken in KAU with an objective to study the effect of pruning levels and different levels of pruning along with chemical regulation on growth, flowering, yield and quality of mango cvs. Mallika and Ratna grown under high density planting system.

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Review of Literature

2. REVIEW OF LITERATURE

The complex phenomenon of flowering in mango is a major concern for the researchers. The studies on the physiology of mango flowering is still a vast area to be explored. Problems in mango cultivation is due to multitude of reasons namely sparse, alternate, irregular or non-flowering, apart from the prevalence of small land holdings, pest and disease attack etc. The productivity in mango is directly related to profuse flowering during the cropping season. Any failure in the development of the inflorescence will lead to the failure of crop. Strategic management of orchards is required for solving this problem. Conventional system of mango cultivation can be modified by adopting the modern techniques of canopy management like high density planting, pruning and use of chemical growth regulators. These techniques will help in suppressing the vegetative phase leading to advanced flowering, extended period of flowering and production of quality fruits. Pruning along with the paclobutrazol application lead to higher productivity in mango (Singh *et al.*, 2017).

This chapter is furnished with various literatures pertaining to major works with respect to the effect of crop regulation through pruning and paclobutrazol application in mango varieties. It has been divided into different subheadings as follows:

2.1. Effect of paclobutrazol on vegetative growth

The paclobutrazol (PBZ) is a substituted triazole, that reduces the vegetative growth by inhibiting gibberellin biosynthesis in plants by way of blocking the conversion of kaurene and kaurenoic acid (Davis *et al.*, 1986).

Kulkarni (1988) found that PBZ reduced the shoot length and height increments in three mango cultivars Banganapalli, Dashehari and Peddarasam under Indian conditions. Application of PBZ (1.25g/tree) was found to be very effective in reducing tree vigour by restricting shoot growth, size and canopy spread of mango grafts.

Charnvichit and Tongumpai (1991), noticed a reduction in canopy diameter and tree height in those trees that were supplied with PBZ as soil drench. An increase in the number of flowering shoots were also noticed in these mango trees and opined that the reduction in vegetative parameters might be due to anti-gibberellic action of PBZ.

Ram *et al.* (2005) observed that PBZ application along with pruning had reduced tree height, length of new shoots and canopy diameter in mango cv. Dashehari while the control trees showed the maximum value for the above vegetative characters.

Kotur (2012) reported a reduction in the vigour of new flushes, shoot length and tree height in the trees of Alphonso treated with PBZ. According to Sarker and Rahim (2012), PBZ application showed a significant reduction in the length of terminal shoots and leaf area while it was maximum in the control trees of 'Amrapali'.

On studying the effect of PBZ drench on vegetative characters Narvariya *et al.* (2015) observed a suppressed vegetative growth in the PBZ treated trees compared to the control.

2.2. Effect of paclobutrazol on flowering

Chacko and Randhawa (1971) reported that heavy rains coinciding with the critical time of flower bud initiation promoted vegetative growth rather than flowering in mango trees.

Precocious and enhanced flowering was found in young and old trees which were subjected to soil application of paclobutrazol compared to the non-treated trees (Hasdeseve and Tongumpai, 1986).

Kulkarni (1988) found that paclobutrazol induced precocious flowering in two mango cultivars Banganapalli and Dashehari. He also reported a reduction in the panicle size in these treatments which he analysed to be either due to the

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negative effect of paclobutrazol or an increase in the number of panicles in the shoots.

An increment in number of perfect flowers was observed in Alphonso mango by Burondkar and Gunjate (1991). He also noticed a narrow sex ratio in the treated trees compared to the untreated ones. Strong anti gibberellin like activity of PBZ might be responsible for early flowering in 'Alphonso' (Kurian and Iyer, 1992).

Winston (1992) noticed that the soil application of PBZ as collar drench was found to be more effective in inducing flowering and fruit set than foliar application. Application of PBZ at rates more than 1g per tree resulted in an unacceptable compaction in flower panicles of mango cv. Kensington Pride.

Soil drenching of PBZ at the rate of 5-10 g per tree at the collar region resulted in increased flowering in Alphonso mango (Burondkar *et al.*, 1993). Kurian and Iyer (1993) reported that soil application of PBZ at the rate of 10g/tree showed a narrowed sex ratio in Alphonso mango. Contradictory to this, a finding by Ram and Tripathi (1993) showed that there is no significant effect of PBZ treatments on panicle length and sex ratio in mango cv. Dashehari under Pantnagar conditions.

Rao *et al.* (1997) reported that PBZ soil drench in August at the rate of 10g in five litres of water in a ring taken 60 cm away from the tree trunk resulted in enhanced flowering during 'off' year in Alphonso mango under Karnataka conditions.

According to Shinde *et al.* (2000), the application of PBZ as soil drench based on crown diameter during the first week of July and August months induced early flowering in Alphonso variety of mango.

Singh (2000) reported that soil application of PBZ (40g/tree) effectively increased the size of panicle and the percentage of hermaphrodite flowers. In a work done by Vijayalakshmi and Srinivasan (2002) in Alphonso observed that

PBZ application in soil @ 2.5g/tree produced maximum number of flowers per panicle with higher percentage of hermaphrodite flowers (30.59%).

In the experiment conducted by Singh *et al.* (2004) to study the effect of various plant bio-regulators on flowering in Dashehari found out that there was a notable increase in the number of panicles per square metre when PBZ was applied @ 5g/tree and 10g/tree. They also observed that manipulation of sex ratio is possible by the application of paclobutrazol and were found to favour more number of hermaphrodite flowers.

Karuna and Mankar (2008) observed that soil application of PBZ suppressed the vegetative growth and promoted profuse flowering in mango cv. Langra. The trees treated with paclobutrazol had longer inflorescence in Carabao mango which he noticed as the effect of PBZ on assimilate partitioning that favoured floral shoots rather than acting as a plant growth retardant (Protacio *et al.*, 2009). He also noticed an increase in starch accumulation in stems of PBZ treated trees suggesting its action on flowering resulting from an increased accumulation of starch.

Suppression in the number of vegetative shoots, shoot length, number of leaves and canopy spread along with the enhanced flowering by the application of paclobutrazol in Dashehari, Chausa, Anwar Ratool was reported by Nafees *et al* (2010)

Sarker and Rahim (2012) reported that the application of PBZ preponed the panicle emergence by 19 days and harvesting by 15 days in the mango variety 'Amrapali'.

Sonowane *et al.* (2016) reported that the soil application of paclobutrazol had increased the total number of flowers and percentage of hermaphrodite flowers in 'Alphonso' and suggested that this effect was due to the anti-gibberellic activity of PBZ that induced more flowers per panicle. They also observed a reduction in the panicle size in the PBZ applied trees.

2.3. Effect of paclobutrazol on fruit set, fruit yield and fruit quality

Collar drench of paclobutrazol had significant effect on fruit number and total fruit weight at harvesting phase when compared to the control trees. But the TSS and average fruit weight remained unaffected by different quantity of paclobutrazol application (Winston, 1992).

Improved flowering, fruit set and fruit retention as a result of PBZ soil drench was observed by various researchers (Sarkar *et al.*, 1988; Goguey, 1990; Burondkar and Gunjate, 1993; Desai and Chundawat, 1994).

According to Shinde *et al.* (2000), irrespective of the time of application, different doses of PBZ have significant effect in increasing the fruit set compared to the control in mango cv. Alphonso.

A study conducted by Vijayalakshmi and Srinivasan (2000) reported that the soil application of paclobutrazol had significantly increased the TSS, total sugars, reducing sugars and reduced the acidity percentage of the fruits obtained from the treated 'Alphonso' tree.

A work conducted by Singh and Singh (2003 a) reported that soil application of PBZ was found to be very effective in inducing more number of flowering shoots (35.18%), improved fruit set (56.17%) and fruit retention (3.97%) in 'off' years in Bombai mango. These treatments also enhanced the TSS, total sugars, reducing sugars and reduced the acidity percentage. Similar results were also obtained in the variety 'Dashehari' by Singh and Singh (2003 b).

An improvement in yield parameters by the soil application of PBZ was reported by Yashitela *et al.* (2005) in 'Tommy Atkins' and 'Keitt'. Compared to other plant growth regulators, PBZ treated Langra variety showed a higher proportion of fruit set per panicle and reduction in fruit drop (Karuna *et al.*, 2007; Karuna and Mankar, 2008).

Trees drenched with various doses of paclobutrazol showed significant increase in percentage of fruit set when compared to the control trees (Nafees *et*

al., 2010). Tandel and Patel (2011) observed an increase in flowering, fruit set and fruit retention at marble and maturity phases of fruits per panicle in cultivars Alphonso, Kesar and Rajpuri.

Singh *et al.* (2011) reported the effect of PBZ on the quality parameters of Dashehari, Chausa and Langra mangoes and found that PBZ drench had increased the TSS, total sugars and reducing sugars in these varieties.

Application of paclobutrazol at the rate of 5.0 g $tree^{-1}$during September induced early and profuse flowering, increased fruit set and reduced fruit drop in turn resulting in higher yield in mango cvs. Alphonso and Prior (Randeep, 2012).

Narvariya *et al.* (2015) conducted an experiment to study the effect of PBZ application in the mango cv. Dashehari and observed that the paclobutrazol treated trees produced maximum flowers per panicle, more hermaphrodite flowers, fruit set per panicle, number of fruits per tree, fruit size and yield compared to the control.

An increase in the fruit yield (kg/ha) and number of fruits per tree were observed in 'Alphonso' subjected to paclobutrazol soil drench. The higher yield was related to the alteration in the source-sink relation by PBZ that might have reallocated the carbohydrate reserve which in turn led to the increased percentage of hermaphrodite flowers and number of fruits retained till maturity (Sonawane *et al.*, 2016).

A study conducted by Sarker and Rahim (2018) observed the positive effect of paclobutrazol application in 'Amrapali' on number of fruits per tree, fruit weight as well as yield per tree. They also reported an increase in the pulp weight, TSS, total sugars, reducing sugars and a decrease in the peel/pulp ratio, stone/pulp ratio and acidity.

2.4. Effect of pruning on vegetative growth

A significant reduction in the tree height and canopy spread was observed in mango cv. Nam Dok Mai Twai No. 4 treated with paclobutrazol drench along with pruning compared to the control trees (Charnvichit and Tongumpai (1991).

Pruning after harvest in Sensation mango showed a synchronous vegetative shoot initiation after thirteen days of pruning. He also observed that there was an increased number of new shoots in pruned than the unpruned trees (Oosthuyse, 1994).

Oosthuyse (1997) had observed that uniform vegetative flushes occured shortly after pruning in the pruned trees compared to the non uniform prolific flushing in unpruned trees.

Yashitela *et al.* (2005) reported that the ideal time for terminal pruning was just after the harvest. Thus it had helped in replacing the exhausted branches with new flushes that were photosynthetically active, which upon maturation (6-7 months) put forth flowered panicles in the trees of 'Tommy Atkins' and 'Keitt'.

Lal and Mishra (2007) studied the effect of pruning on the vegetative growth of Chausa mango. They observed that there was a decrease in tree height and increase in shoot length of light pruned trees compared to the unpruned ones.

Tip pruning helped in synchronising the vegetative flushes in the pruned trees and also in eliminating the flower inhibiting factors in the previously fruited branches. They also noted that the important factor that affected flowering in mango was the age of the last flush (Ramirez and Davenport, 2010). On evaluating the impact of pruning on the flushing pattern of mango trees, Nafees *et al* (2010) observed that the number, time and vigour of vegetative flushes under same agro-climatic region was cultivar specific and was attributed to the genetic makeup of the individual cultivars.

According to Srilatha *et al.* (2015) a reduction in the plant height, canopy diameter, and shoot length was observed in Dashehari plants subjected to pruning operations along with the soil application of paclobutrazol.

Thirupathi and Gosh (2016) investigated the effect of shoot pruning at different times on the vegetative growth in the cv. Mallika and suggested that pruning in the month of June showed the maximum shoot length compared to the other months.

Singh *et al.* (2017) observed a reduction in the tree height (3.30 m) and canopy spread (2.21 m) in the trees subjected to annual tip pruning (20 cm) along with paclobutrazol soil drench.

In tropical 'Chokanan' mango variety the effect of shoot pruning on vegetative growth was directly dependent on the type and timing of pruning cut imposed. A synchronous vegetative growth was exhibited by these trees after pruning (Fadhilnor *et al.*, 2018).

2.5. Effect of pruning on flowering

A delay in flowering was observed in mango cultivars Tommy Atkins, Sensation, Heidi, Kent and Keitt along with a decrease in the number of terminal inflorescence in the pruned trees (Oosthuyse, 1997).

An experiment conducted in Dashehari mangoes by Swaroop *et al.* (2001) had reported that June flushing did not have any impact on the flowering phase and yield parameters in the mango trees grown under Maharastra condition whereas a negative impact was observed by the September flushes on the reproductive phase.

Flowering was enhanced in the mango trees subjected to immediate post harvest pruning. The enhanced flowering may be due to the effect of new flushes which upon maturation become photosynthetically more active than the older leaves and might have resulted in the increased accumulation of the carbon reserve (Ram *et al.*, 2005).

Sharma and Singh (2006) conducted an experiment to study the difference on the effect of tipping, light, moderate and severe pruning on the sex ratio of Amrapali mangoes and observed that the highest sex ratio was found in those flower panicles in the unpruned tree (35.9%) with the lowest in severely pruned trees (26.6%).

Enhancement in flowering was observed in pruned mango trees of 'Chausa', meanwhile the unpruned trees showed a much lesser flowering as a result of increased canopy spread that had led to reduced canopy light interception affecting the photosynthetic ability (Lal and Mishra, 2007).

Singh *et al.* (2010) observed the effect of different levels of pruning intensities on flowering in mango cultivars Amrapali, Dashehari and Mallika. They observed that moderate pruning led to early flowering (50 per cent flowering) compared to the control trees.

Nafees *et al.* (2010) reported the effect of pruning on the emergence of flushes that affected the flowering intensity. Those shoots that failed to produce second vegetative flush on its terminal were found to have the highest flowering percentage compared to the shoots that had undergone second and third flushing.

A study conducted by Thirupathi and Gosh (2016) on the effect of different times of shoot pruning on flowering in the cv. Mallika revealed that there was uniformity in flowering in response to shoot pruning compared to the control trees.

Oleveira *et al.* (2017) observed that the floral bud and panicle formation were more uniform in the shoot tip pruned plants applied with PBZ whereas an asynchronous flowering was noticed in the control plants. The renewal of the shoots by post harvest pruning resulted in the formation of homogenous and vigorous floral buds for the coming season.

Tip pruning helped to increase the number of flowering panicles per tree but not the number of fruits per tree in the mango cultivars 'Honey Gold' and 'Calypso' grown in northern Australian region (Sarkhosh *et al.*, 2018).

2.6. Effect of pruning on fruit characters

A decrease in fruit yield and retention was noted in mango cultivars Tommy Atkins, Sensation, Heidi, Kent and Keitt except Zill subjected to pruning (Oosthuyse, 1997).

Pruning the tree just after the harvest was found to increase the number of fruits per tree and the fruit weight in mango varieties Tommy Atkins and Keitt. The increased fruit weight was due to the increased accumulation of carbohydrates in the pruned branches which received enough time for maturation (Yashitela *et al.*, 2005).

A study conducted by Ram *et al.* (2005) reported that shoot pruning along with PBZ application increased the physical parameters of Dashehari fruits like fruit length, width, volume and weight when compared to the control.

An experiment conducted by Lal and Mishra (2007) on cv. Chausa proved that average fruit weight was maximum in the shoot pruned mango trees in comparison with the unpruned control trees.

Effect of different intensities of pruning on mango cv. Amrapali showed an enhancement in the fruit size (light pruning) and pulp weight (moderate pruning) when compared to the control trees (Pratap *et al.*, 2009).

Singh *et al.* (2010) observed that light pruning increased the fruit weight of Amrapali, Mallika and Dashehari compared to the control trees whereas the average fruit weight decreased in the 'on year' due to the increase in number of fruits per tree. The shoot pruned trees of the above varieties showed the highest fruit volume and pulp: stone ratio.

Rejuvenation pruning in old Alphonso mango trees was found to have an enhancement in the cumulative fruit yield which was double the value (86.3 kg/plant) as compared to the control tree (47.2 kg/plant). They suggested that there was no flowering in the season just after pruning which was later compensated by the increased fruit yield in the following season (Reddy and Kurian, 2011).

Tip pruning the shoots at 20 cm was found effective in enhancing the yield in Guava followed by 10 cm tip pruning. The increase in severity of pruning resulted in higher fruit size and fruit weight compared to the control plants (Thakre *et al.*, 2016).

An experiment conducted in the mango variety 'Atulfo' by García de Niz *et al.* (2014) reported that there is an increased percentage of seedless fruits (57-80%) when the pruning was carried out in June.

While evaluating the effect of different times of pruning on fruiting in the cv. Mallika, the maximum number of fruited panicles per plant was observed in the June pruned trees (Thirupathi and Gosh, 2016).

Oleveira *et al.* (2017) noticed that the tip pruning along with PBZ did not show any significant effect on the fruit characters like fruit length, breadth, pulp weight, total soluble solids in 'Uba' mangoes.

Parulekar *et al.* (2018) observed an increment in the number of fruits per plant, fruit weight and fruit yield (per plant and per ha) in old senile orchards which were rejuvenated by pruning.

2.7. Effect of pruning on fruit yield and quality

Tip pruning (upto 20 cm from tip) was found to give the highest fruit yield compared to the severe pruning in Amrapali mangoes cultivated under high density planting (Pratap *et al.*, 2003). They suggested that tip pruning was better to maintain the optimum metabolic activities in mango trees under high density planting system.

Evaluating the quality parameters of the fruits of varieties 'Tommy Atkins' and 'Keitt', Yashitela *et al.* (2005) observed that the post harvest pruning had increased the total soluble solids in the fruit compared to the unpruned ones. They suggested that the increased TSS is directly correlated to an increase in the photosynthate assimilation by the matured new flushes of the pruned branches.

Ram *et al.* (2005) reported an increment in the total soluble solids in 'Dashehari' subjected to the pruning and PBZ treatment. They also observed a reduction in the titrable acidity in the fruits of those trees which were applied with PBZ just after pruning.

According to Lal and Mishra (2007) the shoot pruned mango cv. Chausa gave the highest value of total soluble solids with the increase in severity of pruning while the control trees reported the least. Similar findings were reported by Adhikari and Kandel (2015) in shoot pruned Guava plant.

On observing the effect of vegetative pruning on fruit quality in mango varieties Mallika, Amrapali and Dashehari, Singh *et al.* (2010) noticed an increase in TSS and reducing sugar in accordance with the increase in severity of the shoot pruning compared to the control.

Srilatha *et al.* (2015) investigated the combined effect of paclobutrazol drench and shoot pruning on fruit characters in Dashehari mangoes and found an increased fruit yield in the unpruned trees applied with PBZ followed by the pruned trees with the PBZ drench compared to the control.

Thirupathi and Gosh (2016) reported the enhancement of fruit yield and quality in relation to different times of shoot pruning in Mallika mango. They observed maximum fruit yield per tree (89.2 kg) and total soluble solids (26.1°B) in June pruned trees while maximum fruit weight (361 g) in trees pruned in September. The control trees showed the lowest fruit weight, TSS and yield.

On evaluating the fruit yield of 'Alphonso' after the shoot pruning treatment, Ghavale *et al.* (2016) observed that there was an increase in the fruit

yield in the lightly pruned trees compared to the severely pruned and the control trees.

A study conducted by Rodge and Pujari (2017) on the influence of shoot pruning on the yield of 'Alphonso' reported that the maximum number of fruits per tree and fruit yield was observed in shoot pruned 'Alphonso' trees than the control. Similar results were observed by Singh *et al.* (2017) in 'Dashehari' mango tree where in the shoot pruning carried out immediately after harvest along with PBZ application had resulted in more number of fruits per tree and fruit yield (kg/tree).

Tip pruning performed immediately after harvest along with PBZ soil drench resulted in increased fruit yield and quality of 'on' year Dashehari mangoes (Barman and Mishra, 2018).

Materials and Methods

3. MATERIALS AND METHODS

The studies on "Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system" were carried out during 2018-2019 in the Mango orchard attached to the Department of Fruit Science, College of Horticulture, Vellanikkara. The experimental location was at an altitude of 22.25 metres above MSL at 10°56' North latitude and 76°28' East longitude with warm humid tropical condition. The experiment was conducted in two mango hybrids.

1. Mallika - Neelum x Dashehari- released from IARI, New Delhi
2. Ratna - Neelum x Alphonso- released from KKV, Dapoli

The experiment was laid out in Completely Randomized Design with seventeen treatments and two replications under high density planting system with spacing of 3 x 3 m and the trees (both Mallika and Ratna) were of seven years age. The layout of the experimental plot is furnished in Fig 1. and the general view of the experimental site is given as Plate 1.

3.1 Treatments

T_1-T_8: Pruning@ 10 cm and 20 cm length respectively during June, July, August and September

T_9 -T_{16}: Pruning @ 10 cm and 20 cm length respectively during June, July, August and September + Paclobutrazol application (commercial formulation) @ 7 ml $tree^{-1}$

T_{17}: Control

Plate 1. General view of the experimental plot

Plate 2. Field board

3.1.1. Treatment details

T1 - Pruning @ 10 cm length
T2 - Pruning @ 20 cm length } June

T3 - Pruning @ 10 cm length
T4 - Pruning @ 20 cm length } July

T5 - Pruning @ 10 cm length
T6 - Pruning @ 20 cm length } August

T7 - Pruning @ 10 cm length
T8 - Pruning @ 20 cm length } September

T9 - Pruning @ 10 cm length +PBZ
T10- Pruning @ 20 cm length + PBZ } June

T11- Pruning @ 10 cm length +PBZ
T12- Pruning @ 20 cm length +PBZ } July

T13- Pruning @ 10 cm length +PBZ
T14- Pruning @ 20 cm length +PBZ } August

T15- Pruning @ 10 cm length +PBZ
T16- Pruning @ 20 cm length +PBZ } September

T17-control

- Paclobutrazol (PBZ) @ 7ml/tree

The pruning operations were carried out before the 5th of every month from June to September. Tip pruning of all the shoots was carried out at two levels *viz*. 10 cm and 20 cm length from the shoot tip with and without paclobutrazol soil drench.

3.2 Preparation of paclobutrazol and method of application

Paclobutrazol is available as a liquid formulation under different trade names and the most popular one is 'Cultar' with the active ingredient paclobutrazol (23% W/W or 25% W/V) and marketed by Syngenta Crop Protection Private Limited. As per the POP of KAU, the recommended dose of cultar is 20 ml/tree for a grown up tree (>15 years old). So as the age of the experimental trees were of only seven years, the dose was taken @ 1 ml for 1 year and calculated as 7ml/tree for drenching the trees in the experimental plot. The 7 ml of cultar was then mixed in 10 litres of water

(1.75 g per tree) and poured into the deep pits in the circular channel taken 60 cm away from the base of the tree trunk covering all the four sides of the tree as per treatment specification (Plate 2).

The manure and fertilizers and all other cultural practices were followed based on the Package of Practices recommendations of KAU (POP, 2016).

3.3. Observations

3.3.1. Vegetative characters

Vegetative characters such as tree height, canopy diameter, time of flushing, length of new shoots, days from pruning to shoot initiation and number of leaves per shoot were recorded.

3.3.1.1. Tree height

Tree height was recorded by measuring the distance from ground level to the top of the tree using a measuring tape and expressed in metre.

3.3.1.2. Canopy diameter

Canopy diameter was recorded by measuring the canopy spread in North-South and East-West directions using a measuring tape and the average values were calculated and expressed in metre.

3.3.1.3. Season of flushing

Season of flushing of each tree under different treatments in Mallika and Ratna were recorded at the time of flushing.

3.3.1.4. Length of new shoots

Length of the new shoots from ten mature shoots selected at random from each replication were recorded using a measuring tape and expressed in centimetres.

Tip pruning of shoot @ 10 cm or 20 cm

Smearing pruned ends with fungicidal paste

Pruned ends smeared with fungicidal paste

Channels taken 60 cm away from trunk

Channels at four sides

Paclobutrazol soil drench @ 7ml/ tree

Plate 3. Steps in pruning and paclobutrazol application

3.3.1.5. Days from pruning to shoot initiation

Number of days from pruning to shoot initiation was recorded for each treatment.

3.3.1.6. Number of leaves per shoot

Number of leaves from ten mature shoots selected at random from each replication was counted separately and recorded.

3.3.2 Flowering characters

Flowering characters like days from pruning to flowering, season of flowering, number of inflorescence per unit area, size of inflorescence, density of flowers in inflorescence, percentage of hermaphrodite flowers and sex ratio were recorded for various treatments.

3.3.2.1 Days from pruning to flowering

Number of days from pruning to flowering was recorded for each treatment.

3.3.2.2. Season of flowering

Season during which flowering occurred for each tree under different treatments in Mallika and Ratna were recorded.

3.3.2.3. Number of inflorescence per unit area

The number of inflorescence per unit square meter area was counted from all the four sides with the help of one square meter wooden frame and average was calculated.

3.3.2.4. Size of inflorescence

Size of inflorescence was measured as the length and breadth of 10 randomly selected inflorescence from four directions and also from the top of the tree. Length of inflorescence was measured from the tip to the

bottom of the inflorescence. The widest part is measured as the breadth of inflorescence. It was measured using a measuring scale and the average was calculated individually for both and expressed in centimetres.

3.3.2.5. Density of flowers in inflorescence

The density of flowers in inflorescence was noted as sparse, medium or dense by visual observations.

3.3.2.6. Percentage of hermaphrodite flowers

The number of male and hermaphrodite flowers was counted from five inflorescences taken from each replication. Percentage of hermaphrodite flowers was calculated as:

$$\text{Hermaphrodite flower (\%)} = \frac{\text{Number of hermaphrodite flowers}}{\text{Total number of flowers}} \times 100$$

3.3.2.7. Sex ratio

Sex ratio is the ratio of number of male flowers to the number of hermaphrodite flowers in the panicle. It is calculated by the formula:

$$\text{Sex ratio} = \frac{\text{Number of hermaphrodite flowers}}{\text{Number of male flowers}} \times 100$$

3.3.3 Fruit characters

Ten fully mature fruits per replication from each treatment were collected and the characters like number of fruits per tree, fruiting duration, fruit weight, fruit length, breadth and circumference, fruit volume, fruit bearing intensity, pulp and peel weight, peel thickness, pulp to peel ratio, days from flowering to harvest and fruit yield was recorded.

3.3.3.1. Number of fruits per tree

The number of fruits per tree was recorded from each treatment during each harvest and the total number of fruits from each treatment was noted.

3.3.3.2. Fruiting duration

Fruiting duration is the days from fruit set to harvest. It was recorded for each replication.

3.3.3.3. Fruit weight

Weight of individual fruits was measured using a weighing balance. The average was calculated for each treatment and expressed in grams.

3.3.3.4. Fruit length, breadth and circumference

The length and breadth of individual fruit were measured using a digital vernier calliper and expressed in centimetres. The circumference of each fruit was measured using thread and scale and expressed in centimetres.

3.3.3.5. Fruit volume

Fruit volume was estimated using water displacement method and expressed in cubic centimetre.

3.3.3.6. Fruit bearing intensity

Visual observation was done to measure the intensity of bearing and was recorded as sparse, medium or dense.

3.3.3.7. Pulp and peel weight

Pulp and peel weight of individual fruit was recorded using weighing balance and expressed in grams.

3.3.3.8. Peel thickness

Peel thickness was measured using a digital vernier calliper for each fruit and expressed in millimetre.

3.3.3.9. Pulp to peel ratio

The ratio of pulp weight to peel weight of individual fruit gave the pulp to peel ratio.

3.3.3.10. Days from flowering to harvest

The duration from flower initiation to harvest was recorded for each replication.

3.3.3.11. Fruit yield

The yield of fruits per tree was calculated and expressed in kg/tree.

3.3.4. Stone characters

From each treatment, ten fully ripen fruits were selected for recording the following stone characters.

3.3.4.1. Stone length, width, thickness

Length, breadth and thickness of the fruit were measured using a digital vernier calliper and expressed in centimetre.

3.3.4.2. Stone weight

Individual stone weight was measured using a weighing balance and expressed in gram.

3.3.4.3. Seed to pulp ratio

The ratio of seed weight to pulp weight was calculated for individual fruits.

3.3.5. Quality parameters of fruit

Quality attributes like total soluble solids, acidity, reducing sugars, non-reducing and total sugars were estimated.

3.3.5.1. Total Soluble Solids

TSS of fruit was measured by a hand refractometer using the juice extracted from the pulp. It was expressed as °Brix.

3.3.5.2. Reducing sugars

Reducing sugar content was estimated using the method given by Lane and Eynon (Ranganna, 1986). Ten gram of fruit sample was grinded with distilled water and clarified using neutral lead acetate. Potassium oxalate was added to remove excess lead acetate and volume made up to 250 ml. The solution was filtered using filter paper and the filtrate was titrated against mixture of Fehling A and Fehling B using methylene blue as indicator. Reducing sugars was calculated as

$$\text{Reducing sugars (\%)} = \frac{0.05 \times \text{Volume made up}}{\text{Titre value} \times \text{Wt of sample}} \times 100$$

3.3.5.3. Total sugars

Total sugars were estimated by boiling 50 ml of the clarified solution (filtrate of reducing sugars) after addition of citric acid and distilled water. After cooling it was neutralized with 1N NaOH and volume made up to 250 ml in a volumetric flask. This solution was titrated against a mixture of Fehling A and Fehling B. The titre value was recorded and total sugar was calculated as

$$\text{Total sugar (\%)} = \frac{0.05x \text{ Volume made up} \times \text{Volume made up}}{\text{Titre value} \times \text{Wt of sample} \times \text{Volume of clarified juice}} \times 100$$

Non-reducing sugars (%) was calculated by substracting reducing sugars (%) from total sugars (%).

3.3.5.4. Titrable acidity

Acidity was estimated by the method given by A. O. A. C. (1984). Ten gram of the sample was grinded with distilled water and made up to 100ml. Ten ml of the filtered solution and ten ml of distilled water was titrated against 0.1 N NaOH using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid and was calculated using the formula

$$\text{Titrable acidity (\%)} = \frac{\text{Titre value x Volume made up x 0.064}}{\text{Wt of sample taken x Volume of the sample}} \times 100$$

3.3.5.5. Sugar/acid ratio

The ratio of total sugars to titrable acidity was calculated to obtain the sugar/acid ratio.

3.3.5.6. Organoleptic scoring of fruits

A score card was prepared based on the parameters like appearance, texture, colour, flavour, odour, taste, after taste and overall acceptability. The evaluation was carried out by a panel of ten judges and the ranking procedure given by Kruskal and Wallis (Seigel, 1959) was followed.

3.3.5.7. Pest and disease incidence

The pest and the disease attack were observed during each phase starting from pruning till harvest. The symptoms, causal organism and the management practices followed were recorded.

3.3.5.8. Statistical analysis

The data were subjected to analysis of variance following the method of Panse and Sukhatme (1978). Wasp 2. 0. and MS-Excel softwares were used for computation and analysis.

Results

4. RESULTS

The results of the study entitled "Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system" are presented in this chapter based on the experiment conducted in the HDP block of Mango orchard attached to the Department of Fruit Science, College of Horticulture, Vellanikkara during 2017-19. The results of the study conducted using two mango hybrids Mallika and Ratna are presented as follows.

4.1 Vegetative characters

The vegetative characters of the hybrids Mallika and Ratna recorded as per the IPGRI crop descriptor (2006), before and after the experiment are presented in Table 1 and 2 respectively.

4.1.1. Tree height

In Mallika, tree height recorded before the imposition of the treatments ranged from 3.23 m to 3.52 m. After the experiment, significant difference was observed for tree height (Table 1a). The tree height was minimal for T16 (3.25 m) and the maximum was recorded for T17 (3.59 m).

The tree height recorded for Ratna varied from 3.26 m to 3.54 m before the experiment. After the treatment imposition T16 recorded the minimum tree height (3.20 m) which was on par with T12 (3.24 m). Maximum tree height was observed for T17 (Table 1a).

4.1.2. Canopy diameter

Before the experiment, canopy diameter measured varied from 3.24 m to 3.58 m in Mallika (Table 1b). After the treatment imposition, the treatments showed significant variation for this parameter and the minimum canopy diameter was observed for the treatment T10 (3.15 m) which was on par with T11 and T12.

Table 1a. Effect of treatments on tree height in Mallika and Ratna

Treatments	Mallika		Ratna	
	Before Treatment (m)	After Treatment (m)	Before Treatment (m)	After Treatment (m)
T1	3.37	3.48^{b}	3.40^{cde}	3.39^{d}
T2	3.23	3.38^{de}	3.43^{cde}	3.49^{b}
T3	3.41	3.49^{b}	3.37^{de}	3.40^{cd}
T4	3.36	3.43^{c}	3.51^{ab}	3.48^{b}
T5	3.52	3.48^{b}	3.54^{a}	3.57^{a}
T6	3.23	3.43^{c}	3.43^{cd}	3.44^{bc}
T7	3.41	3.48^{b}	3.46^{bc}	3.45^{bc}
T8	3.47	3.39^{d}	3.45^{bc}	3.38^{d}
T9	3.29	3.36^{def}	3.36^{de}	3.35^{d}
T10	3.37	3.39^{d}	3.38^{de}	3.28^{ef}
T11	3.40	3.36^{def}	3.42^{cde}	3.40^{cd}
T12	3.30	3.35^{ef}	3.36^{de}	3.24^{fg}
T13	3.40	3.36^{def}	3.26^{f}	3.30^{e}
T14	3.49	3.33^{f}	3.36^{e}	3.38^{d}
T15	3.50	3.36^{def}	3.28^{f}	3.28^{ef}
T16	3.34	3.25^{g}	3.26^{f}	3.20^{g}
T17	3.44	3.59^{a}	3.47^{bc}	3.58^{a}
CD (0.05)	NS	0.03	0.07	0.05

Table 1b. Effect of treatments on canopy diameter in Mallika and Ratna

Treatments	Mallika		Ratna	
	Before Treatment (m)	After Treatment (m)	Before Treatment (m)	After Treatment (m)
T1	3.26	3.28^{d}	3.18^{k}	3.44^{b}
T2	3.33	3.36^{c}	3.31^{hi}	3.35^{c}
T3	3.33	3.51^{b}	3.35^{fgh}	3.34^{c}
T4	3.50	3.33^{c}	3.45^{bcd}	3.47^{b}
T5	3.39	3.53^{b}	3.43^{cde}	3.45^{b}
T6	3.37	3.50^{b}	3.48^{bc}	3.47^{b}
T7	3.26	3.27^{d}	3.48^{bc}	3.49^{b}
T8	3.24	3.26^{d}	3.45^{bcd}	3.38^{c}
T9	3.36	3.36^{c}	3.38^{efg}	3.33^{c}
T10	3.29	3.15^{e}	3.23^{jk}	3.20^{e}
T11	3.38	3.16^{e}	3.28^{ij}	3.20^{e}
T12	3.46	3.18^{e}	3.46^{bcd}	3.27^{d}
T13	3.45	3.33^{c}	3.44^{bcde}	3.34^{c}
T14	3.33	3.36^{c}	3.51^{ab}	3.27^{d}
T15	3.38	3.28^{d}	3.33^{ghi}	3.25^{de}
T16	3.29	3.28^{d}	3.41^{def}	3.26^{d}
T17	3.46	3.65^{a}	3.57^{a}	3.66^{a}
CD (0.05)	NS	0.04	0.07	0.05

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

In Ratna, canopy diameter recorded before the experiment ranged from 3.18 m to 3.57 m (Table 1b). The treatment imposition was found to significantly influence the canopy diameter and the treatments T10 and T11 (3.20 m) recorded the minimum canopy diameter while it was maximum for T17 (3.66 m).

4.1.3. Length of new shoots

In Mallika, the treatments significantly influenced this parameter (Table 2a) and treatment T12 recorded the lowest value (12.35 cm). The length of new shoots was maximal for T17 (17.65 cm).

The longest shoot was observed for treatment T17 (14.60 cm) in Ratna, while shoot length was the shortest for T14 (11.65 cm) followed by T16 and T4 (Table 2b).

4.1.4. Number of leaves per shoot

Number of leaves per shoot in Mallika (Table 2 a) showed significant variation among the treatments. The lowest number was observed for the treatment T12 (8.45) and the highest number was recorded for the treatment T8 (11.94).

In Ratna, significant influence of the treatments were observed (Table 2b) and treatment T8 (10.62) recorded the highest number followed by T16 (10.59) while T2 (9.22) recorded the lowest number.

4.1.5. Season of flushing

In Mallika, flushing started in June for the treatments T1, T2, T9 and T10. While in T17 (control) flushing was observed during the fourth week of October (Table 3a).

In Ratna, flushing started in June for the treatments T1, T2, T9 and T10. While in the treatment T17 (control) flushing was observed during the fourth week of October (Table 3b).

Table 2a. Effect of treatments on length of new shoots and number of leaves per shoot in Mallika

Treatmentss	Length of new shoot (cm)	Number of leaves per shoot
T1	15.75^{c}	9.60^{fg}
T2	14.65^{de}	9.23^{gh}
T3	15.70^{c}	9.73^{defg}
T4	15.25^{cd}	10.66^{bc}
T5	16.65^{b}	10.52^{bcd}
T6	15.50^{c}	9.38^{g}
T7	15.55^{c}	10.36^{bcdef}
T8	15.70^{c}	11.94^{a}
T9	13.35^{f}	10.41^{bcde}
T10	13.35^{f}	10.21^{cdef}
T11	14.60^{e}	9.27^{g}
T12	12.35^{g}	8.45^{h}
T13	14.55^{e}	10.32^{bcdef}
T14	14.25^{e}	10.22^{cdef}
T15	14.40^{e}	9.69^{efg}
T16	13.25^{f}	10.93^{bc}
T17	17.65^{a}	11.08^{b}
CD (0.05)	0.62	0.81

Table 2b. Effect of treatments on length of new shoots and number of leaves per shoot in Ratna

Treatments	Length of new shoot (cm)	Number of leaves per shoot
T1	13.50^{b}	9.77^{f}
T2	$13.20b^{c}$	9.22^{i}
T3	13.15^{b}	9.39^{gh}
T4	11.75^{e}	10.29^{de}
T5	13.85^{a}	9.72^{f}
T6	13.15^{b}	10.55^{ab}
T7	13.50^{b}	9.47^{g}
T8	13.05^{b}	10.62^{a}
T9	12.95^{f}	10.38^{d}
T10	12.45^{de}	10.41^{bcd}
T11	12.55^{de}	9.63^{f}
T12	12.20^{cd}	9.37^{gh}
T13	12.05^{f}	10.40^{cd}
T14	11.65^{e}	10.21^{e}
T15	12.55^{de}	9.31^{hi}
T16	11.80^{f}	10.59^{a}
T17	14.60^{a}	10.54^{abc}
CD (0.05)	0.55	0.14

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

4.1.6. Days from pruning to shoot initiation

The treatments showed significant difference for the days from pruning to shoot initiation in Mallika (Table 3a). The treatment T13 took only minimum number of days (14 days) while T8 took maximum number of days (22 days) for shoot initiation.

In Ratna, significant influence among the treatments was observed and T14 recorded the lowest number of days (15 days) for initiation of shoots (Table 3b). The number of days was the highest for T12 (21.50 days) for this parameter.

4.2 Flowering characters

The flowering characters of Mallika and Ratna are furnished in the Tables 4 and 5 respectively.

4.2.1 Days from pruning to flowering

In Mallika, the treatment imposition had significantly influenced the days from pruning to flowering (Table 4) with the least number of days recorded for the treatment T16 (59.50 days) and the maximum days for T1 (195.50 days).

Similar trend was recorded in Ratna (Table 5) with the minimum number of days for T16 (57.50 days). The maximum number of days from pruning to flowering was observed for T1 (193.50 days).

4.2.2. Season of flowering

In Mallika date of first flower initiation was observed on 2ndNovember for the treatments T16 and T10 and fruit set was observed for T16 and T10 on 11th and 13th December respectively (Table 4).

In Ratna, date of first flower initiation was observed on 1st November for the treatment T10 and fruit set was observed on 10th December (Table 5).

Plate 4. Young flushes of hybrid Mallika and Ratna

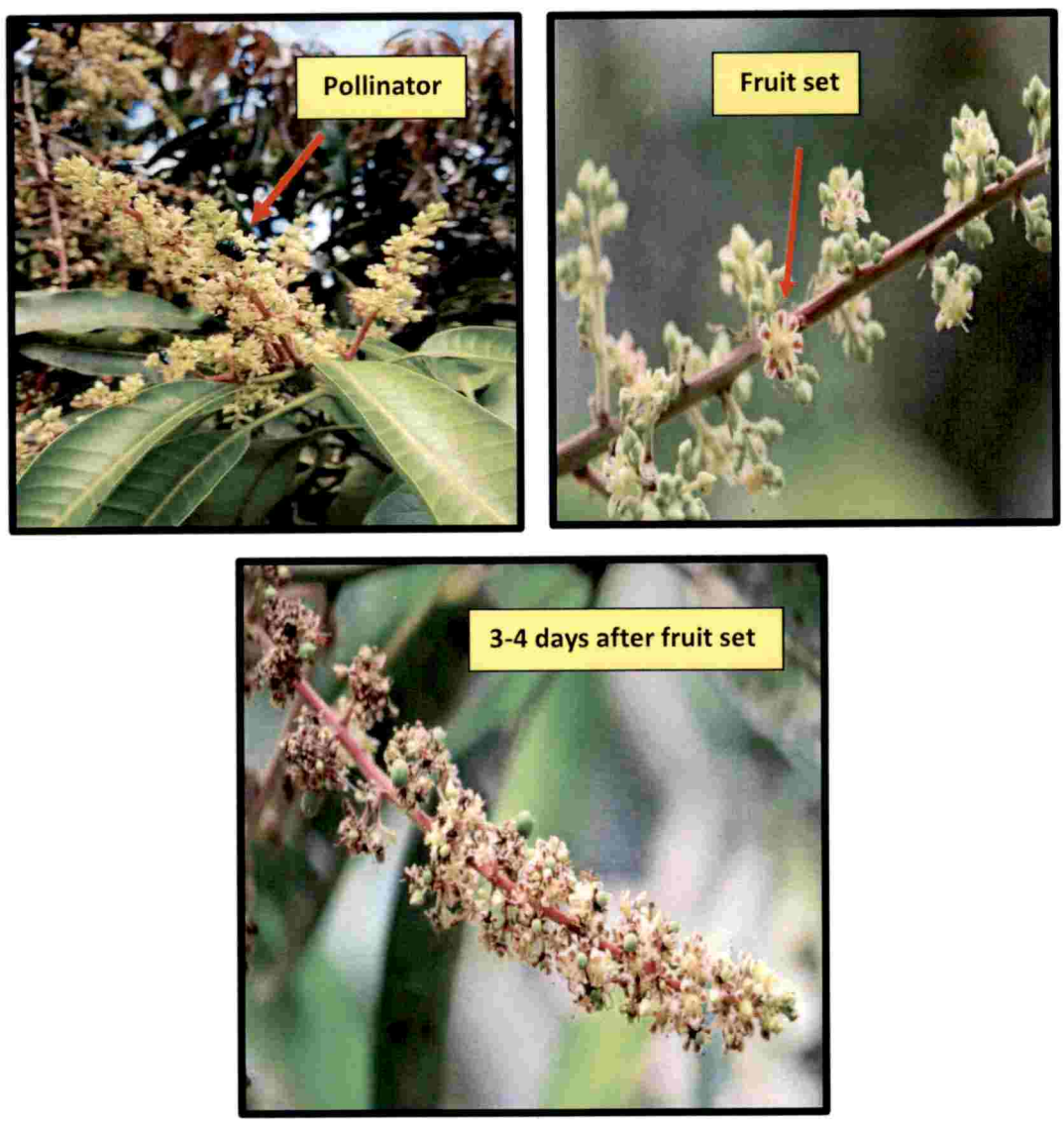

Plate 5. Inflorescence of mango- pollination to fruit set

Table 3a. Effect of treatments on season of flushing and days to shoot initiation in Mallika

Treatments	Days from pruning to shoot initiation	Season of flushing
T1	Last week of June	20.50^{ab}
T2	Last week of June	20.00^{bc}
T3	Third week of July	17.00^{de}
T4	Fourth week of July	17.50^{d}
T5	Fourth week of August	15.50^{ef}
T6	Fourth week of August	17.50^{d}
T7	Fourth week of September	19.50^{bc}
T8	Fourth week of September	22.00^{a}
T9	Fourth week of June	17.50^{d}
T10	Last week of June	19.50^{bc}
T11	Fourth week of July	18.50^{cd}
T12	Fourth week of July	20.50^{ab}
T13	Third week of August	14.00^{f}
T14	Fourth week of August	15.50^{ef}
T15	Fourth week of September	17.50^{d}
T16	Fourth week of September	19.50^{bc}
T17	Fourth week of October	-
CD (0.05)	-	1.95

Table 3b. Effect of treatments on season of flushing and days to shoot initiation in Ratna

Treatments	Days from pruning to shoot initiation	Season of flushing
T1	Third week of June	17.50^{de}
T2	Third week of June	18.50^{cd}
T3	Fourth week of July	17.50^{de}
T4	Fourth week of July	19.50^{bc}
T5	Fourth week of August	17.50^{de}
T6	Fourth week of August	18.50^{cd}
T7	Last week of September	20.50^{ab}
T8	Last week of September	21.00^{ab}
T9	Third week of June	17.50^{de}
T10	Last week of June	20.50^{ab}
T11	Fourth week of July	19.50^{bc}
T12	Fourth week of July	21.50^{a}
T13	Fourth week of August	16.00^{ef}
T14	Fourth week of August	15.00^{f}
T15	Last week of September	19.50^{bc}
T16	Last week of September	20.00^{abc}
T17	Fourth week of October	-
CD (0.05)	-	1.92

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

4.2.3. Days from flower initiation to fruit set

In Mallika, the days taken from flower initiation to fruit set showed significant variation among the treatments (Table 4) with the least number of days taken by T10 and T16 (39.50 days) and the maximum days for T5 and T13 (43.50 days).

In Ratna, the treatments had significantly influenced the days taken from flower initiation to fruit set (Table 5). The treatment T4 recorded the minimum number of days (38.00 days) and T8 recorded the maximum number of days (42.00 days).

4.2.4. Number of inflorescence per unit area

In Mallika, the treatments differed significantly with respect to the number of inflorescence per unit area (Table 6). The maximum number of inflorescence per unit area (Fig. 1a) was recorded for the treatment T10 (15.25) followed by T16 (14.80) and the floral intensity was the lowest in T17 (6.55).

In Ratna (Fig. 1b), the treatments showed a statistically significant variation for this parameter (Table 7). Treatment T10 observed to have the maximum number of inflorescence per unit area (14.60) followed by T16 (14.40) and treatment T17 recorded the minimum value (10.20).

4.2.5. Size of inflorescence

The length and breadth of the inflorescence recorded constituted the size of the inflorescence (Table 6 and 7).

4.2.5.1. Inflorescence length

Length of the inflorescence significantly differed among the treatments (Table 6). The maximum length of the inflorescence was recorded for T1 (42.69 cm) and the minimum length was recorded for T16 (33.07 cm).

Table 4. Effect of treatments on days to flowering and days to fruit set in Mallika

Treatments	Days from pruning to flowering	Season of flowering		Days from flower initiation to fruit set
		Date of flower initiation	Date of fruit set	
T1	195.50[a]	15-Dec	25-Jan	42.00[ab]
T2	179.00[b]	04-Nov	15-Dec	41.50[abc]
T3	149.50[e]	01-Dec	10-Jan	41.50[abc]
T4	166.50[c]	14-Dec	26-Jan	42.50[ab]
T5	132.50[f]	14-Dec	27-Jan	43.50a
T6	128.50[g]	12-Dec	23-Jan	42.50[ab]
T7	100.00[j]	13-Dec	24-Jan	42.00[ab]
T8	105.5[i]	19-Dec	01-Feb	42.50[ab]
T9	159.50[d]	13-Nov	25-Dec	41.50[abc]
T10	149.50[e]	02-Nov	13-Dec	39.50[c]
T11	150.00[e]	15-Nov	27-Dec	42.50[ab]
T12	124.50[h]	08-Nov	18-Dec	41.00[bc]
T13	91.50[k]	27-Nov	11-Jan	43.50[a]
T14	104.50[i]	28-Nov	09-Jan	42.50[ab]
T15	87.00[l]	01-Dec	12-Jan	42.50[ab]
T16	59.50[m]	02-Nov	11-Dec	39.50[c]
T17	-	08-Dec	19-Jan	41.00[bc]
CD (0.05)	1.61	-	-	2.08

Table 5. Effect of treatments on days to flowering and days to fruit set in Ratna

Treatments	Days from pruning to flowering	Season of flowering		Days from flower initiation to fruit set
		Date of flower initiation	Date of fruit set	
T1	193.50[a]	17-Dec	24-Jan	38.50[de]
T2	151.50[d]	30-Nov	07-Jan	39.50[bcde]
T3	149.50[e]	01-Dec	09-Jan	40.50[abcd]
T4	162.00[b]	18-Dec	25-Jan	38.00[e]
T5	162.50[b]	15-Dec	24-Jan	40.50[abcd]
T6	128.50[h]	10-Dec	20-Jan	41.50[ab]
T7	99.50[l]	14-Dec	21-Jan	39.00[cde]
T8	105.50[k]	20-Dec	02-Feb	42.00[a]
T9	160.50[c]	11-Nov	22-Dec	40.50[abcd]
T10	150.50[de]	01-Nov	10-Dec	41.00[abc]
T11	133.50[g]	01-Dec	08-Jan	39.50[bcde]
T12	126.50[i]	06-Nov	16-Dec	40.50[abcd]
T13	144.50[f]	04-Nov	14-Dec	41.50[ab]
T14	115.50[j]	17-Nov	25-Dec	39.50[bcde]
T15	87.50[m]	30-Nov	07-Jan	39.50[bcde]
T16	57.50[n]	03-Nov	14-Dec	41.50[ab]
T17	-	08-Dec	18-Jan	40.50[abcd]
CD (0.05)	1.41	-	-	2.10

Values not sharing a common superscript in the column differ significantly with each other (P<0.05)

Significant difference among the treatments was observed in Ratna (Table 7). The inflorescence length was maximum in treatment T5 (41.23 cm) which was on par with T16 (41.10 cm) and the minimum length was observed for T16 (35.07 cm).

4.2.5.2. Inflorescence breadth

In Mallika, significant variation was observed among the treatments with respect to the inflorescence breadth (Table 6). The treatment T17 recorded the maximum inflorescence breadth (23.54 cm) while the minimum inflorescence breadth was observed for T10 (16.18 cm).

Significant difference was observed among the treatments with respect to the inflorescence breadth in Ratna (Table 7) and the treatment T4 recorded the maximum inflorescence breadth (25.85 cm). The minimum inflorescence breadth was observed for T16 (19.08 cm).

4.2.6. Density of flowers in inflorescence

In Mallika, treatments significantly influenced the density of flowers in the inflorescence and all the treatments were observed to have medium dense inflorescence except T17 (Table 8).

The treatments differed significantly with respect to the density of flowers in the inflorescence in Ratna. The treatments T1 to T8 were observed to have medium dense inflorescence whereas the treatments T9 to T16 were found to have highly dense inflorescence (Table 9).

4.2.7. Percentage of male flowers

In Mallika, treatment showed significant difference for this parameter (Table 8) and the minimum percentage of male flowers was observed in the treatment T10 (67.69%) which was on par with T16 (67.78%) and T15 (67.93%).

A significant variation was observed among the treatments for percentage of male flowers in Ratna (Table 9). The maximum percentage of male flowers

Table 6. Effect of treatments on inflorescence characters in Mallika

Treatments	No. of inflorescence/m^2	Size of inflorescence	
		Inflorescence length (cm)	Inflorescence breadth (cm)
T1	7.60^{hi}	42.69^{a}	22.22^{g}
T2	7.85^{g}	41.13^{d}	22.61^{f}
T3	7.45^{ij}	42.38^{b}	23.22^{b}
T4	7.75^{gh}	40.38^{e}	22.94^{d}
T5	7.15^{k}	39.43^{g}	23.17^{c}
T6	7.33^{j}	39.82^{f}	20.52^{h}
T7	7.45^{ij}	33.84^{j}	22.57^{f}
T8	7.70^{gh}	33.65^{j}	22.86^{e}
T9	12.60^{d}	34.35^{i}	17.97^{j}
T10	15.25^{a}	33.86^{j}	16.18^{q}
T11	12.64^{d}	34.75^{h}	18.49^{i}
T12	14.10^{c}	34.70^{h}	17.08^{n}
T13	11.50^{f}	34.56^{hi}	17.23^{l}
T14	12.65^{d}	34.42^{i}	17.17^{m}
T15	12.25^{e}	33.27^{k}	17.48^{k}
T16	14.80^{b}	33.07^{k}	16.27^{op}
T17	6.55	42.06^{c}	23.54^{a}
CD (0.05)	0.16	0.24	0.05

Table 7. Effect of treatments on inflorescence characters in Ratna

Treatments	No. of inflorescence/m^2	Size of inflorescence	
		Inflorescence length (cm)	Inflorescence breadth (cm)
T1	10.85^{jk}	39.85^{d}	23.72^{d}
T2	11.75^{g}	40.35^{c}	23.08^{f}
T3	11.25^{h}	39.18^{e}	23.63^{e}
T4	11.70^{g}	40.27^{c}	25.85^{a}
T5	10.70^{k}	41.23^{a}	24.38^{c}
T6	10.95^{ij}	41.10^{a}	24.89^{b}
T7	11.10^{hi}	39.22^{e}	24.32^{c}
T8	11.25^{h}	40.74^{b}	24.93^{b}
T9	13.50^{ef}	36.49^{f}	20.88^{h}
T10	14.60^{a}	35.34^{i}	19.73^{k}
T11	13.90^{d}	36.09^{g}	19.69^{k}
T12	14.20^{c}	35.08^{j}	21.42^{g}
T13	13.40^{f}	35.46^{i}	20.17^{i}
T14	13.60^{e}	36.38^{f}	19.97^{j}
T15	13.40^{f}	35.87^{h}	19.49^{l}
T16	14.40^{b}	35.07^{j}	19.08^{m}
T17	10.20^{l}	35.97^{gh}	23.73^{d}
CD (0.05)	1.81	0.15	0.08

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

was observed for the treatment T17 whereas the minimum percentage (70.41%) of male flowers was observed for the treatment T16.

4.2.8. Percentage of hermaphrodite flowers

In Mallika, the treatments showed significant influence for this parameter (Table 8).The treatment T10 (32.31%) recorded the maximum percentage of hermaphrodite flowers and was on par with T16 (32.22%) and T14 (32.07%), whereas T17 recorded the minimum percentage (18.47%).

In Ratna, the treatments differed significantly with respect to the percentage of hermaphrodite flowers (Table 9). The treatment T16 (29.60%) produced the maximum percentage of hermaphrodite flowers which was closely followed by T10 (29.17 %). The percentage of hermaphrodite flower produced was the minimum for T17 (20.65%).

4.2.9. Sex ratio

In Mallika, the treatment showed a significant influence for the sex ratio (Table 8). The highest sex ratio was observed for T10 (47.73) followed by T16 (47.54) and the lowest sex ratio was observed for T17 (22.66).

The treatments differed significantly for this parameter in Ratna (Table 9) and the highest sex ratio was observed for T16 (42.04) followed by T10 (41.19). The lowest sex ratio was recorded by T17 (26.03).

4.3 Fruit characters

The fruit characters of the varieties Mallika and Ratna as influenced by the treatments are provided in Table 10 and 11 respectively.

4.3.1. Number of fruits per tree

In Mallika (Fig. 2a), the treatments differed significantly with respect to the number of fruits per tree (Table 10) and the highest number of fruits per tree

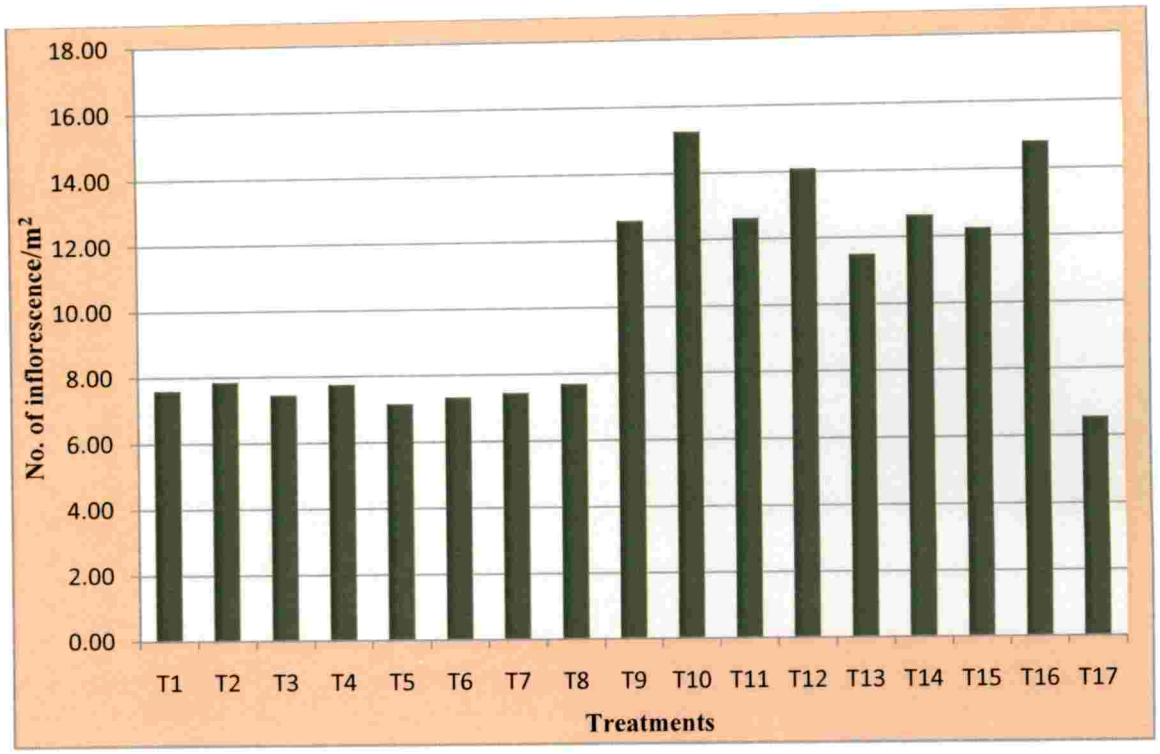

Fig 1 a. Effect of treatments on no. of inflorescence per square metre of hybrid Mallika

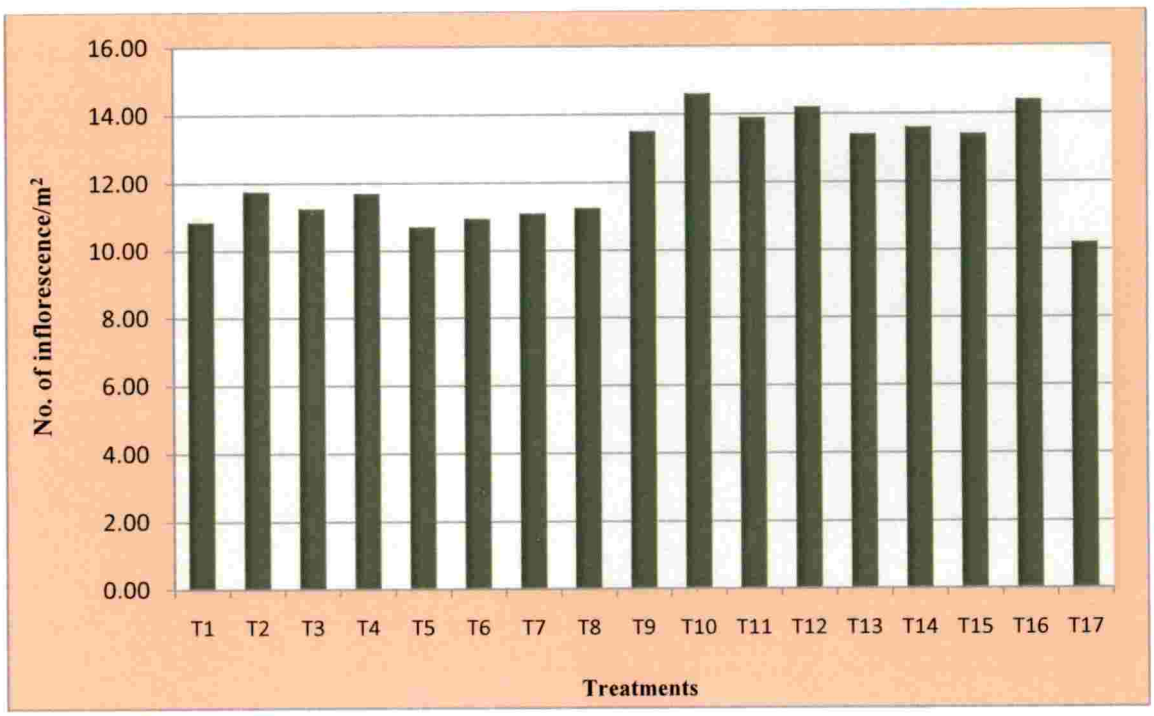

Fig 1b. Effect of treatments on no. of inflorescence per square metre of hybrid Ratna

Table 8. Effect of treatments on inflorescence characters in Mallika

Treatments	Density of flowers in inflorescence	Male flowers (%)	Hermaphrodite flowers (%)	Sex ratio
T1	Medium	79.19^{c}	20.81^{k}	29.65^{i}
T2	Medium	77.13^{f}	24.27^{g}	26.29^{k}
T3	Medium	79.08^{c}	20.92^{k}	28.57^{j}
T4	Medium	77.78^{d}	22.22j	26.45^{k}
T5	Medium	80.56^{b}	19.44^{l}	32.04^{h}
T6	Medium	75.74^{g}	22.87^{h}	24.13^{l}
T7	Medium	79.37^{c}	20.64^{k}	26.00^{k}
T8	Medium	77.49^{e}	22.52^{i}	29.06^{j}
T9	Medium	69.38^{k}	30.63^{c}	44.15^{d}
T10	Medium	67.69^{m}	32.31^{a}	47.73^{a}
T11	Medium	72.87^{h}	27.14^{f}	37.24^{g}
T12	Medium	68.72^{l}	31.28^{b}	45.53^{c}
T13	Medium	72.04^{i}	29.49^{d}	38.82^{f}
T14	Medium	70.52^{j}	32.07^{a}	41.82^{e}
T15	Medium	67.93^{m}	27.96^{e}	47.21^{b}
T16	Medium	67.78^{m}	32.22^{a}	47.54^{ab}
T17	Sparse	81.53^{a}	18.47^{ms}	22.66^{m}
CD (0.05)	-	0.29	0.29	0.52

Table 9. Effect of treatments on inflorescence characters in Ratna

Treatments	Density of flowers in inflorescence	Male flowers (%)	Hermaphrodite flowers (%)	Sex ratio
T1	Medium	77.97^{b}	22.03^{m}	28.26^{m}
T2	Medium	75.51^{g}	24.49^{h}	32.43^{h}
T3	Medium	77.97^{b}	22.04^{m}	28.27^{m}
T4	Medium	74.70^{i}	25.31^{f}	33.88^{f}
T5	Medium	76.47^{d}	23.54^{k}	30.78^{k}
T6	Medium	75.81^{f}	24.19^{i}	31.91^{i}
T7	Medium	77.90^{b}	22.11^{m}	28.38^{m}
T8	Medium	75.31^{h}	24.70^{g}	32.80^{g}
T9	High	76.77^{c}	23.24^{l}	30.27^{l}
T10	High	70.83^{m}	29.17^{b}	41.19^{b}
T11	High	72.10^{l}	27.91^{c}	38.70^{c}
T12	High	73.15^{k}	26.86^{d}	36.71^{d}
T13	High	76.17^{e}	23.83^{j}	31.29^{j}
T14	High	72.25^{l}	27.75^{c}	38.41^{c}
T15	High	74.24^{j}	25.77^{d}	34.71^{e}
T16	High	70.41^{n}	29.60^{a}	42.04^{a}
T17	Sparse	79.35^{a}	20.65^{n}	26.03^{n}
CD (0.05)	-	0.17	0.17	0.31

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

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was recorded for T10 (31.50). The lowest number of fruits was recorded for T17 (19.00).

In Ratna (Fig 2b) treatments exhibited a significant variation for this parameter (Table 11) and the highest number of fruits was observed for T10 (34.50) which was on par with T16 (34.00). The lowest number of fruits per tree was recorded for T17 (20.50).

4.3.2. Fruit weight

In Mallika, a statistically significant difference was observed among the treatments for this parameter (Table 10). Treatment T16 registered the highest fruit weight (624.03 g) followed by T10 (612.33 g) and T14 (609.48 g). The lowest fruit weight was recorded for T17 (392.9 g).

In Ratna, the treatment imposition had a significant influence on fruit weight (Table 11) with the heaviest fruit recorded by the treatment T16 (468.89 g) which was on par with T10 (465.48 g) and T14 (463.35 g).

4.3.3. Fruit yield

In Mallika, the treatments varied significantly (Table 10) and the fruit yield was highest for T10 (19.31 kg/tree) followed by T16 (17.79 kg/tree). The lowest fruit yield was recorded by the control trees (7.47 kg/tree).

Significant influence was exhibited among the treatments in Ratna (Table 11) and the maximum fruit yield was recorded for the treatment T10 (16.06 kg/tree) and was on par with T16 (15.95 kg/tree). The treatment T17 recorded the minimum fruit yield (6.12 kg/tree).

4.3.4. Fruit length

In Mallika (Fig 3a), the treatments differed significantly (Table 12) and the longest fruit was obtained for treatment T16 (14.55 cm) followed by T10 (14.49 cm). The fruits of T17 were recorded to be the shortest (13.03 cm).

Sparse Dense

Plate 6. Density of Inflorescence

Table 10. Effect of treatments on yield of fruits of Mallika

Treatments	No. of fruits/tree	Fruit weight (g)	Fruit yield (kg/tree)
T1	22.00^{g}	473.38^{jkl}	10.42^{ij}
T2	23.50^{ef}	491.38^{gh}	11.55^{fgh}
T3	21.50^{g}	463.83^{l}	9.97^{j}
T4	24.50^{de}	485.23^{hi}	11.89^{fg}
T5	21.50^{g}	471.18^{kl}	10.13^{ij}
T6	23.50^{ef}	476.63^{ijk}	11.20^{gh}
T7	22.50^{fg}	481.75^{hij}	10.84^{hi}
T8	24.00^{e}	499.33^{g}	11.98^{f}
T9	25.50^{cd}	577.73^{d}	14.74^{d}
T10	31.50^{a}	612.88^{b}	19.31^{a}
T11	23.50^{ef}	563.93^{e}	13.25^{e}
T12	26.50^{c}	590.00^{c}	15.64^{c}
T13	24.50^{de}	544.20^{f}	13.33^{e}
T14	25.50^{cd}	609.48^{b}	15.54^{c}
T15	24.00^{e}	577.10^{d}	13.85^{e}
T16	28.50^{b}	624.03^{a}	17.79^{b}
T17	19.00^{h}	392.90^{m}	7.47^{k}
CD (0.05)	1.31	9.84	0.76

Table 11. Effect of treatments on yield of fruits of Ratna

Treatments	No. of fruits/tree	Fruit weight (g)	Fruit yield (kg/tree)
T1	22.50^{efg}	342.03^{h}	7.69^{g}
T2	24.50^{d}	368.93^{f}	9.04^{f}
T3	21.50^{gh}	325.75^{i}	7.01^{h}
T4	24.00^{de}	365.80^{fg}	8.78^{f}
T5	22.50^{efg}	324.43^{i}	7.30^{gh}
T6	24.00^{de}	358.83^{g}	8.62^{f}
T7	22.00^{fgh}	344.93^{h}	7.59^{gh}
T8	23.50^{def}	364.35^{fg}	8.57^{f}
T9	27.50^{b}	428.65^{d}	11.79^{c}
T10	34.50^{a}	465.48^{ab}	16.06^{a}
T11	26.50^{bc}	415.78^{e}	11.02^{de}
T12	28.00^{b}	457.53^{b}	12.82^{b}
T13	24.50^{d}	423.10^{de}	10.37^{e}
T14	25.00^{cd}	463.35^{ab}	11.58^{cd}
T15	24.50^{d}	443.48^{c}	10.86^{e}
T16	34.00^{a}	468.98^{a}	15.95^{a}
T17	20.50^{h}	298.43^{j}	6.12^{i}
CD (0.05)	1.57	8.43	0.68

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

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In Ratna (Fig 3b), significant difference was observed among the treatments with respect to the fruit length (Table 13). Treatments T16 and T12 recorded the maximum fruit length (10.86 cm) and was on par with T10 (10.84 cm). The minimum fruit length was observed for T1 (10.24 cm).

4.3.5. Fruit breadth

In Mallika, the treatments differed significantly with respect to the fruit breadth (Table 12). The treatment T16 (9.86 cm) recorded the maximum fruit breadth which was on par with T10 (9.85 cm). Lowest fruit breadth was observed for T7 (9.16 cm).

Significant difference among the treatments was observed in Ratna (Table 13). The maximum fruit breadth was recorded for the treatment T16 (9.45 cm) while T3 and T13 recorded the minimum fruit breadth (9.15 cm).

4.3.6. Fruit circumference

Fruit circumference statistically differed among the treatments in Mallika (Table 12) and the maximum fruit circumference was observed for T16 (28.65 cm) followed by T10 and T12 (28.50 cm). The fruit circumference was the lowest for T7 (26.35 cm).

In Ratna, the treatments significantly varied with respect to the fruit circumference (Table 13) and the treatment T16 (26.60 cm) recorded the maximum fruit circumference and was on par with T10, T14, T12, T13, T2 and T4. The fruit circumference was the lowest for T3 (25.33 cm).

4.3.7. Fruit volume

In Mallika, the treatments varied significantly (Table 12) and the fruit volume was the highest for the treatment T16 (460.30 cm^3) and was found to be on par with T10 (454.14 cm^3). The fruit volume was the lowest for T17 (296.73 cm^3).

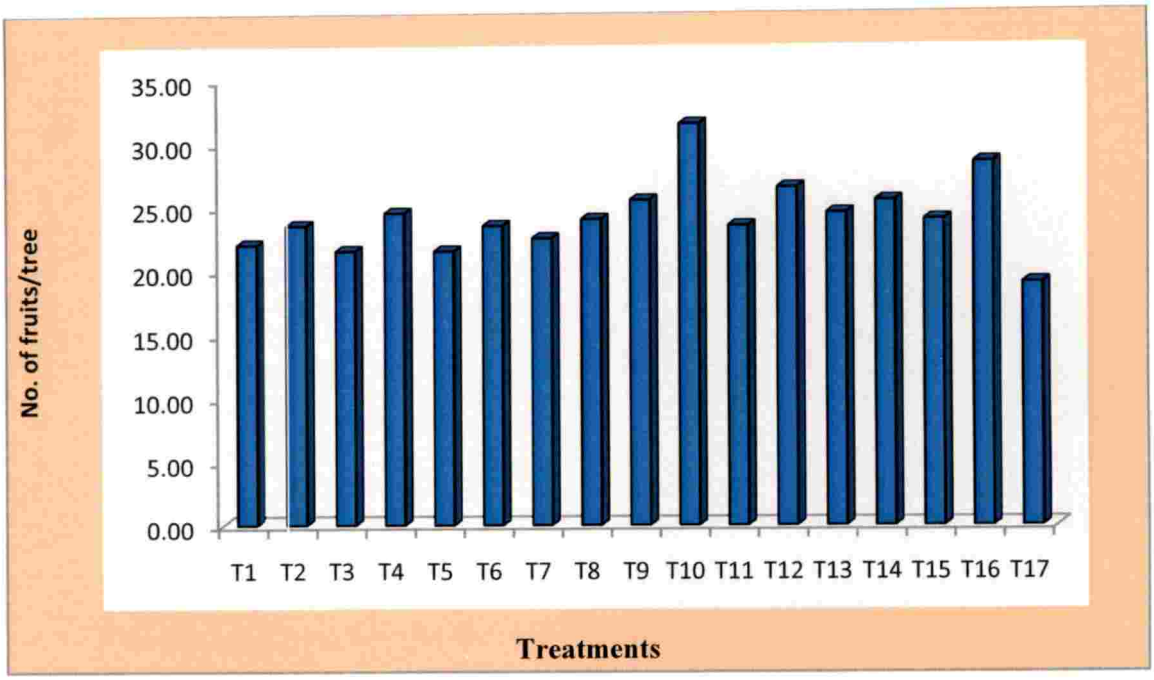

Fig 2 a. Effect of treatments on no. of fruits per tree of hybrid Mallika

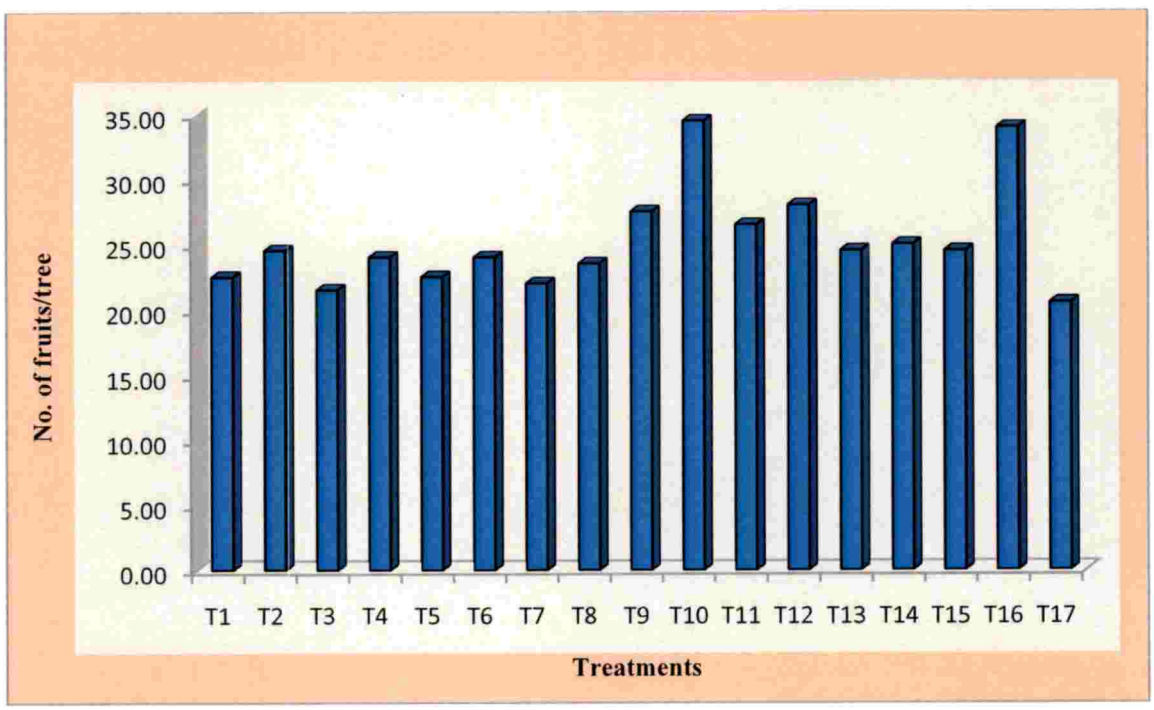

Fig 2 b. Effect of treatments on no. of fruits per tree of hybrid Ratna

Table 12. Effect of treatments on physical parameters of fruits of Mallika

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit circumference (cm)	Fruit volume (cm^3)
T1	13.18^{k}	9.23^{g}	26.55^{ef}	409.84^{f}
T2	13.48^{j}	9.64^{e}	26.58^{ef}	410.57^{f}
T3	13.68^{h}	9.25^{g}	26.40^{fg}	398.20^{h}
T4	14.11^{e}	9.55^{f}	26.58^{ef}	405.67^{fg}
T5	13.12^{k}	9.17^{hi}	26.48^{fg}	400.50^{gh}
T6	13.60^{i}	9.66^{e}	26.70^{e}	400.67^{gh}
T7	13.12^{k}	9.16^{i}	26.35^{g}	399.74^{gh}
T8	13.75^{g}	9.57^{f}	27.48^{d}	418.34^{e}
T9	14.41^{cd}	9.25^{g}	27.55^{cd}	443.43^{b}
T10	14.49^{ab}	9.85^{a}	28.50^{ab}	454.14^{a}
T11	13.99^{f}	9.73^{d}	28.45^{b}	421.29^{de}
T12	14.48^{bc}	9.75^{d}	28.50^{ab}	427.53^{d}
T13	14.12^{e}	9.77^{c}	27.55^{cd}	425.98^{d}
T14	14.39^{d}	9.81^{b}	28.45^{b}	445.86^{b}
T15	14.37^{d}	9.78^{c}	27.68^{c}	435.94^{c}
T16	14.55^{a}	9.86^{a}	28.65^{a}	460.30^{a}
T17	13.03^{l}	9.18^{h}	26.45^{fg}	296.73^{i}
CD (0.05)	0.07	0.02	0.19	6.86

Table 13. Effect of treatments on physical parameters of fruits of Ratna

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit circumference (cm)	Fruit volume (cm^3)
T1	10.24^{h}	9.16^{d}	25.60^{bcd}	216.47^{fgh}
T2	10.45^{e}	9.32^{b}	26.48^{a}	225.00^{e}
T3	10.25^{h}	9.15^{d}	25.33^{d}	209.50^{h}
T4	10.74^{b}	9.25^{c}	26.48^{a}	213.93^{gh}
T5	10.37^{f}	9.26^{c}	25.43^{bcd}	219.47^{efg}
T6	10.46^{e}	9.27^{c}	25.50^{bcd}	221.52^{ef}
T7	10.31^{g}	9.17^{d}	25.38^{cd}	218.70^{efg}
T8	10.33^{g}	9.18^{d}	25.53^{bcd}	223.38^{ef}
T9	10.25^{h}	9.17^{d}	25.70^{bc}	281.51^{d}
T10	10.84^{a}	9.26^{c}	26.53^{a}	299.01^{b}
T11	10.57^{d}	9.25^{c}	25.60^{bcd}	282.44^{d}
T12	10.86^{a}	9.26^{c}	26.50^{a}	289.80^{c}
T13	10.54^{d}	9.15^{d}	26.48^{a}	279.40^{c}
T14	10.65^{c}	9.28^{c}	26.53^{a}	290.21^{c}
T15	10.74^{b}	9.27^{c}	25.73^{b}	282.29^{d}
T16	10.86^{a}	9.45^{a}	26.60^{a}	308.70^{a}
T17	10.55^{d}	9.16^{d}	25.55^{bcd}	201.37^{i}
CD (0.05)	0.03	0.04	0.33	7.23

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

In Ratna, treatments exhibited a significant difference with respect to the fruit volume (Table 13) and the treatment T16 registered the maximum fruit volume (308.70 cm^3) followed by T10 (299.01 cm^3). The least value (296.73 cm^3) was recorded for the control trees (T17).

4.3.8. Pulp weight

Significant influence was observed among the treatments for pulp weight in Mallika. The treatment T16 (540.53 g) recorded the maximum pulp weight followed by T10 (528.88 g) which was on par with T14 (524.46). The minimum pulp weight (300.78 g) was observed for T17 (Table 14).

The treatments had significant variation with respect to the pulp weight in Ratna (Table 15) and the treatment T16 (408.03 g) recorded the maximum pulp weight and was on par with T10 (401.83 g) and T14 (400.11 g). The pulp weight recorded was minimal for T17 (230.05 g).

4.3.9. Peel weight

In Mallika, there was no significant variation among the treatments for peel weight and the value ranged from 43.27g for T1 to 45.67 g for T4 (Table 14).

In Ratna, there was a significant difference among the treatments (Table 15) and the minimum peel weight was recorded for the treatment T17 (24.85 g). The maximum peel weight was observed for T3 (26.66 g).

4.3.10. Peel thickness

In Mallika, the treatments did not significantly differ with respect to the peel thickness and the values ranged from 0.57 mm for the treatment T17 to 0.74 mm for T4 (Table 14).

Similar trend was observed in Ratna, and the values of peel thickness ranged from 0.51 mm for treatment T2 to 0.70 mm for T15 (Tabl

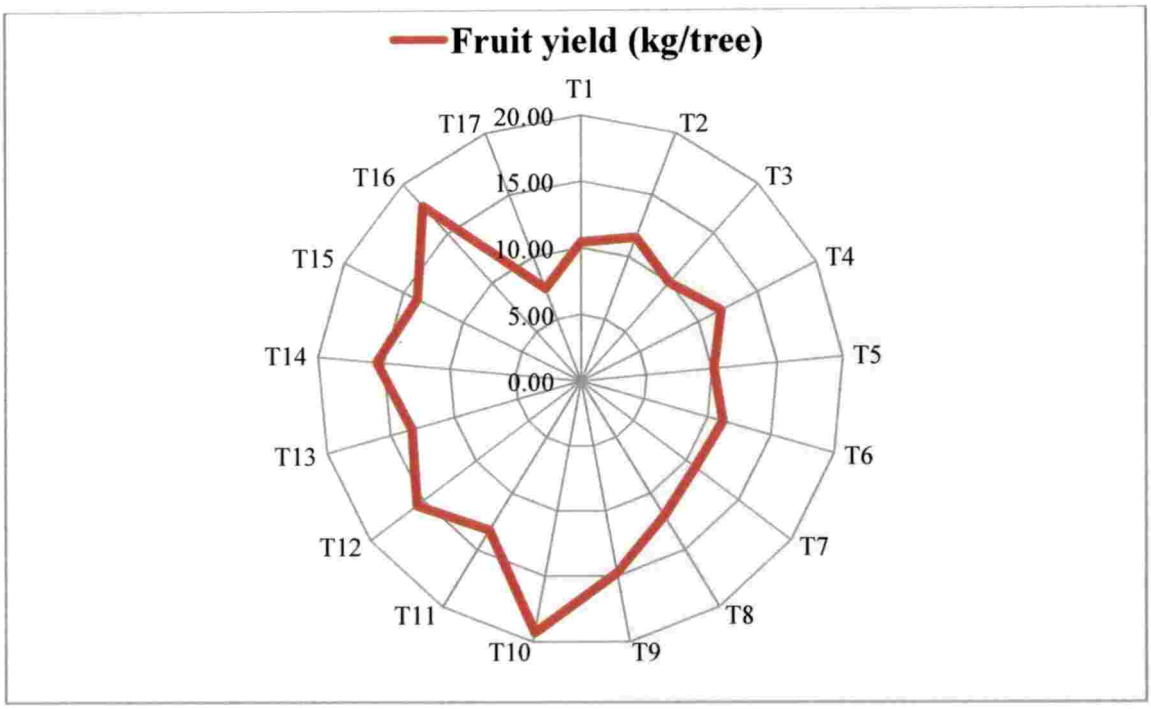

Fig 3 a. Effect of treatments on fuit yield of hybrid Mallika

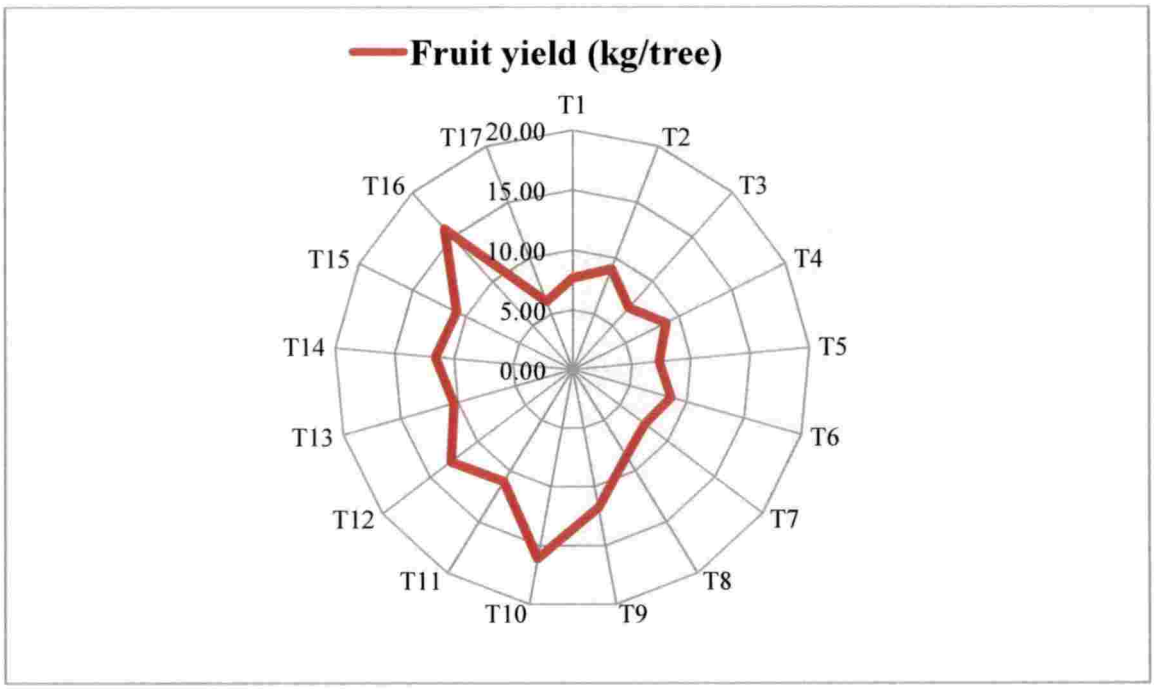

Fig 3 b. Effect of treatments on fruit yield of hybrid Ratna

Treatment T10 (20 cm + PBZ- June) Treatment T17- control

Plate 7. Effect of treatments on fruit number of Mallika

Treatment T10 (20 cm + PBZ- June) Treatment T17-control

Plate 7. Effect of treatments on fruit number of Ratna

Table 14. Effect of treatments on physical parameters of fruit pulp and peel of Mallika

Treatments	Pulp weight (g)	Peel weight (g)	Peel thickness (mm)	Pulp/peel ratio
T1	385.91^{ij}	43.27	0.69	8.92^{fg}
T2	401.02^{h}	45.32	0.64	8.85^{fg}
T3	375.49^{k}	44.64	0.67	8.42^{g}
T4	394.70^{hi}	45.67	0.74	8.65^{g}
T5	383.17^{jk}	43.39	0.62	8.84^{fg}
T6	389.42^{ij}	44.21	0.71	8.81^{fg}
T7	393.88^{hi}	45.43	0.65	8.71^{g}
T8	412.30^{g}	43.89	0.61	9.40^{f}
T9	493.69^{d}	44.41	0.61	11.13^{cd}
T10	528.88^{b}	43.76	0.69	12.09^{ab}
T11	477.80^{e}	44.53	0.63	10.73^{de}
T12	504.61^{c}	43.55	0.70	11.59^{bc}
T13	457.78^{f}	45.12	0.66	10.15^{e}
T14	524.46^{b}	43.57	0.66	12.04^{ab}
T15	491.70^{d}	44.85	0.66	10.98^{cd}
T16	540.53^{a}	43.88	0.63	12.32^{a}
T17	300.78^{l}	43.49	0.57	6.92^{h}
CD (0.05)	10.24	NS	NS	0.69

Table 15. Effect of treatments on physical parameters of fruit pulp and peel of Ratna

Treatments	Pulp weight (g)	Peel weight (g)	Peel thickness (mm)	Pulp/peel ratio
T1	276.00^{h}	26.37^{ab}	0.61	10.41^{i}
T2	305.08^{f}	26.60^{a}	0.51	11.47^{fg}
T3	258.98^{i}	26.66^{a}	0.54	9.72^{j}
T4	299.85^{fg}	25.57^{cdefg}	0.62	11.73^{f}
T5	257.27^{i}	26.63^{a}	0.62	9.66^{jk}
T6	299.67^{fg}	25.26^{fgh}	0.59	11.87^{f}
T7	280.73^{h}	25.34^{efg}	0.63	11.08^{gh}
T8	293.08^{g}	26.63^{a}	0.64	11.00^{h}
T9	367.31^{d}	25.71^{cde}	0.65	14.29^{d}
T10	401.83^{ab}	25.18^{gh}	0.58	15.96^{a}
T11	351.54^{e}	25.93^{bc}	0.54	13.56^{e}
T12	395.19^{b}	25.80^{cd}	0.57	15.32^{b}
T13	359.43^{de}	25.47^{defg}	0.68	14.12^{d}
T14	400.11^{ab}	25.69^{cdef}	0.61	15.58^{ab}
T15	381.41^{c}	25.59^{cdefg}	0.70	14.91^{c}
T16	408.03^{a}	26.46^{a}	0.58	15.42^{b}
T17	230.05^{j}	24.85^{h}	0.67	9.26^{k}
CD (0.05)	9.48	0.45	NS	0.41

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

4.3.11. Pulp/peel ratio

The treatments varied significantly in Mallika (Table 14) and the highest pulp/peel ratio was observed in the treatment T16 (12.32) which was on par with T10 (12.09) and T14 (12.04). Pulp/peel ratio recorded was minimal for T17 (6.92).

In Ratna, significant difference among the treatments were observed for this parameter (Table 15) and the maximum pulp/peel ratio was observed for T10 (15.96) which was on par with T14 (15.58). Pulp/peel ratio recorded was minimal for T7 (9.26).

4.3.12. Fruiting duration

In Mallika, the fruiting duration differed significantly among the treatments (Table 16). The treatments T12 (81.00 days) recorded the shortest fruiting duration while the longest fruiting duration was observed for T17 (96.50 days).

Significant difference among the treatments were observed in Ratna (Table 17) and the minimum fruiting duration was recorded for the treatment T13 (81.50 days) whereas T17 recorded the longest fruiting duration (102.50 days).

4.3.13. Days from flowering to harvest

The treatments differed significantly with respect to the days from flowering to harvest (Table 16). The least number of days were observed for the treatment T12 (122.50 days) was on par with T10 (123.00 days). The maximum number of days from flowering to harvest was recorded for T17 (138.00 days).

In Ratna, the treatments varied significantly for this parameter (Table 17) and the minimum number of days from flowering to harvest was recorded for T13 (121.50 days) and was on par with T10 and T16. The treatments T17 recorded the maximum number of days from flowering to harvest (143.50 days).

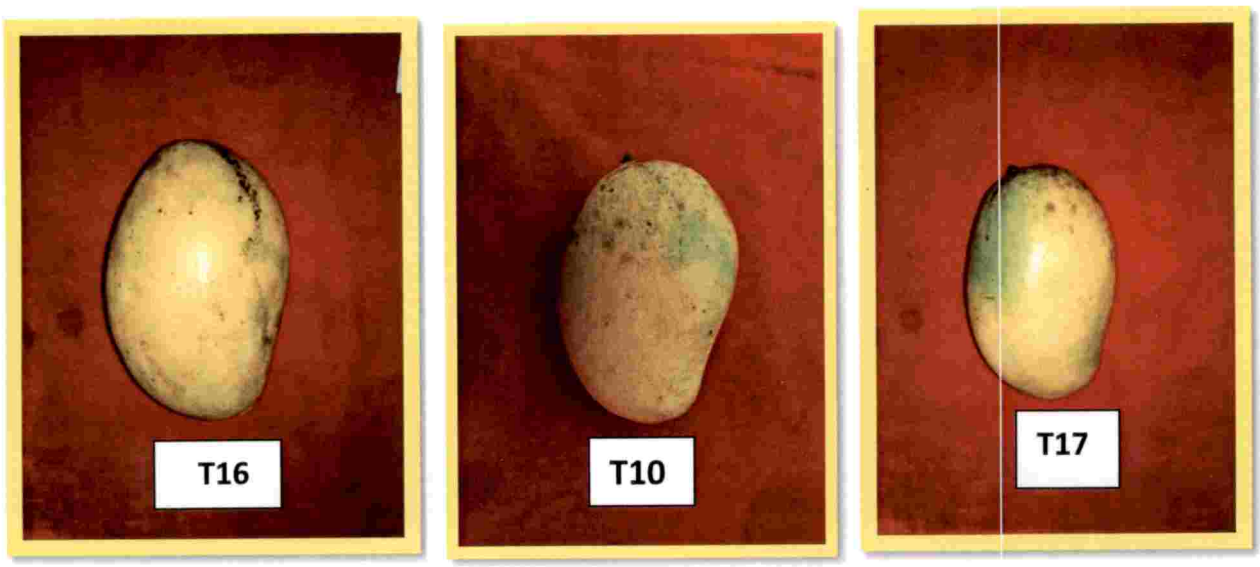

Plate 9. Effect of treatments on fruit size of Mallika

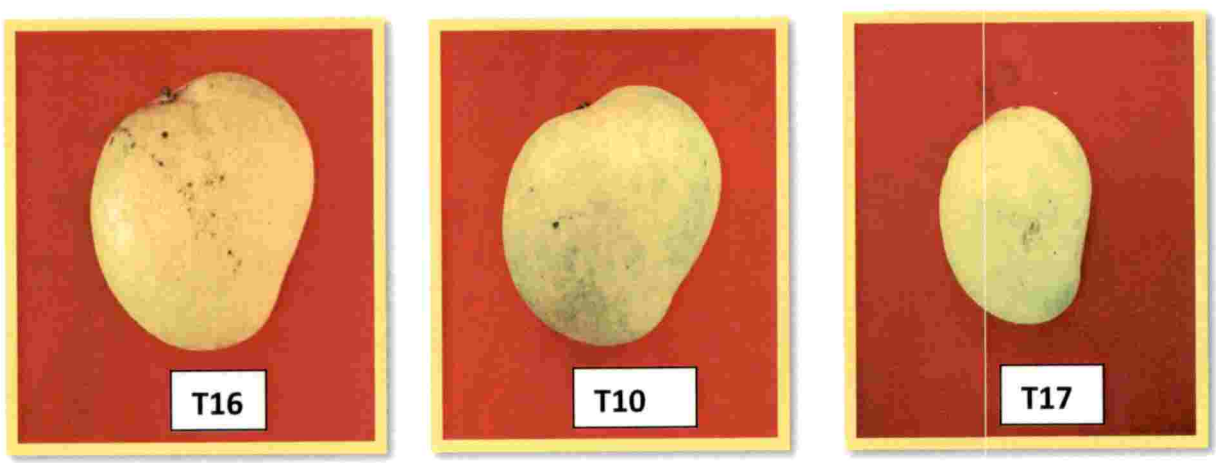

Plate 10. Effect of treatments on fruit size of Ratna

Table 16. Effect of treatments on duration of fruiting and days to harvest in Mallika

Treatments	Fruiting duration (days)	Days from flowering to harvest	Days from fruit set to harvest	Fruit bearing intensity
T1	90.50^{cd}	129.50^{def}	89.50^{gh}	Medium
T2	81.50^{i}	123.00^{g}	81.50^{k}	Medium
T3	84.50^{h}	126.00^{fg}	93.50^{de}	Medium
T4	92.50^{b}	133.00^{bcd}	90.50^{fg}	Medium
T5	90.50^{cd}	130.00^{cdef}	92.00^{ef}	Medium
T6	91.50^{bc}	130.00^{cdef}	97.50^{c}	Medium
T7	93.00^{b}	130.50^{bcde}	94.50^{d}	Medium
T8	88.00^{ef}	126.00^{fg}	59.50^{op}	Medium
T9	89.50^{de}	132.00^{bcde}	118.00^{a}	Medium
T10	86.50^{fg}	124.00^{g}	79.50^{l}	Medium
T11	95.50^{a}	129.00^{def}	74.50^{n}	Medium
T12	81.00^{i}	122.50^{g}	76.50^{m}	Medium
T13	85.50^{gh}	128.50^{ef}	108.50^{b}	Medium
T14	92.50^{b}	134.00^{abc}	88.50^{h}	Medium
T15	87.50^{f}	131.00^{bcde}	83.50^{j}	Medium
T16	91.50^{bc}	134.50^{ab}	85.50^{i}	Medium
T17	96.50^{a}	138.00^{a}	99.00^{c}	Low
CD (0.05)	1.70	4.36	1.69	-

Table 17. Effect of treatments on duration of fruiting and days to harvest in Ratna

Treatments	Fruiting duration (days)	Days from flowering to harvest	Days from fruit set to harvest	Fruit bearing intensity
T1	90.50^{d}	127.50^{e}	91.50^{e}	Medium
T2	85.50^{fg}	124.50^{f}	86.50^{g}	Medium
T3	83.50^{hi}	123.00^{fg}	95.50^{c}	Medium
T4	90.00^{de}	129.00^{de}	92.50^{de}	Medium
T5	91.50^{d}	131.00^{cd}	93.00^{cd}	Medium
T6	97.50^{b}	138.50^{b}	91.50^{b}	Medium
T7	94.50^{c}	133.00^{c}	92.00^{c}	Medium
T8	91.00^{d}	128.00^{e}	87.50^{e}	Medium
T9	88.50^{e}	127.50^{e}	89.50^{e}	Medium
T10	82.50^{ij}	122.50^{fg}	81.50^{fg}	Medium
T11	84.50^{gh}	124.00^{f}	86.00^{f}	Medium
T12	86.50^{f}	127.00^{e}	77.50^{e}	Medium
T13	81.50^{j}	121.50^{g}	122.50^{fg}	Medium
T14	93.50^{c}	131.50^{c}	89.50^{e}	Medium
T15	88.50^{e}	127.00^{e}	87.00^{fg}	Medium
T16	82.50^{ij}	123.50^{fg}	87.00^{f}	Medium
T17	102.50^{a}	143.50^{a}	96.50^{a}	Low
CD (0.05)	1.58	2.42	2.43	-

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

4.3.14. Days from fruit set to harvest

In Mallika, the treatments showed significant difference for the days from fruit set to harvest (Table 16). The minimum number of days from fruit set to harvest was observed for the treatment T10 (59.50 days) whereas maximum number of days were recorded for T9 (118 days).

The treatment varied significantly for the number of days from fruit set to harvest in Ratna (Table 7). The least number of days for this parameter was observed for the treatment T10 (81.50 days). The treatment T13 recorded the maximum number of days from fruit set to harvest (122.50 days).

4.3.15. Fruit bearing intensity

The fruit bearing intensity in Mallika was medium for all the treatments except the treatment T17 which recorded a low fruit bearing intensity (Table 16).

In Ratna, a similar trend was observed for the fruit bearing intensity and the treatment T17 recorded low fruit bearing intensity while a medium fruit bearing intensity was registered for all other treatments (Table 17).

4.4. Stone characters

The stone characters like length, width, thickness, weight and pulp/stone ratio of the cvs. Mallika and Ratna as influenced by the treatments are provided in Tables 18 and 19, respectively.

4.4.1. Stone length

In Mallika, the treatments differed significantly with respect to the stone length (Table 18). The treatment T16 (11.38 cm) recorded the minimum stone length which was on par with T15 (11.52 cm). The stone length recorded was maximal for T5 (13.65 cm).

The influence of the treatments showed significant variation in Ratna (Table 19) and the minimum stone length was observed for T6 (7.37 cm). The

Table 18. Effect of treatments on stone characters of fruits of Mallika

Treatments	Stone length (cm)	Stone width (cm)	Stone thickness (cm)	Stone weight (g)	Pulp/stone ratio
T1	13.33^{d}	5.54^{bcd}	1.72^{a}	44.21^{bcd}	8.73^{jk}
T2	13.54^{ab}	5.50^{bcd}	1.66^{a}	45.05^{b}	8.90^{ijk}
T3	13.40^{bcd}	5.47^{bcd}	1.67^{a}	43.71^{cde}	8.59^{k}
T4	12.76^{e}	5.46^{bcd}	1.67^{a}	44.87^{b}	8.80^{jk}
T5	13.65^{a}	5.55^{bc}	1.48^{cd}	44.63^{bc}	8.59^{k}
T6	13.50^{abc}	5.47^{bcd}	1.48^{cd}	43.00^{ef}	9.06^{ij}
T7	13.39^{cd}	5.62^{b}	1.59^{abc}	42.45^{fg}	9.28^{hi}
T8	12.58^{f}	5.48^{bcd}	1.51^{bcd}	43.14^{def}	9.56^{h}
T9	12.42^{g}	5.43^{bcd}	1.65^{ab}	39.64^{k}	12.46^{cd}
T10	11.84^{i}	5.37^{cd}	1.41^{d}	40.24^{jk}	13.15^{b}
T11	11.83^{i}	5.54^{bcd}	1.58^{abc}	41.60^{ghi}	11.49^{f}
T12	11.56^{j}	5.44^{bcd}	1.64^{ab}	41.84^{gh}	12.06^{e}
T13	11.57^{j}	5.57^{b}	1.60^{abc}	41.31^{hij}	11.09^{g}
T14	12.10^{h}	5.43^{bcd}	1.58^{abc}	41.45^{ghi}	12.65^{c}
T15	11.52^{jk}	5.48^{bcd}	1.48^{cd}	40.57^{ijk}	12.12^{de}
T16	11.38^{k}	5.35^{d}	1.48^{cd}	39.62^{k}	13.64^{a}
T17	13.62^{cd}	5.96^{a}	1.58^{abc}	48.63^{a}	6.19^{l}
CD (0.05)	0.15	0.20	0.15	1.11	0.40

Table 19. Effect of treatments on stone characters of fruits of Ratna

Treatments	Stone length (cm)	Stone width (cm)	Stone thickness (cm)	Stone weight (g)	Pulp/stone ratio
T1	8.36^{c}	4.76^{abcd}	2.59^{a}	39.50^{bcd}	6.99^{ef}
T2	8.42^{bc}	4.71^{bcdef}	2.52^{abcde}	37.24^{cdef}	8.20^{d}
T3	8.41^{bc}	4.63^{efgh}	2.58^{ab}	40.11^{bc}	6.50^{f}
T4	8.79^{d}	4.62^{efgh}	2.54^{abc}	40.39^{abc}	7.44^{e}
T5	8.47^{bc}	4.79^{abc}	2.53^{abcd}	40.54^{ab}	6.39^{f}
T6	7.72^{d}	4.81^{ab}	2.50^{abcdef}	39.11^{bcd}	7.50^{e}
T7	8.35^{c}	4.65^{defgh}	2.49^{abcdef}	38.86^{bcd}	7.23^{e}
T8	8.51^{b}	4.61^{fgh}	2.47^{bcdef}	39.42^{bcd}	7.60^{de}
T9	7.44^{gh}	4.62^{efgh}	2.48^{bcdef}	35.63^{ef}	10.31^{b}
T10	7.59^{ef}	4.63^{efgh}	2.37^{f}	38.46^{bcde}	10.45^{b}
T11	$7.53f^{g}$	4.64^{defgh}	2.47^{bcdef}	38.30^{bcde}	9.18^{c}
T12	7.48^{fgh}	4.55^{h}	2.40^{def}	36.54^{def}	10.82^{b}
T13	7.67^{de}	4.74^{bcde}	2.39^{ef}	38.21^{bcde}	9.41^{c}
T14	7.40^{gh}	4.68^{cdefg}	2.38^{f}	37.55^{bcdef}	10.66^{b}
T15	7.43^{gh}	4.72^{bcdef}	2.43^{cdef}	36.48^{def}	10.46^{b}
T16	7.37^{h}	4.59^{gh}	2.38^{f}	34.49^{f}	11.84^{a}
T17	8.66^{a}	4.87^{a}	2.61^{a}	43.53^{a}	5.29^{g}
CD (0.05)	0.13	0.12	0.13	3.22	0.70

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

treatments T14, T15 and T9 were found to be on par. The treatment T4 (8.79 cm) recorded the maximum stone length.

4.4.2. Stone width

Stone width in Mallika showed a significant variation among the treatments (Table 18) and the minimum width was recorded by T16 (5.35 cm) which was on par with T10 (5.37 cm). Maximum stone width was observed in T17 (5.96 cm).

In Ratna, the treatments differed significantly for this parameter (Table 19) and the treatment T12 was observed to have the minimum stone width (4.55 cm) which was on par with T16 (4.59 cm). The stone width recorded was maximal for T17 (4.87 cm).

4.4.3. Stone thickness

The imposition of treatments significantly influenced the stone thickness in Mallika (Table 18) and the minimum stone thickness was observed for T10 (1.41 cm). The stone thickness recorded was maximal for T1 (1.72 cm).

In Ratna, among the treatments significant variation was found (Table 19). The treatment T10 recorded the minimum stone thickness (2.37 cm). Maximum stone thickness was recorded for T17 (2.61 cm).

4.4.4. Stone weight

In Mallika, the treatments differed significantly for stone weight (Table 18) and T16 recorded the lowest stone weight (39.62) and is on par with T9 (39.64 g). The treatment T17 recorded the highest stone weight among the treatments (48.63 g).

Similar trend was observed in Ratna (Table 19) and the minimum stone weight was observed for the treatment T16 (34.49 g) and was followed by T9 (35.63 g). The stone weight recorded was maximal for T17 (43.53 g).

Table 20. Effect of treatments on sugar content of fruits of Mallika

Treatments	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T1	4.76^{de}	10.86^{de}	15.62^{ij}
T2	4.59^{de}	11.33^{abc}	15.92^{gh}
T3	4.54^{e}	11.09^{abcd}	15.63^{ij}
T4	5.13^{bc}	10.45^{e}	15.58^{ij}
T5	4.89^{cd}	10.93^{cd}	15.82^{hi}
T6	4.74^{de}	10.92^{cd}	15.66^{ij}
T7	4.69^{de}	11.49^{a}	16.18^{f}
T8	4.72^{de}	11.39^{ab}	16.10^{fg}
T9	5.13^{bc}	10.99^{bcd}	16.12^{fg}
T10	5.51^{a}	11.29^{abc}	16.86^{a}
T11	5.44^{a}	10.81^{de}	16.25^{ef}
T12	5.45^{a}	11.16^{abcd}	16.60^{bcd}
T13	5.40^{ab}	11.04^{bcd}	16.44^{de}
T14	5.48^{a}	11.30^{abc}	16.77^{abc}
T15	5.27^{ab}	11.28^{abc}	16.55^{cd}
T16	5.50^{a}	11.36^{ab}	16.80^{ab}
T17	4.58^{e}	10.87^{d}	15.45^{j}
CD (0.05)	0.30	0.41	0.24

Table 21. Effect of treatments on sugar content of fruits of Ratna

Treatments	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T1	3.56^{gh}	14.24^{cd}	17.79^{cdef}
T2	3.42^{i}	14.15^{cdef}	17.57^{f}
T3	3.37^{i}	14.17^{cde}	17.54^{f}
T4	3.13^{j}	14.86^{a}	17.99^{bcd}
T5	3.46^{hi}	14.38^{bc}	17.84^{cdef}
T6	4.02^{de}	13.72^{gh}	17.74^{def}
T7	3.60^{g}	14.62^{ab}	18.22^{ab}
T8	3.75^{f}	13.88^{efg}	17.63^{ef}
T9	3.92^{e}	14.02^{defg}	17.95^{bede}
T10	4.29^{a}	13.98^{defg}	18.29^{ab}
T11	4.04^{d}	13.48^{h}	17.73^{def}
T12	4.07^{cd}	14.16^{cde}	18.23^{ab}
T13	4.10^{cd}	13.99^{defg}	18.09^{abc}
T14	4.18^{bc}	14.02^{defg}	18.20^{ab}
T15	4.24^{ab}	13.80^{fgh}	17.83^{cdef}
T16	4.31^{a}	14.09^{cdef}	18.40^{a}
T17	3.56^{gh}	13.97^{defg}	17.53^{f}
CD (0.05)	0.11	0.36	0.35

Values not sharing a common superscript in the column differ significantly with each other ($P<0.05$)

4.4.5. Pulp/stone ratio

The pulp/stone ratio in Mallika showed a significant difference among the treatments (Table 18). The highest pulp/stone ratio was recorded by the treatment T16 (13.64) and was followed by T10 (13.15). Pulp/stone ratio recorded was the lowest for T17 (6.19).

In Ratna, treatments differed significantly with respect to the pulp/stone ratio (Table 19). and the highest pulp/stone ratio was observed for the treatment T16 (11.84) followed by T12 (10.82). The treatment T17 recorded the lowest value (5.29) for pulp/stone ratio.

4.5. Quality parameters

The quality attributes of the fruits of Mallika and Ratna as influenced by the treatments are tabulated in Tables 20 and 21 respectively.

4.5.1. Reducing sugars

Content of reducing sugars showed significant variation among the treatments in Mallika (Table 20) and the maximum amount of reducing sugar was recorded for the treatment T10 (5.51 %) which was on par with T16, T12 and T11. The treatment T3 recorded the minimal amount (4.54%) for reducing sugar.

In Ratna, the treatments exhibited a significant difference for this parameter (Table 21) and the highest percentage of reducing sugar was observed for the treatment T16 (4.31 %) and was found to be on par with T10 (4.29 %) and T15 (4.24 %). The amount recorded was the minimum for T4 (3.13%).

4.5.2. Non reducing sugars

In Mallika, non reducing sugars varied significantly among the treatments (Table 20). The highest percentage of non-reducing sugars was observed for T7 (11.49 %) which was on par with T8 (11.39 %). The treatment T4 recorded the lowest percentage (10.45%).

Table 22. Effect of treatments on TSS, sugar/acid and brix/acid ratio of fruits of Mallika

Treatments	Total Soluble Solids (°Brix)	Titrable acidity (%)	Sugar/acid ratio	Brix/acid ratio
T1	24.60^{efg}	0.36^{bcde}	44.01^{defg}	69.31^{cde}
T2	24.45^{fg}	0.36^{bcde}	44.40^{defg}	68.25^{de}
T3	24.35^{gh}	0.37^{bcdef}	42.29^{efgh}	65.92^{def}
T4	24.38^{gh}	0.35^{bcdef}	44.54^{defg}	69.70^{bcde}
T5	24.15^{hi}	0.36^{bcde}	44.49^{defg}	67.93^{def}
T6	24.03^{i}	0.39^{ab}	39.92^{gh}	61.24^{ef}
T7	24.05^{i}	0.35^{bcdef}	46.62^{sdef}	69.32^{cde}
T8	24.45^{fg}	0.43^{a}	37.91^{h}	57.57^{ef}
T9	25.13^{bc}	0.36^{bcde}	45.10^{defg}	70.29^{cde}
T10	25.45^{a}	0.30^{f}	54.79^{a}	80.21^{f}
T11	24.58^{efg}	0.35^{bcdef}	48.85^{bcd}	73.10^{bcd}
T12	24.85^{cde}	0.34^{cdef}	46.78^{cdef}	70.73^{bcde}
T13	24.70^{def}	0.32^{def}	47.33^{cde}	70.14^{bcde}
T14	24.90^{cd}	0.36^{bcde}	46.83^{cdef}	79.68^{abc}
T15	25.38^{ab}	0.32^{def}	51.46^{abc}	78.92^{abc}
T16	25.53^{a}	0.31^{ef}	54.11^{ab}	85.09^{a}
T17	22.73^{j}	0.38^{abc}	41.21^{fgh}	60.62^{ef}
CD (0.05)	0.29	0.05	5.79	10.55

Table 23. Effect of treatments on TSS, sugar/acid and brix/acid ratio of fruits of Ratna

Treatments	Total Soluble Solids (°Brix)	Titrable acidity (%)	Sugar/acid ratio	Brix/acid ratio
T1	22.40^{g}	0.28	64.13	80.73^{abcde}
T2	22.23^{g}	0.25	69.65	88.09^{ab}
T3	21.85^{h}	0.30	59.47	74.10^{de}
T4	21.60^{h}	0.30	60.25	72.28^{ef}
T5	22.25^{g}	0.28	64.63	80.66^{abcde}
T6	23.05^{f}	0.28	62.89	81.77^{abcde}
T7	22.48^{g}	0.30	63.93	76.29^{bcde}
T8	23.08^{f}	0.29	60.80	81.08^{abcde}
T9	24.10^{cd}	0.29	63.68	85.45^{abcd}
T10	24.58^{a}	0.29	62.61	86.26^{abc}
T11	24.20^{bcd}	0.29	61.61	84.11^{abcde}
T12	23.88^{d}	0.30	61.27	80.26^{cde}
T13	23.45^{e}	0.31	57.97	75.17^{abcde}
T14	24.48^{ab}	0.30	61.83	81.89^{abcde}
T15	24.33^{abc}	0.30	60.44	80.44^{abcde}
T16	24.55^{ab}	0.28	67.00	89.39^{a}
T17	20.80^{i}	0.34	51.62	61.21^{f}
CD (0.05)	0.37	NS	NS	11.98

Values not sharing a common superscript in the column differ significantly with each other (P<0.05)

Significant difference was also observed in Ratna among the treatments imposed (Table 21). The maximum amount of non-reducing sugars was recorded by the treatment T4 (14.86 %) which was on par with T7 (14.62 %). The recorded percentage was the minimum for T11 (13.48%).

4.5.3. Total sugars

In Mallika, the treatments differed significantly for total sugars (Table 20) and the maximum amount of total sugars was recorded for the treatment T10 (16.86 %) which was found on par with T16 (16.80 %). The lowest amount of total sugars was observed for T17 (15.45 %).

In Ratna, the treatments showed a significant variation with respect to the total sugars (Table 21). The treatment T16 was observed to have the maximum total sugars (18.40 %). The treatments T10, T12, T7 and T14 were found on par. The amount of total sugars was the lowest (17.53%) for T17.

4.5.4. Total Soluble Solids

In Mallika, treatments exhibited a significant variation with respect to the total soluble solids (Table 22). The highest TSS was observed for the treatment T16 (25.53°Brix) followed by T10 (25.45°Brix). The TSS was lowest for the treatment T17 (22.73°Brix).

Significant effects were observed among the treatments in Ratna (Table 23). The treatment T10 recorded the highest TSS (24.58°Brix). The treatments T16 (24.55°Brix) and T14 (24.48°Brix) were found to be on par. The treatment T17 recorded the lowest value (20.80°Brix).

4.5.5. Titrable acidity

Titrable acidity showed a significant difference among the treatments in Mallika (Table 22). The lowest acidity was observed for the treatment T10 (0.30 %) and the highest was recorded for T3 (0.43%).

Table 24. Organoleptic scoring of fruits of Mallika

Treatments	Appearance	Colour	Texture	Flavour	Odour	Taste	After Taste	Overall Acceptability	Total Score
T1	7.55 (8.25)	7.25 (8.50)	7.10 (7.10)	7.40 (8.25)	7.65 (11.30)	7.65 (9.20)	7.70 (9.00)	7.35 (7.65)	52.40
T2	7.35 (9.70)	6.70 (4.75)	6.45 (4.10)	7.50 (9.70)	7.45 (4.90)	7.25 (5.30)	7.40 (6.10)	7.30 (6.70)	50.70
T3	6.55 (8.30)	6.95 (6.55)	7.05 (7.25)	7.30 (8.30)	6.35 (4.80)	7.65 (9.70)	7.65 (8.60)	7.45 (8.45)	50.00
T4	7.35 (6.75)	7.40 (8.55)	7.10 (7.10)	7.20 (6.75)	7.55 (11.90)	7.50 (7.70)	7.55 (7.55)	7.40 (7.50)	51.65
T5	7.20 (10.55)	7.00 (6.05)	7.50 (10.20)	7.55 (10.55)	7.40 (12.00)	7.50 (8.10)	7.55 (8.00)	7.35 (7.50)	52.05
T6	7.55 (7.85)	6.40 (3.85)	7.45 (10.10)	7.25 (7.85)	7.65 (4.95)	6.60 (2.95)	6.55 (3.00)	6.50 (3.60)	49.55
T7	7.35 (10.10)	7.10 (7.10)	6.65 (4.65)	7.55 (10.10)	7.20 (4.40)	7.40 (7.00)	7.40 (6.85)	7.20 (6.30)	50.75
T8	7.75 (14.25)	7.60 (11.30)	7.70 (11.20)	8.10 (14.25)	7.85 (12.70)	8.40 (15.00)	8.35 (14.35)	8.05 (12.80)	56.20
T9	7.40 (7.10)	7.35 (8.00)	7.95 (13.80)	7.15 (7.10)	7.25 (6.25)	7.50 (6.95)	7.50 (7.30)	7.60 (8.75)	52.35
T10	8.35 (9.20)	8.25 (13.30)	7.85 (12.45)	7.45 (9.20)	8.40 (11.40)	8.00 (10.70)	8.00 (11.45)	8.20 (13.40)	56.25
T11	7.10 (7.95)	7.60 (10.10)	7.50 (9.40)	7.35 (7.95)	7.30 (5.00)	7.55 (8.35)	7.55 (7.35)	7.45 (7.95)	51.80
T12	7.50 (7.75)	7.70 (10.80)	7.10 (7.10)	7.30 (7.75)	7.55 (11.30)	7.75 (8.90)	7.75 (9.90)	7.85 (10.50)	52.80
T13	7.45 (7.15)	7.57 (9.55)	7.17 (6.70)	7.20 (7.15)	7.45 (10.30)	7.67 (7.65)	7.57 (7.30)	7.42 (7.65)	51.92
T14	7.55 (6.75)	7.85 (11.50)	7.10 (7.10)	7.20 (6.75)	7.60 (11.80)	7.70 (8.25)	7.70 (9.30)	7.75 (9.90)	52.60
T15	8.20 (8.75)	7.95 (12.55)	7.70 (11.50)	7.45 (8.75)	8.45 (9.50)	8.00 (11.15)	8.00 (11.05)	7.90 (11.15)	55.70
T16	8.65 (13.75)	8.30 (14.60)	8.40 (16.00)	8.10 (13.75)	8.70 (15.70)	8.85 (16.40)	8.75 (16.15)	8.75 (16.00)	60.20
T17	6.55 (8.85)	6.90 (5.95)	7.05 (7.25)	7.35 (8.85)	6.35 (4.80)	7.80 (9.70)	7.85 (9.75)	7.25 (7.20)	50.20
Kendall's W[a]	0.47	0.41	0.46	0.22	0.59	0.47	0.43	0.54	

In Ratna, the treatments did not differ significantly for this parameter (Table 23) and the titrable acidity ranged from 0.25 % for the treatment T2 to 0.34% for T17.

4.5.6. Sugar/acid ratio

In Mallika, the treatments differed significantly with respect to the sugar/acid ratio (Table 22). The treatment T10 recorded the maximum sugar/acid ratio (54.79) followed by T16 (54.11%). The treatment T8 recorded the lowest sugar/acid ratio (37.91).

In Ratna, the treatments did not show any significant difference for sugar/ acid ratio (Table 23) and the values ranged from 51.62 for the treatment T17 to 69.65 for T2.

4.5.7. Brix/acid ratio

The treatments showed significant variation with respect to the brix/ acid ratio in Mallika (Table 22). The maximum brix/acid ratio was observed for the treatment T16 (85.09) which was on par with T14 (79.68) and T15 (78.92).

In Ratna, a significant variation among the treatments were recorded for the brix/acid ratio (Table 23). Treatment T16 (89.39) which was on par with T2 (88.09) recorded the maximum brix/acid ratio. The minimum brix/acid ratio was observed for T17 (61.21).

4.6. Organoleptic scoring of the fruits

Data corresponding to the sensory evaluation of the fruits of Mallika and Ratna under different treatments are presented in Tables 24 and 25.

In mango, appearance, colour, taste, after taste, flavour contributes to the fruit quality. It was evaluated using a nine point hedonic scale using score card for eight attributes-appearance, colour, texture, odour, flavour, taste, after taste, overall acceptability. The sensory test was carried out after the ripening of fruits.

Table 25. Organoleptic scoring of fruits of Ratna

Treatments	Appearance	Colour	Texture	Flavour	Odour	Taste	After Taste	Overall Acceptability	Total Score
T1	7.50 (8.95)	7.65 (10.15)	7.15 (8.15)	7.65 (7.95)	7.55 9.15	7.65 (8.85)	7.70 (8.15)	7.45 (9.00)	52.65
T2	7.40 (8.85)	6.95 (5.70)	6.35 (3.55)	7.25 (10.25)	7.40 (9.10)	7.25 (5.05)	7.45 (3.55)	7.35 (6.15)	50.45
T3	6.40 (3.75)	7.20 (7.10)	6.90 (6.65)	7.65 (7.85)	6.25 (3.35)	7.65 (8.60)	7.65 (6.65)	7.55 (8.60)	50.05
T4	7.40 (8.15)	7.50 (8.35)	7.05 (7.40)	7.50 (6.95)	7.40 (8.00)	7.50 (7.35)	7.55 (7.40)	7.50 (7.50)	51.90
T5	7.25 (7.20)	7.30 (7.05)	7.30 (9.55)	7.50 (9.60)	7.30 (7.30)	7.50 (7.75)	7.65 (9.55)	7.45 (8.65)	51.95
T6	7.60 (9.90)	6.55 (3.45)	7.05 (7.25)	6.60 (7.40)	7.50 (8.85)	6.60 (3.00)	6.65 (7.25)	6.60 (3.35)	48.60
T7	7.25 (6.85)	7.20 (7.05)	6.45 (4.00)	7.40 (8.65)	7.10 (5.75)	7.40 (6.95)	7.30 (4.00)	7.30 (6.40)	50.20
T8	7.80 (11.85)	7.90 (11.65)	7.45 (9.80)	8.40 (13.30)	7.70 (10.85)	8.40 (14.80)	8.35 (9.80)	8.20 (14.30)	56.30
T9	7.30 (7.70)	7.30 (7.30)	7.85 (13.65)	7.50 (7.35)	7.35 (13.65)	7.50 (7.35)	7.50 (13.65)	7.50 (7.15)	52.50
T10	8.25 (14.05)	8.15 (13.30)	7.75 (12.80)	8.00 (9.45)	8.45 (15.00)	8.00 (11.35)	7.95 (12.80)	8.15 (10.65)	56.55
T11	7.20 (6.85)	7.45 (8.15)	7.20 (8.45)	7.55 (8.85)	7.25 (7.70)	7.55 (7.85)	7.70 (8.45)	7.55 (8.55)	52.00
T12	7.45 (8.15)	7.65 (10.00)	7.30 (9.85)	7.75 (8.65)	7.50 (8.70)	7.75 (9.65)	7.75 (9.85)	7.75 (9.45)	53.25
T13	7.40 (8.05)	7.52 (8.90)	7.17 (7.65)	7.67 (8.05)	7.40 (8.10)	7.67 (8.40)	7.67 (7.65)	7.37 (8.10)	52.33
T14	7.50 (8.65)	7.75 (9.70)	7.25 (9.15)	7.70 (7.65)	7.55 (9.20)	7.70 (9.25)	7.70 (9.15)	7.65 (8.80)	53.05
T15	8.30 (14.40)	8.10 (12.80)	7.70 (12.60)	8.00 (8.30)	8.35 (14.95)	8.00 (10.95)	8.10 (12.60)	7.95 (11.70)	56.40
T16	8.60 (15.90)	8.65 (15.90)	8.35 (16.15)	8.85 (14.35)	8.60 (15.10)	8.85 (16.50)	8.70 (16.15)	8.70 (16.05)	60.65
T17	6.40 (3.75)	7.20 (6.45)	6.85 (6.35)	7.80 (8.40)	6.30 (3.80)	7.80 (9.35)	7.65 (6.35)	7.15 (8.60)	49.95
Kendall's W[a]	0.49	0.42	0.49	0.18	0.51	0.46	0.41	0.39	

In Mallika, among the seventeen treatments, the highest score for appearance was recorded for treatment T16 and the lowest for T3 and T17. The maximum score for texture was recorded for T16 and minimum for T2. For flavour, the highest score was recorded for T16 and the lowest for T9. The highest score for odour was recorded for T16 and lowest for T3 and T17. For taste the highest score was recorded for T16 and lowest for T6. The maximum score for after taste was recorded for T16 and minimum for T6. Finally for the overall acceptability the highest score was recorded for T16 and the lowest for T6.

Among the seventeen treatments in Ratna, the highest score for appearance was recorded for treatment T16 and the lowest for T3 and T17. The maximum score for texture was recorded for T16 and minimum for T6. For flavour, the highest score was recorded for T16 and the lowest for T3. The highest score for odour was recorded for T16 and lowest for T3. For taste the highest score was recorded for T16 and lowest for T6. The maximum score for the after taste was recorded for T16 and minimum for T6. Finally for the overall acceptability the highest score was recorded for T16 and the lowest for T6.

4.7. Major pest and disease incidence

The observations on major pest and disease incidence in mango including the causal agent, damage caused, symptoms etc were recorded. The details are given below

4.7.1. Pest incidence

a. Mango thrips (*Scirtothrips spp*: Thripidae)

Young leaves were curled along the midrib and were distorted. Both the nymphs and adults were found to suck the sap from the leaf tissues. The excretions of these insects led to sooty mould infestation that covered the leaf lamina and reduced the photosynthetic surface area of the leaves. For controlling the thrips, oberon @ 0.8 ml/tree was mixed in 2 litres of water and sprayed using a rocker sprayer on the affected trees.

b. Mango leaf hopper (*Ideoscopus clypealis*: Cicadellidae)

Adult and the nymphs caused the damage by sucking the sap from the leaves and flowers. They caused crinkling and drying of affected parts. The faecal excretion led to sooty mould development on the leaf surface and inflorescence. The inflorescence dried up due to the attack. Confidor 350 SC @ 0.5 ml/tree mixed in 2l of water was sprayed on the affected trees against the hopper attack.

c. Leaf eating caterpillars (*Euthalia achonthea*: Nymphalidae)

The leaf eating baron caterpillar feeded on the leaf lamina. It damaged the leaf and reduced the photosynthetic area. No management practice was followed since it was a minor attack.

d. Fruit fly (*Bactrocera dorsalis*: Tephritidae)

The female punctured the outer wall of the mature fruits to insert the eggs and caused egg laying injury. The maggots fed on the mesocarp and caused rotting of the fruits after maturity and led to less acceptability of the fruits by the consumers. Methyl eugenol pheromone trap @ 1 trap/ 15 cent were placed in the plot as a management measure against fruit fly. It is a type of sex pheromone trap that attracted the male fruit fly.

4.7.2. Diseases

a. Anthracnose (*Collectotrichum gleosporioides*)

It affected the leaves severely by the formation of sunken, black lesions that later coalesced resulting in the drying of affected part and formation of holes in the leaf. Affected young leaves became malformed due to the attack and remained small and distorted. Indofil @ 3g/l of water was sprayed on the flushes using a rocker sprayer.

b. Powdery mildew (*Oidium mangiferae*)

The attack was noticed on the inflorescence. The powdery mass covered the entire inflorescence and led to the complete drying. This led to the decrease in the number of flowers in the panicle which in turn affected the fruit set and yield. Folicur @ 1.5ml/l was sprayed on the affected trees to reduce the powdery mildew attack.

Discussion

5. DISCUSSION

Mango is considered as India's gift to the world, but its commercial cultivation is plagued by multitude of problems. The important issues in mango flowering in tropics are climatic conditions, environmental factors, hereditary character of the varieties, incidence of pests and diseases and the unawareness of regulating the time of flowering to take advantage of the market opportunities. Pruning is an important operation in high density orchards for proper canopy management and to produce high quality marketable fruits. Application of paclobutrazol (PBZ), a substituted triazole which is having anti-gibberellin effect is now recommended widely for inducing flowering, improving fruit yield and production of quality fruits in mango.

In the present experiment, the influence of different levels of pruning and time of pruning along with paclobutrazol application on growth, flowering, fruit characters and yield parameters in two mango hybrids, Mallika and Ratna planted under high density planting system were evaluated during 2017-19. The results obtained from the experiment are discussed in this chapter as follows.

5.1 Vegetative characters

Pruning treatments along with paclobutrazol application resulted in the suppression of tree height and canopy diameter in both the hybrids Mallika and Ratna.

Minimum tree height was observed for T16 (pruning of shoots at 20 cm length during September and drenched with paclobutrazol (PBZ) @ 7ml/tree) and maximum was observed in T17 (control) in both the hybrids. Application of paclobutrazol resulted in reduction of canopy diameter as observed for T10 (pruning of shoots at 20 cm length during June and drenched with PBZ), T11 (pruning of shoots at 10 cm length during July and drenched with PBZ) and T12 (pruning of shoots at 20 cm length during July and drenched with PBZ) in

Mallika, and T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) and T11 (pruning of shoots at 10 cm length during July and drenched with PBZ) in Ratna showing the lowest values.

In high density planting system pruning is essential to maintain canopy dimensions. A significant reduction in tree height and canopy spread was observed in mango cv. Nam Dok Mai Twai No.4 by pruning and paclobutrazol application (Charnvichit and Tongumpai, 1991). Tree height, length of new shoots and canopy diameter were seen reduced in the mango variety Dashehari imposed with pruning coupled with paclobutrazol drench (Ram *et al.*, 2005). Paclobutrazol was found to have a suppressive effect on vegetative characters of Alphonso (Kotur, 2012) and Dashehari (Srilatha *et al.*, 2015 and Narvariya *et al.*, 2015) varieties of mango. Annual tip pruning at 20 cm length along with paclobutrazol application was found to decrease the tree height and canopy spread (Singh *et a*l., 2017). Light pruning resulted in reduced tree height in Chausa mango variety compared to the unpruned trees (Lal and Mishra, 2007).

The substituted triazole 'paclobutrazol' which is a gibberellic acid synthesis inhibitor has resulted in the suppression of elongation of the shoots leading to the reduction in tree height for these treatments. In mango, paclobutrazol application when combined with the pruning operation was found to help in maintaining the tree size and increasing the productivity.

Length of new shoots was observed to be reduced in length in the pruned trees applied with paclobutrazol. Shortest shoots were observed for the treatments T12 (pruning of shoots at 20 cm length during July and drenched with PBZ) in Mallika and T14 (pruning of shoots at 20 cm length during August and drenched with PBZ) in Ratna. An increase in the number of leaves was observed in the trees which were subjected to pruning treatments. The maximum number of leaves per shoot was recorded for the treatment T8 (pruning of shoots at 20 cm length during September) in both the hybrids whereas the minimum number of leaves were observed for treatment T12 (pruning of shoots at 20 cm length during July and

drenched with PBZ) in Mallika and T2 (pruning of shoots at 20 cm length during June) in Ratna. Early shoot development was observed in all the treatments when compared to control. Days from pruning to shoot initiation was the lowest in trees pruned during August month along with paclobutrazol application in both Mallika and Ratna.

Synchronisation of vegetative growth of tree canopy in an orchard is the initial step in flowering management programme as the physiological maturity of all shoots will be the same. The vegetative growth is directly related to the type and time of all the pruning cut performed (Fadhilnoor *et al.*, 2018). Tip pruning in mango resulted in synchronous flushing that matured uniformly and marked the beginning of the annual flowering programme. (Oosthuyse, 1994; Oosthuyse, 1997; Davenport, 2006).

Soil application of paclobutrazol was found to be effective in reducing the shoot length by restricting the shoot growth (Kulkarni, 1988 and Burondkar and Gunjate, 1993; Kotur, 2012; Sarkar and Rahim, 2012). Paclobutrazol which is an anti gibberellin will suppress the activity of gibberellins leading to the production of shorter shoots and is also found to lower the active forms of cytokinins in the treated trees which may also contribute to reduction in shoot growth (Kurian and Iyer, 1992).

The blocking of the Kaurene biosynthesis phase of the GA synthesis pathway by the action of paclobutrazol resulted in the reduction of shoot growth in these treated trees.

5.2 Flowering characters

Flowering in mango is a complex phenomenon hence it is unpredictable and easily affected by the weather condition prevailing in that particular region. A reduction or absence of inflorescence results in complete crop failure. On recording the flowering characters in the present experiment, a significant effect of paclobutrazol on flowering was observed in both the hybrids Mallika and Ratna.

In Mallika, the minimum number of days from pruning to flowering was observed in treatment T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) whereas it was highest for T1 (pruning at 10 cm length during June) in both the hybrids. The flower initiation and fruit set was the earliest for the treatments T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) and T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) in Mallika. In Ratna, treatment T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) showed early flower initiation and fruit set among the treatments. The minimum number of days from flower initiation to fruit set was observed for T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Mallika and T4 (pruning at 20 cm length during July) in Ratna. Pruning along with paclobutrazol showed early flowering and fruit set in the present study. Early flowering and fruit set leading to early harvest is advantageous in catching an early market fetching higher price.

The time of flower bud initiation is an important step to schedule the cultural operations in mango. In mango floral inhibitor is actually a vegetative promoter (VP). Vegetative or reproductive induction at the time of shoot initiation seems to be governed by the ratio of the floral promoting (FP) and inhibiting factors. Vegetative promoters are associated with gibberellin synthesis pathway. So to induce flowering in warmer conditions, the level of vegetative promoter (VP) should drop to sufficiently lower levels with the stem age (4 months) to raise the FP/VP ratio. In tropics, regardless of the temperature floral induction occurs in the terminal shoots of those mango trees that have attained sufficient dormancy period (4-5 months). The resting period is cultivar specific in mango (Davenport, 2007).

Gibberellins are derivatives of tetra cyclic diterpinoid compounds that blocks flowering in mango (Jacob and Chandler, 1987). Since the triazoles inhibit the synthesis of Kaurene oxidase in the gibberellin synthesis pathway leading to the biosynthesis of gibberellins, application of paclobutrazol which is a triazole substitute will lead to early flowering and production of more number of

flowering shoots in mango (Burondakar and Gunjate, 1991, 1993; Junthasri *et al.*, 2000 and Yeshitela *et al.*, 2005).

Reduction in gibberellins and increase in the content of cytokinin and abscisic acid results in floral initiation in mango. The accumulation of abscisic acid in the buds during floral initiation regulates the leaf water potential and sap flow and also optimises carbohydrate availability whereas cytokinin helps in maintaining the differentiation activity. A reduction in the gibberellin is required for the induction of flowering as this helps in the accumulation of carbohydrates for floral initiation. Increased assimilate supply to the shoot apex contributes to the floral initiation (Jacobsen and Chandler, 1987).

Gibberellin levels increases in the shoots of mango trees during the vegetative growth period and decline during maturation stage and attains low level at the time of flowering (Chen, 1987). In pruned trees the concentration of starch in the new shoots is more than that in the unpruned trees at the time of flowering. Davenport (2007) observed uniform flowering in pruned trees. Tip pruning also stimulated lateral shoot development and improved the number of productive shoots resulting in higher yield.

Precautious and enhanced flowering was observed in mango trees subjected to paclobutrazol drench (Hasdeseve and Tongumpai, 1986; Kulkarni, 1988). Post harvest pruning resulted in enhanced flowering by the production of new flushes which upon maturation became photo synthetically active than the older leaves and might have resulted in an accumulation of more carbon reserve (Ram *et al.*, 2005). The renewal of shoots by post harvest pruning resulted in uniformity of floral bud and panicle formation as observed in shoot tip pruned plants applied with paclobutrazol. The flowering was preponed in the mango variety Amrapali by the application of PBZ by 19 days and harvesting by 15 days. Early flowering by paclobutrazol application might be due to the strong anti-gibberllin activity (Kurian and Iyer, 1992).

Number of inflorescence per square meter was the highest in T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) in both Mallika and Ratna. As compared to control more number of inflorescence per square metre was higher for all the treatments. Pruning level of 20 cm produced more inflorescence, while pruning along with the paclobutrazol application registered a further improvement in the inflorescence production. The shortest panicle was observed in the treatment T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in both the varieties, whereas the inflorescence width was minimum in the paclobutrazol drenched trees of treatment T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) in Mallika and T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Ratna. In general, a reduction in panicle size was observed in all paclobutrazol treated trees.

Tip pruning helped in increasing the number of flowering panicles per tree in mango cultivars Honey Gold and Calypso (Sarkhosh, 2018). Percentage of hermaphrodite flowers and sex ratio was found to be maximum in the trees pruned at 20 cm length during June and drenched with paclobutrazol (T10) in Mallika and trees pruned at 20 cm length during September and drenched with paclobutrazol (T16) in Ratna. In Alphonso an increased number of perfect flowers were observed by Burondkar and Gunjate (1991) by the soil application of paclobutrazol.

Paclobutrazol drench at the rates greater than 1g/tree resulted in compaction of inflorescence in mango cultivar Kensington Pride (Winston, 1992; Shinde *et al.*, 2000). An increase in the percentage of hermaphrodite flowers was observed by the soil application of PBZ in Alphonso (Singh, 2000; Vijayalakshmi and Srinivasan, 2002). The number of panicles per square meter increased with application of PBZ and it was observed that the sex ratio could be manipulated favourably by inducing more number of hermaphrodite flowers in variety Dashehari (Singh *et al.,* 2004). The total number of flowers and hermaphrodite flowers were found to increase in Alphonso subjected to PBZ application and this

can be attributed to anti gibberellic activity of PBZ that induced more number of panicles (Sonowane *et al.*, 2016).

Paclobutrazol acts as a promoter for floral shoot initiation rather than a plant growth retardant by reducing the gibberellin content leading to the accumulation of starch by the assimilate partitioning mechanism resulting in increased flowering.

5.3. Fruit and yield parameters

From the experiment it was observed that all the treatments recorded more number of fruits per tree, higher fruit weight and yield per tree, pulp weight and pulp to peel ratio. Highest number of fruits was recorded for the treatment T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) followed by T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Mallika and similar trend was observed in Ratna. Fruit weight and pulp weight was maximum in the treatment T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Mallika while the fruit weight was maximum in T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) and pulp weight in T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) which was on par with T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Ratna.

Collar drench of paclobutrazol was found to increase the number of fruits and the fruit weight compared to the control trees (Winston, 1992). Increased flowering and fruit set was observed in mango trees subjected to paclobutrazol drench resulting in higher yield in mango cultivars Alphonso and Prior (Randeep, 2012; Parulekar *et al.*, 2018). Paclobutrazol treated mango trees of Dashehari variety produced more hermaphrodite flowers, higher fruit set per panicle, number of fruits per tree, fruit size and yield compared to the control. Higher yield in paclobutrazol applied trees were related to the alteration in the source sink relation that might have reallocated the carbohydrate reserve (Sonawane *et al.*, 2016). In Amrapali, an increased number of fruits per tree, fruit weight and yield per tree

were observed due to the positive effect of paclobutrazol (Sarkar and Rahim, 2018). The paclobutrazol application increased the fruit set and fruit retention at the marble and maturity phases of fruits in Alphonso, Kesar and Rajpuri and this can be the reason for the increased number of fruits per tree and higher yield in the paclobutrazol treated trees of these three varieties (Tandel and Patel, 2011).

The fruit characters in terms of fruit length, breadth, circumference, volume were evaluated in this experiment. The fruit length, breadth, circumference and volume were maximum in the treatment T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in both the hybrids.

Post harvest pruning increased the number of fruits per tree and fruit weight due to the accumulation of carbohydrates in the pruned branches that received enough time for maturation (Yashitela *et al.*, 2005). In shoot pruned trees fruit volume and pulp to stone ratio was higher in the 'on year' (Singh et al, 2010). As the severity of pruning increased the fruit size and fruit weight were found to increase accordingly (Thakre *et al.*, 2016). Tip pruning of the shoots along with PBZ increase the fruit length, breadth, pulp weight in Uba mangoes (Oleveira *et al.*, 2017). Maximum number of fruited panicles per plant was observed in the June pruned trees in the hybrid Mallika (Thirupathi and Gosh, 2016). Tip pruning upto 20 cm recorded the highest fruit yield compared to severe pruning in Amrapali mangoes under HDP (Pratap *et al.*, 2003). The combined effect of PBZ and shoot pruning resulted in an increased fruit yield in Dashehari (Srilatha *et al.*, 2015). June pruned trees of Mallika recorded maximum fruit yield per tree while September pruned trees recorded the maximum fruit weight (Thirupathi and Gosh, 2016).

5.4 Stone characters

The effect of treatments on stone characters like stone length, width, thickness, weight and pulp to stone ratio in Mallika and Ratna were observed in the current experiment.

The stone characters recorded were minimum for T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in both the varieties and the pulp to stone ratio was maximum for the same.

An increased percentage of seedless fruits (57 to 80%) were observed when pruning was carried out in Atulfo mango (Garcia De Niz *et al.*, 2014).

5.5 Quality parameters

The quality parameters of the fruits of Mallika and Ratna like TSS, reducing sugars, non reducing sugars, total sugars, titrable acidity and sugar to acid ratio were recorded for the treatments under study. From the experiment it was observed that the highest percentage of reducing sugars was observed in T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) in Mallika which was on par with T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) whereas it was maximum for T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Ratna which was on par with T10 (pruning of shoots at 20 cm length during June and drenched with PBZ). In Mallika, the maximum amount of non reducing sugars were recorded in the treatment T7 (pruning of shoots at 10 cm length during September) and the total sugars were observed in the treatment T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) which was on par with T16 (pruning of shoots at 20 cm length during September and drenched with PBZ). In Ratna, the maximum amount of non-reducing sugars was recorded by the treatment T4 and the total sugars was maximum for T16 (pruning of shoots at 20 cm length during September and drenched with PBZ). The maximum total soluble solids was recorded for the treatment T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Mallika whereas it was maximum in T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) which was on par with T16 (pruning of shoots at 20 cm length during September and drenched with PBZ) in Ratna. The percentage of titrable acidity

was minimum in the treatment T10 (pruning of shoots at 20 cm length during June and drenched with PBZ) in Mallika and was non-significant in Ratna.

An increase in TSS, total sugars, reducing sugars and reduction in acidity was observed in the paclobutrazol drenched trees of Alphonso (Vijayalakshmi and Srinivasan, 2000). Improvement in TSS, total sugars and reducing sugars were observed in Dashehari, Chausa and Langra mangoes by the application of paclobutrazol (Singh et al, 2011). Increment in the total soluble solids in Dashehari was observed in the pruned trees drenched with paclobutrazol (Ram *et al*, 2005). The total soluble solids increased with the severity of pruning levels in Chausa mangoes (Lal and Mishra, 2007; Singh *et al*., 2010) and Guava (Adhikari and Kandel, 2015). An increase in the TSS was observed by June pruning compared with the control trees in Mallika (Thirupathi and Gosh, 2016). The increased TSS content in the fruits may be associated with the rapid hydrolysis of the polysaccharides to soluble sugars by the increased translocation of carbohydrate by altering the source-sink relationship. The increased sugar content in the fruits is attributed to the increased accumulation of carbohydrates by the assimilate partitioning mechanism induced by paclobutrazol. The unidirectional flow of assimilates to the developing fruits were noticed due to the suppression of vegetative growth.

Summary

6. SUMMARY

The experiment entitled "Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system" was carried out in the HDP block of Mango orchard attached to the Department of Fruit Science, College of Horticulture, Vellanikkara. It was aimed at studying the effect of different levels and time of pruning with and without the paclobutrazol application on growth, flowering, yield and quality of mangoes of the cvs. Mallika and Ratna. The results obtained are summarised as follows.

1. Pruning treatments (20 cm) along with paclobutrazol application (T16, T14, T12, T10) resulted in the suppression of tree height both the cultivars Mallika and Ratna. While the canopy diameter was suppressed in 20 cm pruned trees drenched with paclobutrazol during June (T10) in Mallika and June and July months (T10 and T11) in Ratna. A reduction in the length of new shoot was reported in Mallika (T12) and Ratna (T14) which were subjected to 20 cm pruning combined with paclobutrazol drench.

2. Early flowering was observed in the trees of both varieties imposed with June pruning (20 cm) along with the paclobutrazol drench (T10).

3. Maximum number of inflorescence per unit area was observed in the 20 cm June pruned trees of Mallika and Ratna treated with paclobutrazol (T10).

4. A reduction in the length (T16) and breadth of the inflorescence (T10) was observed in 20 cm September and June pruned trees of Mallika respectively subjected to paclobutrazol application. In Ratna, the September pruned (20 cm) trees coupled with paclobutrazol drench produced compact inflorescence (T16) in terms of both length and breadth.

5. Flower initiation was earliest in the June and September 20 cm pruned treatments applied with paclobutrazol (T10 and T16) in Mallika whereas it was the 20 cm June pruned treatment T16 applied with paclobutrazol in Ratna. Earliest fruit set was observed in T16 (20 cm September pruned trees subjected

to paclobutrazol application) in Mallika whereas it was in the treatment T10 (20 cm June pruned trees subjected to paclobutrazol application) in Ratna.

6. The maximum number of inflorescence per unit area, percentage of hermaphrodite flowers and sex ratio was highest in June 20 cm pruned trees of Mallika subjected to paclobutrazol drench (T10). While in Ratna the 20 cm September pruned trees of T16 applied with paclobutrazol recorded the highest sex ratio and hermaphrodite flowers.

7. Physical parameters of the fruits like fruit length, breadth, circumference, volume, pulp weight were significantly influenced by 20 cm pruning combined with the paclobutrazol application.

8. The number of fruits per tree and yield (kg/tree) was maximum in the trees of treatment T10 subjected to 20 cm June pruning along with paclobutrazol application in both the varieties. Whereas the maximum fruit weight and pulp weight was observed for T16, the 20 cm pruned treatment applied with paclobutrazol during September in both Mallika and Ratna.

9. Stone characters of the fruits such as stone length, width, thickness, weight and pulp/stone ratio were significantly reduced in both the cultivars subjected to 20 cm pruning coupled with paclobutrazol.

10. The minimum days from fruit set to harvest was observed in the paclobutrazol applied 20 cm pruned trees of June of the treatment T10 in both the hybrids.

11. Qualitative parameters of the fruits improved by the pruning treatments (20 cm) along with the paclobutrazol application. Total sugars and reducing sugars were maximum in the June pruned trees of Mallika (T10) whereas in Ratna the September pruning was found to be effective (T16). Whereas the highest TSS was observed for the fruits of September 20 cm pruned treatment T16 (Mallika) and June T10 treatment (Ratna) drenched with paclobutrazol.

References

REFERNCES

Adhikari, S. and Kandel, T. P. 2015. Effect of time and level of pruning on vegetative growth, flowering, yield and quality of guava. *Int. J. Fruit Sci.*, 15(3): 290-301.

Barman, P. and Mishra, D. 2018. Tip pruning for synchronized vegetative growth and controlling alternate bearing in mango (*Mangifera indica*). *Indian J. Agr. Sci.*, 88(46): 21-627.

Burondkar, M. M. and Gunjate, R. T. 1991. Regulation of shoot growth and flowering in Alphonso mango with paclobutrazol. *Acta Hort.*, 291: 79-84.

Burondkar, M.M. and Gunjate, R. T. 1993. Control of vegetative growth and induction of regular and early cropping in 'Alphonso' mango with paclobutrazol. *Acta Hort.*, 341: 206-15.

Chacko, E. K. and Randhawa, G. S. 1971. Towards an understanding of the factors affecting flowering in mango (*Mangifera indica* L.). *Andhra Agric. J.*, 18: 226–36.

Charnvichit, S., Tongumpai, P. 1991. September. Effect of paclobutrazol on canopy size control and flowering of mango, cv. 'Nam dok Mai Twai' No. 4, after hard pruning. *Acta Hort.*, 291:60-63

Chen, Y., Steinitz, B., Cohen, A. and Elber, Y. 1982. The effect of various iron containing fertilizers on growth and propagation of Gladiolus grandiflorus. *Scientia Hort.*, 18 (2):169-175.

Davenport T. L. 2006. Pruning strategies to maximize tropical mango production from the time of planting to restoration of old orchards. *Hort Sci.*, 41: 544–8.

Davenport, T.L., 2007. Reproductive physiology of mango. *Brazilian J. Plant Physiol.*, 19(4): 363-376.

Davis, S. J. and Stassen P. J. C. 1997. Mango model: starch distribution in different tissues of Sensation mango tree of varying ages. *Acta Hort.*, 455: 143-150.

Desai, M. M. and Chundawat, B. S. 1994. Regulation of flowering in mango by Paclobutrazol. *Indian J. Hort.*, 51 (1): 9-15.

Fadhilnor, A. and Malik, T. T. A. 2018. Manipulation of branching and architectural structures of mango trees by shoot pruning. *J. Trop. Agric. and Fd. Sc.*, 46(1): 47-54.

García De Niz, D. A., Esquivel, G. L., Montoya, R.B., Arrieta Ramos, B. G., Santiago, G. A., Gomez Aguilar, J. R. and Sao José, A. R. 2014. Vegetative and reproductive development of 'Ataulfo' mango under pruning and paclobutrazol management. *J. Agr. Sci. Tech.*, 16: 385-393.

Ghavale, S. L., Pujari, K. H. and Patil, S. 2016. Studies on the effect of pruning on flowering behaviour of mango cv. Alphonso. *Int. J. Trop. Agric.*, 34(4): 991-996.

Goguey, T. 1990. Effet d'applications répétées de Cultar (paclobutrazol) sur *Mangifera indica* L. var. Valencia. *Fruits.* 45(6): 599–607.

Hasdiseve, C. and Tongumpai, P. 1986. Effect of paclobutrazol on vegetative growth, flowering and fruit setting of mango cv. Nam Dok Mai. *Proc. Kasetsart Univ. Conf.* 24: 295-302.

Jacobsen, J. V. and Chandler, P. M. 1987. Gibberellin and abscisic acid in germinating cereals. In *Plant hormones and their role in plant growth and development, Springer Dordrecht.* 164-193.

Junthasri, R., Nartvaranant, P., Subhadrabandhu, S. and Tongumpai, P. 2000. Flower induction for producing offseason mango in Thailand. *J. Appl. Hort.*, 2(1): 65-70.

Karuna, K. And Mankar, A. 2008. Effect of urea, paclobutrazol and plant bio regulators on vegetative growth and productivity of Langra mango. *Orissa J. Hort.*, 36(2):88-92.

Karuna, K. And Mankar, A. And Singh, J. 2007. Effect of urea and growth substances on yield and quality of mango cv. Langra. *Orissa J. Hort.*, 35(1): 67-70.

Kotur, S.C., 2012. Effect of Paclobutrazol Application on Nutrient Dynamics, Vigour and Fruit Yield in'Alphonso'Mango (*Mangifera indica* L.). *J. Hort. Sci.*, *7*(2): 134-137.

Kulkarni, V. J. 1988. Chemical control of tree vigour and the promotion of flowering and fruiting in mango (*Mangifera indica* L.) using paclobutrazol. *J. Hort. Sci.* 63: 557-66.

Kurian, R. M. and Iyer, C. P. A. 1992. Stem anatomical characters in relation to tree vigour in mango (*Mangifera indica* L.). *Sci. Hort.* 50(3): 245-253.

Kurian, R. M. and Iyer, C. P. A., 1993. Chemical regulation of tree size in mango (Mangifera indica L.) cv. Alphonso. III. Effects of growth retardants on yield and quality of fruits. *J. Hort. Sci.*, *68*(3): 361-364.

Lal, B. and Mishra, D. 2007. Effect of pruning on growth and bearing behaviour of mango cv. Chausa. *Indian J. Hort.*, 64(3): 268-270.

Nafees, M., Anwar, R., Jameel, M., Aslam, M. N., Ahmad, S., Akhtar, F. Z. and Memon, N., 2010. Flushing pattern of mango (*Mangifera indic*a L.) cultivars in response to pruning of panicles and its effect on carry over effect of floral malformation. *Pak. J. Agri. Sci.*, 47(1): 13-18.

Nafeez, M., Faqueer, M., Ahmad, S., Alam Khan, M., Jamil, M. and Naveed Aslam, M. 2010. Paclobutrazol soil drenching upresses vegetative growth, reduces malformation and increases production in mango. *Int. J. Fruit Sci.*, 10: 431-440.

Narvariya, S. S., Vandana, D., Singh, C. P. and Kamlesh, K. 2015. Efficacy of cultar on growth, flowering and yield behavior of mango (*Mangifera indica* L.) cv Dashehari. *Environment and Ecology*. 33(2A): 827-831.

Oliveira, G. P., Siqueira, D. L. D., Salomão, L. C. C., Cecon, P.R. and Machado, D. L. M., 2017. Paclobutrazoland branch tip pruning on the flowering induction and quality of mango tree fruits. *Pesq. Agropec. Trop.*, 47(1): 7-14.

Oosthuyse, S. A., 1994. Pruning of Sensation mango trees to maintain their size and effect uniform and later flowering. *South Afi. Mango Growers' Assoc. Yearbook*. 14:1-5.

Oosthuyse, S.A., 1997. Tree size maintenance pruning of mango trees after harvest: is cropping negatively affected or not?. *South Afr. Mango Growers' Assoc. Yearbook*. 17: 33-36.

Parulekar, Y.R., Haldankar, P.M., Kulkarni, M.M., Dalvi, N.V., Desai, V.S., Kadam, J.J. and Patil, S.T., 2019. Studies on rejuvenation of old and senile orchards of Alphonso mango in Konkan region of Maharashtra. *Hortic. Soc. India.* 76(2): 364-367.

Pratap Bhanu, Sharma H. C., Goswami A. M., Singh S. K. and Mishra L. N. 2003. Effects of pruning on photosynthetic rate, canopy micro-climate and yield of mango cv. Amrapali under high-density planting. *Indian J. Hort.*, 60: 339–2.

Protacio, C. M., Quinto, J. E., Serrano, E. P., Marquez, I. P. and Rodriguez, F. M. 2009. Unravelling the mechanism of mango flowering. *Acta Hort.,* 820: 259-270.

Ram, R. B., Vismil, R. S. and Lal, B. 2005. Effect of pruning severities and paclobutrazol on bearing behaviour of rejuvenated mango trees cv. Dashehari. *New Agric.*, 16(1/2): 1-9.

Ram, S. and Tripathi, P.C., 1993. Effect of cultar on flowering and fruiting in high density Dashehari mango tree. *Indian J. Hort.*, 50(4): 292-295.

Ramírez, F. and Davenport, T. L. 2010. Mango (Mangifera indica L.) flowering physiology. *Scientia Hort.*, 126(2): 65-72.

Randeep, K. R., 2012. *Chemical regulation of cropping in mango* MSc (Hort) thesis, Kerala Agricultural University, 89p.

Rao, M. M., Srihari, D., Patel, V. S. and Madalagiri, M. B. 1997. Further studies on chemical induction of flowering on fruited shoots in 'off' phase Alphonso mango trees. *Karnataka J. Agric. Sci.,* 10: 598-600.

Reddy, Y.T.N. and Kurian, R.M., 2011. Studies on Rejuvenation of Old, Unproductive'Alphonso'Mango Trees in Orchards. *J. Hortl. Sci.*, *6*(2):145-147.

Rodge, B. M. and Pujari, K. H. 2017. Studies on effect of pruning on reproductive shoots and yield of mango cv. Alphonso. *Asian J. Hort.*, 12(2): 218-222.

Sarkar, C. B. and Rahim, M. A. 2012. Vegetative growth, harvesting time, yield and quality of mango (*Mangifera indica* L.) as influenced by soil drench application of paclobutrazol. *Bangladesh J. Agri.* 37(2): 335-348.

Sarker, B.C. and Rahim, M.A. 2018. Influence of paclobutrazol on growth, yield and quality of mango. *Bangladesh J. Agri.*, 43(1): 1-12.

Sarkhosh, A., McConchie, C. and Khadivi, A., 2018. The effects of different tip-pruning times on flowering, yield, and maturity of two mango cultivars in subtropical climate of Northern Territory (Katherine region) from Australia. *Scientia Hort.*, 234: 140-145.

Sharma, R. R. and Singh, R. 2006. Pruning intensity modifies canopy microclimate, and influences sex ratio, malformation incidence and development of fruited panicles in 'Amrapali'mango (*Mangifera indica* L.). *Scientia Hort.*, 109(2): 118-122.

Shinde, A. K., Waghmare, G. M., Wagh, R. G. and Burondkar, M. M., 2000. Effect of dose and time of paclobutrazol application on flowering and yield of mango. *Indian J. Plant Physiol.*, 5(1): 82-84.

Singh, A. K., Singh, C. P. and Bora, L., 2017. Impact of pruning on growth, yield and quality of mango cv. Dashehari. *J. Hortl. Sci.*, 12(2):118-123.

Singh, J. and Singh, S. 2003 a. Effect of cultar on flowering, fruiting and fruit quality of mango cv. Bombai. *Hort. J.*, 16(1): 33-39.

Singh, S. and Singh, J. 2003 b. Regulation of shoot growth, flowering, fruiting with cultar in mango cv. Dashehari. *Orissa J. Hort.*, 31(1): 40-43.

Singh, S. K., Singh, S. K. and Sharma, R. R., 2010. Pruning alters fruit quality of mango cultivars (*Mangifera indica* L.) under high density planting. *J. Trop. Agric.* 48(2): 55-57.

Singh, S. K., Singh, S. K. and Sharma, R. R., 2010. Pruning alters fruit quality of mango cultivars (*Mangifera indica* L.) under high density planting. *J. Trop. Agric.* 48(2): 55-57.

Singh, V. K. and Singh, A. 2003. Effect of paclobutrazol on regularity of bearing in mango (*Mangifera indica* L.). *Physiol. Mol. Biol. Plants.* 9: 239-248.

Singh, V. K., Shukla, K. C., Tyagi, P.K. and Singh, J. N., 2011. Effect of paclobutrazol application on fruit quality of mango (*Mangifera indica* L.). *New Agric.*, 22(1): 15-17.

Singh, Z. 2000. Effect of (2RS, 3RS) paclobutrazol on tree vigour, flowering, fruit set and yield in mango. *Acta Hort.*, 525: 459-462.

Sonawane, H. S., Pujari, K. H., Ghavale, S. L. and Nawale, R. N. 2016. Studies on effect of foliar sprays of paclobutrazol and cycocel on flowering behaviour of mango cv. Alphonso. *Int. J. Trop. Agric.* 34(2): 471-477.

Sonawane, H.S., Pujari, K.H., Ghavale, S.L. and Nawale, R.N., 2016. Studies on effect of foliar sprays of paclobutrazol and cycocel on flowering behaviour of mango cv. Alphonso. *Int. J. of Trop. Agric.*, 34(2): 471-477.

Srilatha, V., Reddy, Y. T. N., Upreti, K. K. and Jagannath, S. 2015. Tree vigor and hormonal changes in response to pruning and paclobutrazol application in mango (Mangifera indica L.) cv Dashehari. *Environ. and Ecol.*, 33(4): 1413-1417.

Swaroop, M., Ram, S., Singh, C. P., Shukla, P., 2001. Effect of pruning on growth, flowering and fruiting in mango. *Indian J. Hortic.* 58: 303–308

Tandel, Y. N. and Patel, N. L. 2011. Effect of chemicals on growth, yield and economics of mango (*Mangifera indica* L.). *Karnataka J. Agri. Sci.*, 24(3): 362-365.

Thakre, M., Lal, S., Uniyal, S., Goswami, A. K. and Prakash, P. 2016. Pruning for crop regulation in high density guava (*Psidium guajava* L.) plantation. *Spanish J. Agric. Res.*, 14(2):905p.

Thirupathi, N. and Ghosh, S. N. 2016. Effect of shoot pruning on flowering, yield and quality of mango cv. Mallika grown in laterite soil. *J. Crop and Weed*, 12(2): 50-52.

Vijayalakshmi, D. and Srinivasan, P. S., 2000. Improving the quality attributes of 'off' year Alphonso mango through chemicals and growth regulators. *Orissa J. Hort.*, 28(1): 31-33.

Winston, E.C. 1992. Evaluation of paclobutrazol on growth, flowering and yield of mango cv. Kensington Pride. *Aust. J. Exp. Agric.*, 32(1): 97-104.

Yeshitela, T., Robbertse, P. J., Stassen, P. J. C. 2005. Effects of pruning on flowering, yield and fruit quality in mango (*Mangifera indica). Aust. J. Exp. Agric.*, 45: 1325–1330.

Appendices

Score card for organoleptic evaluation

Name of the judge:

Date :

	T1	T2	T3	T4	T5	T6	C1	C2
Appearance								
Colour								
Body								
Flavour								
Taste								
After taste								
Odour								
Overall acceptability								

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature:

EFFECT OF CROP REGULATION ON YIELD AND QUALITY OF MANGO (*Mangifera indica* L.) UNDER HIGH DENSITY PLANTING SYSTEM

by

AMRITA MANOHAR
(2017-12-005)

Abstract of the Thesis

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(FRUIT SCIENCE)

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF FRUIT SCIENCE
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2019

ABSTRACT

Mango (*Mangifera indica* L.) is the choicest fruit of the world owing to its nutritional qualities, appearance, taste and flavour. Low productivity of mango is a major concern among the mango growers. Adoption of management techniques like high density planting, pruning and use of growth regulators are found to improve the productivity of the orchards. The present study entitled "Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system" was conducted in the Mango orchard attached to the Department of Fruit Science, College of Horticulture, Vellanikkara during 2017-2019. Seven year old trees of two popular mango hybrids, Mallika and Ratna grown under HDP system were selected for the experiment. The experiment consisted of 17 treatments with 2 replications. Data on vegetative, floral, fruit, stone and quality parameters were recorded for both the hybrids during the period of study.

The vegetative growth parameters like tree height, canopy diameter, length of new shoots and number of leaves per shoot exhibited significant variation among the treatments in both the hybrids Mallika and Ratna. Growth parameters were found to be suppressed in the trees which were pruned at 20 cm length and drenched with paclobutrazol (PBZ) @ 7ml/tree. Early emergence of new shoots was recorded for all the treatments in which pruning was carried out during the month of June irrespective of the level of pruning and PBZ application in both the hybrids. Minimum number of days for shoot initiation after pruning was observed in trees which were pruned in August month and applied with PBZ in both Mallika and Ratna.

Results revealed that the minimum number of days from pruning to flowering was observed in T16 (pruned at 20 cm length during September and drenched with PBZ @ 7ml/tree) in both the hybrids Mallika (59.50 days) and Ratna (57.50 days). Flower initiation was the earliest in the treatments T10 (pruned at 20 cm length during June and drenched with PBZ @ 7ml/tree) and T16 in Mallika (2nd Nov) and T10 in Ratna (1st Nov). Earliest fruit set was observed for T16 in Mallika (11th Dec.) and for T10 in Ratna (10th Dec.). The minimum number of days from flower initiation to fruit set was recorded for treatments T10 and T16 in Mallika (39.50 days) and T4 in Ratna (38 days).

Maximum number of inflorescence per unit area was recorded for the treatment T10 in both the hybrids Mallika (15.25) and Ratna (14.60). A reduction in the length of inflorescence was observed in T16 in both the hybrids Mallika (33.07 cm) and Ratna (35.07 cm) whereas the breadth of inflorescence was minimum for the treatment T10 in Mallika (16.18 cm) and

T16 in Ratna (19.08 cm). The percentage of hermaphrodite flowers and sex ratio was observed to be higher for T10 in Mallika and for T16 in Ratna. Maximum number of fruits per tree in both Mallika (31.50) and Ratna (34.50) were recorded for T10. The fruit weight was the highest for T16 in both the hybrids Mallika (624.03 g) and Ratna (468.89 g). The total yield per tree was maximum for T10 Mallika (19.31 kg/tree) and Ratna (16.06 kg/tree).

The physical parameters of fruit like fruit length, breadth, circumference, volume and pulp weight was maximum for T16 in both Mallika and Ratna. Peel weight and peel thickness did not show any significant variation among the treatments in both the hybrids. Pulp/peel ratio was recorded to be the highest for T16 in Mallika (12.32) and for T10 in Ratna (15.96).The duration of fruiting was minimum for T12 in Mallika and for T13 in Ratna. Minimum number of days from flowering to harvest was recorded for T12 in Mallika and for T13 in Ratna. In both Mallika and Ratna, the number of days taken from fruit set to harvest was minimum for T10. The stone characters of the fruits such as stone length, width, thickness and weight showed a significant reduction in both the hybrids subjected to pruning at 20 cm length and drenched with PBZ. Pulp/stone ratio recorded was the highest for T16 in Mallika (13.64) and for T10 in Ratna (11.84).

On evaluating the quality parameters of the fruits in terms of reducing sugars, total sugars, TSS and sugar/acid ratio the treatments T16 and T10 were found to be superior. Organoleptic evaluation of fruits of both Mallika and Ratna revealed that T16 was the best among all the treatments followed by T10. During the period of study the incidence of major pests like thrips, mango hoppers, leaf eating caterpillars and fruit flies and major diseases like anthracnose and powdery mildew were observed in the orchard.

In the present study it was observed that vegetative parameters which favoured early flowering, fruit set and harvesting were observed for the treatments T16 and T10 in both the hybrids. The earliest harvest of fruits was obtained from the trees subjected to treatment T10 in both Mallika and Ratna. Any method which aid in advancing the harvesting of fruits without affecting the quality will help to catch the early market which in turn will lead to fetch a premium price for the early mangoes making the cultivation of mango under HDP system all the more remunerative. Number of fruits per tree and yield per tree was also higher for T10 in both the hybrids. But with regard to fruit weight and fruit quality parameters treatments T16 was found to be superior in both Mallika and Ratna and was comparable with T10.