

**“STUDIES ON EFFECT OF SPECIAL
HORTICULTURAL PRACTICES ON INDUCTION OF
FLOWERING IN MANGO (*Mangifera indica* L.)
CV. RATNA”**

By

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DAPOLI- 415 712, DIST. RATNAGIRI (M.S.) – 415 712**

May, 2021

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A thesis submitted to the

Dr. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH,
DAPOLI, (Agricultural University)

DIST. RATNAGIRI (M.S.), INDIA

In partial fulfillment of the requirements for the degree of

Master of Science

(Horticulture)

in

FRUIT SCIENCE

by

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Reg. No. : HDPM/19/0192

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C E R T I F I C A T E

This is to certify that, the thesis entitled “**STUDIES ON EFFECT OF SPECIAL HORTICULTURAL PRACTICES ON INDUCTION OF FLOWERING IN MANGO (*Mangifera indica* L.) CV. RATNA**” submitted to the College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra State), in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE**, embodies the results of a piece of bona-fide research carried out by **Mr. AGHAV RUSHIKESH DATTATRAY** (Regd. No. 0192) under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during this course of investigation and the sources of literature has been duly acknowledged by him.

Place: Dapoli

Date: 13/07/2021


(P. M. Haldankar)

Chairman,
Advisory Committee and
Research Guide

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While travelling on the path of life and education, many hands pushed me forward, Enlightened by their knowledge and experience, it felt necessary to sharp my feelings in words even through carrying of feelings in words is difficult, still a little effort is being done to access the never-ending helping hands. At this moment, I would remember the almighty 'Shree Ganesha' who has made each impossible work a reality in my life, the fruits of which I am expressing here.

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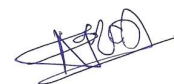
George Alito has well said "Friendship is feeling safe with a person having neither to weight thoughts nor measure words." Words in my command are inadequate to express my heartfelt thanks to my all-friends **Hemant, Santosh, Akshay, Vishal, Mayuresh, Pratik, Suraj, Vaibhav, Shubham, Sandip, Mayur, Bhakti, Nilam, Renuka, Bhagyshala, Ruchita, Madhu, Manali, Vrushali** and seniors **Ashish dada, Avdhut dada, Omkar dada and Sayali didi** for their support, encouragement, help, and for standing by my side whenever I needed them to share my feelings and dreams so that I never feel alone on my way. My thanks and appreciations also go to my colleague in developing the thesis and people who have willingly helped me out with their abilities.

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Finally thanking the Almighty for this wonderful life.....

Place: Dapoli

Date: June, 2021



Rushikesh Dattatray Aghav

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**COLLEGE OF HORTICULTURE, DAPOLI,
DIST. RATNAGIRI, (M.S.) 415 712**

Title of Thesis	: “Studies on effect of special horticultural practices on induction of flowering in mango (<i>Mangifera indica</i> L.) cv. Ratna”
Name of the student	: Mr. Aghav Rushikesh Dattatray
Registration No.	: HDPM/19/0192
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ABSTRACT

The present investigation entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was carried out at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.) during season of 2020-21. The experiment was laid out in Randomized Block Design with ten treatments namely, T₁ (girdling on first fortnight of October), T₂ (girdling on first fortnight of November), T₃ (girdling on first fortnight of October and November), T₄ (girdling on first fortnight of October and tip pruning), T₅ (girdling on first fortnight of November and tip pruning), T₆ (girdling on first fortnight October and November and tip pruning), T₇ (tip pruning), T₈ (removal of new shoots below old shoot), T₉ (smudging) and T₁₀ (control) which were replicated three times.

The morphological parameters *viz.*, days required from treatment exposure to panicle emergence, flowering intensity, length and width of panicle, no. of rachis per panicle, hermaphrodite flowers (%), fruit set, fruit retention (%), yield and days required from flowering to harvesting were significantly varied due to girdling,

tip pruning and smudging. The chemical parameters of the fruits were not influenced significantly by girdling, tip pruning and smudging.

Treatment T₅ (girdling on first fortnight of November and tip pruning) showed best performance for flowering intensity (62.27 %), hermaphrodite flowers (15.01 %), fruit set (8.53 %), fruit retention (0.95 %) and the yield (144.00 no. of fruits/tree, 61.58 kg/tree). T₇ (tip pruning) resulted in early panicle emergence (40.83 days) which led to early harvest (134.87 days).

The physical parameters *viz.* fruit weight, fruit length, fruit diameter, pulp weight and pulp to stone ratio were affected significantly due to girdling, tip pruning and smudging.

From present investigation, it was concluded that girdling and tip pruning in mango cv. Ratna helped for early panicle emergence and further led to early harvest with high yield.

**बागवाणी महाविद्यालय, दापोली,
जिला रत्नागिरी, (महाराष्ट्र राज्य) ४१५७१२**

प्रबंध का शिर्षक	:	“विशेष बागायती पद्धतियों के अध्ययन, का आम के रत्ना जाती के फुलधारणा पर प्रभाव”
छात्र का नाम	:	श्री. आघाव ऋषिकेश दत्तात्रय
पंजीकरण क्रमांक	:	एचडीपीएम / १९ / ०१९२
अनुसंधान के मार्गदर्शक	:	डॉ. पी. एम. हळदणकर अनुसंधान संचालक, डॉ. बा. सा. कोकण कृषि विद्यापीठ, दापोली, जिला - रत्नागिरी
प्रस्तुत करने का वर्ष	:	जून, २०२१

गोषवारा

प्रस्तुत प्रयोग शिर्षक “विशेष बागायती पद्धतियों के अध्ययन, का आम के रत्ना जाती के फुलधारणा पर प्रभाव” का आयोजन बागवानी महाविद्यालय, डॉ. बालासाहेब सावंत कोकण कृषि विद्यापीठ, दापोली (महाराष्ट्र) में साल २०२०-२१ के दौरान की गई। प्रस्तुत प्रयोग यादृच्छिक गुट (आर.बी.डी.) रूपरेखा में दस उपचारों के साथ रखा गया था, अर्थात् टी_१ (अक्टूबर के पहले पखवाड़े में गर्डलींग), टी_२ (नवंबर के पहले पखवाड़े में गर्डलींग), टी_३ (अक्टूबर और नवंबर के पहले पखवाड़े में गर्डलींग), टी_४ (अक्टूबर के पहले पखवाड़े में गर्डलींग और टिप छंटाई), टी_५ (नवंबर के पहले पखवाड़े में गर्डलींग और टिप छंटाई), टी_६ (अक्टूबर और नवंबर के पहले पखवाड़े में गर्डलींग और टिप छंटाई), टी_७ (टिप छंटाई), टी_८ (टिप छंटाई पुराने शूट के नीचे), टी_९ (स्मजिंग) और टी_{१०} (नियंत्रक) जो की तीन बार नकल किया गया।

बाह्य आकृती विज्ञान के मापदंडों का अध्ययन करते समय यह सामने आया की, उपचार से पुष्पगुच्छ का ऊद्भव के लगणे वाले दिन, पुष्पगुच्छ की लंबाई और चौड़ाई, फुलों की तीव्रता, संयुक्त फुलों की संख्या, फल धारणा, फल

प्रतिधारणा, उपचार से लेकर काटने तक लगनेवाले दिनों की संख्या इन पर गर्डलींग, टिप छंटाई और स्मजिंग का सकारात्मक परिणाम दिखाई दिया। रासायनिक मापदंडों पर गर्डलींग, टिप छंटाई और स्मजिंग का कोई भी प्रभाव दिखाई दिया।

उपचार टी₆ (नवंबर के पहले पखवाड़े में गर्डलींग और टिप छंटाई), इसका फूलों की तीव्रता (६२.२७ %), संयुक्त फूल (१५.०१ %), फल धारणा (८.५३ %), फल प्रतिधारण (०.९५ %) और उत्पन्न (१४४.०० फल की संख्या /पेड़, ६१.५८ किलो / पेड़)। टी₆ (टिप छंटाई) के परिणाम स्वरूप जल्दी पुष्पगुच्छ ऊद्भव (४०.८३ दिन) जिससे जल्दी कटाई (१३४.८७ दिन) हुई।

भौतिक मापदंड जैसे फल की लंबाई, फल का व्यास, फल का वजन, लुगदी का वजन, लुगदी से गुटली का प्रमाण इनपर गर्डलींग, टिप छंटाई, और स्मजिंग का सकारात्मक परिणाम दिखाई दिया।

प्रस्तुत प्रयोग से यह निष्कर्ष निकलता है कि, रत्ना आम में गर्डलींग और टिप छंटाई से जल्दी कण ऊद्भव होता है और जल्दी कटाई होती है और उत्पन्न में बढोतरी होती है।

**उद्यानविद्या महाविद्यालय, दापोली,
जिल्हा रत्नागिरी, (महाराष्ट्र राज्य) ४१५७१२**

प्रबंध शिर्षक	: “विशेष बागायती पद्धतीच्या अभ्यासाचा, आंब्याच्या रत्ना जातीवरील फुलांच्या समावेशावर होणारा परिणाम”
विद्यार्थ्यांचे नाव	: श्री. आघाव ऋषिकेश दत्तात्रय
नोंदणी क्रमांक	: एचडीपीएम / १९ / ०१९२
संशोधन	: डॉ. पी. एम. हळदणकर
मार्गदर्शकाचे नाव	संशोधन संचालक, डॉ. बा. सा. कोकण कृषि विद्यापीठ, दापोली, जिल्हा - रत्नागिरी
प्रबंध करण्याचे वर्ष	: जून, २०२१

सारांश

प्रस्तुत प्रयोग शिर्षक “विशेष बागायती पद्धतीच्या अभ्यासाचा, आंब्याच्या रत्ना जातीवरील फुलांच्या समावेशावर होणारा परिणाम” हा उद्यानविद्या महाविद्यालय, डॉ. बाळासाहेब सावंत कोकण कृषि विद्यापीठ, दापोली जिल्हा रत्नागिरी (महाराष्ट्र) येथे २०२० - २१ या वर्षी केला गेला. सदर प्रयोग यादृच्छिक गट (आर.बी.डी.) रुपरेषेमध्ये दहा उपचार, जसे टी_१ (ऑक्टोबरच्या पहिल्या पंधरवड्यात गर्डलींग), टी_२ (नोव्हेंबरच्या पहिल्या पंधरवड्यात गर्डलींग), टी_३ (ऑक्टोबरच्या आणि नोव्हेंबरच्या पहिल्या पंधरवड्यात गर्डलींग), टी_४ (ऑक्टोबरच्या पहिल्या पंधरवड्यात गर्डलींग आणि डोळ खुडणे), टी_५ (नोव्हेंबरच्या पहिल्या पंधरवड्यात गर्डलींग आणि डोळ काडणे), टी_६ (ऑक्टोबरच्या आणि नोव्हेंबरच्या पहिल्या पंधरवड्यात गर्डलींग आणि डोळ खुडणे), टी_७ (डोळ खुडणे), टी_८ (नविन फांदीची छाटणी जून्या फांदी पर्यंत), टी_९ (स्मजिंग) आणि टी_{१०} (नियंत्रण) जे तीन वेळा प्रतिकृत केले गेले.

वरील अभ्यास करताना असे आढळून आले की, उपचारपासून ते मोहोर फुटण्यासाठी लागणारे दिवस, मोहोराची तीव्रता, मोहोराची लांबी आणि रुंदी, संयुक्त फुले, फळ धारणा, फळे टिकून राहणे, उत्पन्न, उपचार ते काढणी पर्यंत लागणारे दिवस यांच्यावर गर्डलींग, डोळ खुडणे, आणि स्मजिंग (धुर करणे) याचा सकारात्मक परिणाम झाला. रासायनिक मापदंडांवर गर्डलींग, डोळ खुडणे, आणि स्मजिंग (धुर करणे) याचा परिणाम झाला नाही.

उपचार टी_१ (नोव्हेंबरच्या पहिल्या पंधरवड्यात गर्डलींग आणि डोळ खुडणे) मध्ये मोहोराची तीव्रता (६२.२७ %), संयुक्त फुले (१५.०१ %), फळ धारणा (८.५३ %), फळ टिकवणे (०.९५ %) आणि उत्पन्न (१४४.०० फळांची संख्या / झाड, ६१.५८ किलो / झाड). टी_१ (डोळ खुडणे) मुळे परिणामी लवकर मोहोर फुटला (४०.८३ दिवस) त्यामुळे लवकर काढणी झाली (१३४.८७ दिवस).

भौतिक मापदंड जसे फळाची लांबी, फळाचा व्यास, फळाचे वजन, गराचे वजन, गर ते कोई प्रमाण यांच्यावर गर्डलींग, डोळ खुडणे, आणि स्मजिंग (धुर करणे) याचा सकारात्मक परिणाम दिसून आला.

सदर प्रयोगामध्ये असा निष्कर्ष निघाला की रत्ना आंब्यामध्ये गर्डलींग आणि डोळ खुडल्याने मोहोर लवकर येतो तसेच फळाची लवकर काढणी घेऊन उत्पन्नसुद्धा चांगले दिसते.

CHAPTER I

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the oldest and most popular fruits having adorable flavour and taste of the tropical world. Mango belongs to the family Anacardiaceae and genus *Mangifera*. From *Mangifera* almost all the commercial cultivars of mango are included in single species *Mangifera indica* in India. Mango is cross-pollinated allopolyploid crop having chromosome number $2n=40$. It is the most important tropical fruits of the world. Mango is called as “King of the fruits” (Purseglove, 1972). Vavilov (1926) suggested that mango is originated from Indo-Burma region. It has been variously called *Amra*, *Atisourabha*, *Chuta*, *Sahakara*, *Rasala*, in ancient Sanskrit literature.

Mango can be grown on a various soil under different climatic conditions. It can be grown on lateritic, alluvial sandy loam, sandy soils except in black cotton soil with poor drainage. It performs well in soils with slightly acidic pH. It does not grow well in soils having pH beyond 7.5. Soils having good drainage are ideal for mango. The pH of the soil in the range of 5.0 to 7.0 is suitable (Pawar, 2016).

It is commercially cultivated in more than 111 countries. Mango production of the world is 42.00 million tonnes (Anon., 2020 a). In India, mango is established on 40 per cent of area under fruit crops. India is the major mango producer in the world, with an area of 2.3 million ha and the annual production of 20.30 million tonnes with productivity of 8.8 MT/ha (Anon., 2020 b).

India contributes about 64 per cent of the world mango production. According to the Agricultural and Processed Food production Export Development Authority (APEDA), during 2019-2020 India exported 49,658.68 million tonnes of fresh mango fruits which worth Rs. 56.11 million USD. United Arab Emirates, United Kingdom, United states, Oman, Qatar, Nepal, Kuwait, Saudi Arabia, Bangladesh and Singapore are major destination for export of mangoes (Anon., 2020 c).

In Maharashtra, mango orchards are established on 0.157 million ha with a production of 0.566 million tonnes and productivity of 3.2 MT/ha (Anon., 2019 a). The Konkan region of Maharashtra is a major mango belt which comprises of Palghar, Thane, Raigad, Ratnagiri and Sindhudurg districts. In Konkan, 1,03,960 ha area is under mango cultivation having annual production of 2.80 lakh mt. The productivity of mango in Konkan is 2.69 t/ha (Anon., 2019 b).

Among the various commercial varieties, the variety Ratna was released by DBSKKV, Dapoli (M.S.). The parentage of Ratna is Neelum and Alphonso (1981). The tree is semi dwarf in growth habit. The fruits are large ovate in shape (400-500g) with firm and fibre less deep orange colour pulp. It is regular in bearing. It is excellent for processing as well as table purpose (Salvi *et al.*, 2018). The demand for this variety is increasing day by day owing to good keeping quality and spongy tissue free fruits. It flowers and matures late as compared to Alphonso. The induction of early flowering results in early maturity of fruits. Such fruits earn greater rates in the market as compared to late maturing fruits.

Weather during initiation of flowering in the month of October and November play important role in induction of flowering at appropriate time. It is often noticed that climatic fluctuations in October-November lead to production of vegetative flush instead of flowering flush. This new flush requires another 80-100 days to mature and produce flowers and as a result, flowering is considerably delayed. The late flowering leads to delayed fruit development and harvesting. The late harvested fruits fetch low market rates. It is often noticed that many of these new shoots do not produce flowers and hence the flowering is sparse which produce poor yield (Soudagar *et al.*, 2018).

Girdling is one of the means to improve the earliness and intensity of flowering in mango (Urban *et al.*, 2009). Girdling is the special horticultural practice in which removal of the bark in circular manner of either branch or trunk of woody plants. It interrupts the basipetal movement of assimilates through phloem which results in accumulation of carbohydrates above girdle which ultimately helps for induction of early and ensured flowering. Girdling modifies phloem transport between canopy and root and manipulate the distribution of photosynthate, mineral nutrients and plant bio- regulators (Goren *et al.*, 2004). It is a special practice for stimulating fruit trees into more productive usage, usually carried out by cutting through the phloem only deep as the cambium layer and removing a strip of tissue. Girdling stops or reduces the flow of sap via the phloem to the lower parts of the tree. The accumulation of carbohydrates in the canopy provide a rich source of energy for flowering, fruit set and development.

The studies on the evidence of involvement of leaf generated floral stimulus have opened up new vistas in the direction of research on physiology of flowering in mango (Davenport, 2007). Annual shoot tip pruning in mango provides reliable synchronized flowering in selected shoots year after year (Davenport, 2006 and Soudagar *et. al.*, 2018). This is particularly useful where trees have a vegetative flush just prior to flowering. The young flushes are cutback up to matured wood; the resulting flush can be floral one. It not only causes a uniform flush of growth throughout the canopy but also it removes growth and flower inhibiting factors in stem derived from the previous season's flowering and fruiting panicles. Shoot pruning reduce the auxin synthesis at the apex of the branches (Taiz and Zeiger, 2012), directing the transport of assimilates and cytokinin's to the axillary buds of branches under flowering condition, induce the formation of axillary inflorescences (Srivastava, 2002).

Smudging is an ancient method of inducing mango to flower (Wester, 1920). It is practiced in certain parts of the Philippines to obtain early flowering of 'Carabao' and 'Pico' mango. Ethylene has been identified as the active agent responsible for flowering during smudging (Dutcher, 1972).

The changing trend from agrochemical-based production to green farming have made farmers to seek for practices that are environmentally friendly and help for less or no chemical residues in fruits. Now-a-days, fruit producers are looking for non-chemical farm practices while maintaining high fruit quality. These practices play key role in the changing climate scenario. The practices such as girdling, tip pruning (removal of new

shoots) and smudging help for inducing flowering, increases fruit setting and yield as well as physical and chemical composition of fruits.

In recent years, the climatic variation in Konkan region especially during occurrence of flowering in mango are adversely affecting the time of emergence of flowering. Instead of flowering, the vegetative shoots are produced. Paclobutrazol is recommended for induction of regular flowering of mango in konkan region. In spite of application of paclobutrazol the vegetative shoots appears due to climatic fluctuation especially delayed rains in October and November. Girdling and tip pruning may be of help in mango to induce flowering even under climatic aberrations. Hence, a study entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was conducted as a field experiment with following objectives.

1. To study the effect of special horticultural practices *viz.* girdling, tip pruning and smudging on induction of flowering in mango cv. Ratna.
2. To study the effect of special horticultural practices *viz.* girdling, tip pruning and smudging on fruit set and yield in mango cv. Ratna.

CHAPTER II

REVIEW OF LITERATURE

The research investigation entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was carried out during the year 2020-2021 from October 2020 to June 2021. In mango cv. Ratna the delayed and abnormal rain and variation in temperature results induction of vegetative flush instead of flowering which considerable delay harvesting. The late harvest of fruits fetches low market price causing significant economic loss to mango growers. The induction of early and regular flowering will help in minimizing the losses from above problems. Girdling is a special horticultural practice for stimulating fruit trees into more generative utilization, usually carried by cutting through the phloem only as deep as the cambium layer and separate the strip of tissue. Carbohydrates increased above the girdle portion which ultimately helps for induction of early and assured flowering. Wide variety of fruit species are girdled to increase fruit size, advance maturity and improve yield. Stem girdling is generally used in apples, grapes, olive, orange, grapefruits and peaches (Larue and Johnson, 1989; Goren *et al.*, 2004).

Tip pruning (removal of new shoots) is useful where the tree produce a vegetative flush instead of flowering. In tip pruning such young flushes are cut back up to mature wood, it help to induce flowering from mature shoot. Tip pruning also help to maintain tree size. Shoot pruning reduces the auxin synthesis at the apex of the branches (Taiz and Zeiger, 2012), directing the transport of assimilates and cytokinins to the

axillary buds of branches under flowering conditions, induce the formation of axillary inflorescences (Srivastava, 2002). Previously several studies have been conducted on pruning in mango tree in relation to better light penetration, fruit set and yield (Sharma and Singh, 2006).

Smudging is an ancient method of inducing mango to flower (Wester, 1920). It is practiced in certain parts of the Philippines to obtain early flowering of 'Carabao' and 'Pico' mango. Ethylene has been identified as the active agent responsible for flowering during smudging (Dutcher, 1972).

The research on girdling, tip pruning and smudging in mango is very limited and hence information relevant to all these practices in mango tree and other horticultural crops have been reviewed and presented under following sub- heads:

- 2.1 Effect of girdling, tip pruning and smudging on initiation of flowering.
- 2.2 Effect of girdling, tip pruning and smudging on sex ratio, fruit set and fruit retention.
- 2.3 Effect of girdling, tip pruning and smudging on fruit development and yield.
- 2.4 Effect of girdling, tip pruning and smudging on physical parameters and chemical composition of fruits.

2.1 Effect of girdling, tip pruning and smudging on initiation of flowering span.

2.1.1 Effect of girdling on initiation of flowering in mango and other fruit crops.

The high ratio of carbohydrates to nitrogen is major factor determining fruit bud formation and fruit bearing played a dominating role for a long time (Kraus and Kraybill, 1918).

Gaskins (1963) exhibited in trial with 4-year-old mango seedling that flowering was elevated substantially by girdling in October. However, girdling in January had no effect. Among trees in two populations, about 40 per cent flowered in response to girdling in October. Less than 20 per cent of the untreated trees produced flowers in mango cv. Open pollinated seedling of Saigon mango.

Das Chowdhury (1969) attributed the favorable effect on flower initiation to appreciably increased concentration of all carbohydrates and the high C:N ratio caused by the girdling treatment in mango.

Ishihata and Kawabata (1978) noticed that ringing on spring shoots from July to September was most effective on the induction of flower bud formation in mango cv. Carabao.

Pandey (1989) reported that ringing of branches in late summer or early winter in mango trees can induce flowering in the “off” years and increase flowering in “on” years, also gives supporting evidences to the fact that nitrogen and carbohydrate reserves play an important role in floral initiation in mango by increasing the C/N ratio of shoots.

According to Chacko (1991), girdling can be suggested as a way to promote floral induction in mango.

Schechter and Proctor (1994) stated that the positive effect of girdling was related to changes in translocation and accumulation of carbohydrates, with changes in hormones concentration gibberellins, IAA and cytokinin which lead to promote flowering and improve fruit set in apple cv. Sturdeespur Delicious.

As per Shao *et al.* (1998), girdling improved leaf N content, C/N ratio and carbohydrate which improved flowering and fruit set in Citrus tree.

Urban *et al.* (2009) opined that girdling is one of the ways to improve the earliness and intensity of flowering in mango cv. Cogshall.

Haldankar *et al.* (2014) stated that the girdling treatments influenced the flowering and days required for flowering in jamun cv. Konkan Bahadoli. A deep cut on tertiary branches contributed for flowering in maximum plants (100% and 75%). After the exposure of treatments, earliest flowering was recorded in T₂ (deep cut on tertiary branches).

Shinde *et al.* (2014) demonstrated that earliest flowering was recorded in ringing during first fortnight of May which was followed by ringing during second fortnight of May. It was further observed that delay in ringing also delayed the emergence of flowering in mango cv. Alphonso.

Ramona and Stanica (2015) reported that girdling significantly reduced the time needed for inflorescence emergence and the duration of flowering. Results showed that the flowering duration was 9 days in girdled variant (removing a

bark strip of 5 mm wide from lateral fruiting branches), while it took 14 days in control (ungirdled) in Chinese date (*Ziziphus jujube* mill.).

Ibrahim *et al.* (2016) suggested that number of flowers per branch of Washington navel orange trees was significantly affected by the girdling treatments in the two seasons. The highest number of flowers per branches (329.44 and 330.56 flowers) were produced in girdled branches against (293.00 and 288.78 flowers) those of girdled limbs in the first and second seasons, respectively.

Warang *et al.* (2019) indicated that minimum number of days (39.33 days) were required for emergence of flower panicle in T₄ (removal of new shoots on first fortnight of September) in mango cv. Alphonso.

Nachare (2020) studied effect of girdling and removal of new shoots on induction of flowering in mango cv. Ratna and noticed that girdling and removal of new shoots helped for early induction of flowering.

2.1.2 Effect of removal of new shoots and smudging on initiation of flowering span in mango and other fruit crops.

Sen and Mallik (1947) conducted experiments at the Fruit Research Station, Sabour, India with the Langra mango in order to study the effect of smudging treatment on the plant under the local conditions. It was apparent that smudging had stimulating effect on growth, but the nature of growth, reproductive or vegetative, depends on other factors and concluded that smudging could induce flowering only if the shoot is in condition to flower.

Daniel and Rao (1969) found a slight delay of bud sprouting by 3 to 4 days in the least severe pruning (7 node level) in comparison to the most severe pruning (1 node level) in cv. Anab-e-Shahi grapes.

Godara *et al.* (1977) reported that severely pruned vines took lesser number of days for bud sprouting and flowering compared to lightly pruned ones in 'Beauty Seedless' grapes.

Pruning increase photosynthetic translocation to fruits and roots which regulates flower bud formation with increase in knowledge of light interception in apple (Jackson, 1980).

Srinivas and Haribabu (1997) opined that time of pruning had significant influence on various parameters of flowering in Ber. Early pruning (first fortnight of April under Hyderabad conditions) advanced the date of flowering with lesser number of days required to come to flowering in association with earlier fruit maturity as compared to late pruned trees.

Nagao *et al.* (2000) found that December pruning of vegetative flushes affected flowering of 'Kaimana' lychee in Hawaii and concluded that tip pruning increased the number of panicles.

December pruning slightly increased the hermaphrodite flowers in mango cv. Dashehari (Mohan *et al.*, 2001).

Swaroop *et al.* (2001) evaluated tree pruned in month of July and reported that the maximum number of panicles were observed in mango cv. Dashehari.

Yeshitela *et al.* (2003) investigated that when the apical bud was removed, the inhibited bud induced and released and

started 10 developing lateral inflorescence in mango cvs. Kiett and Tommy Atkins.

According to Davenport (2006), tip pruning forces a synchronized flush from pruned stems, which results in synchronized flowering in mango cv. Keitt.

Pruning helped in reducing the tree size and highest bud emergence in Guava (Singh and Bal, 2006).

Lal and Mishra (2007) studied the effect of pruning on growth and bearing behaviour of mango cv. Chausa. Under pruning treatments, the highest flowering (58.40%) was observed in trees which received second order pruning followed by trees which received first order pruning and thinning out of central leader with (46.62% and 44.78%) flowering respectively. In unpruned trees, only 36.14% flowering was noticed.

To induce uniform flowering in mango cv. 'Alphonso', tip pruning at 2.5 cm below terminal portion resulted in a regulation of vegetative growth and resulted in regular flowering in mango cv. Alphonso (Waghmare and Joshi, 2008)

Samra *et al.* (2010) investigated that combination of PGR with pinching are promising for mango to delayed panicle emergence and full bloom in "Zebda" variety.

Singh *et al.* (2010) studied the influence of pruning intensity on flowering, fruit yield and floral malformation in three mango cultivars namely Amrapali, Mallika and Dashehari planted under high density with 4 pruning treatments viz. control (I₀), light pruning with 30 cm from apex (I₁), moderately pruning with 60 cm from apex (I₂) and severe pruning with 90 cm from apex (I₃). It was concluded that days required for panicle emergence in light pruning (I₁) is early (189 (2006) and

182 (2007) DAP) while it was delayed (194 (2006), 192 (2007) DAP) in un-pruned trees (I₀) with time lag of + about 5 to 10 days. The shoot sprouts appeared little early after pruning which may be due to immediate loss of apical dominance and early shoot production which attained the desired maturity to give rise to early panicle emergence.

Gopu *et al.* (2014) assessed the various pruning levels and reported days taken for first flowering was minimum (169 days) in pruned tree as compared to control (198 days) and showed uniform flower per panicle in mango cv. Alphonso.

Kumar *et al.* (2014) stated that number of days taken for sprouting, number of shoots emerged, number of retained shoots, shoot length, girth of shoots and fruit yield were markedly promoted by the 30 per cent pruning intensity than rest of the treatment in Ber cv. Banarsi Karaka.

Bhagawati *et al.* (2015) studied effect of pruning intensities on the performance of guava plants under mid-hill conditions of eastern Himalayas and found that days taken to first vegetative bud appeared with early bud appeared in severe pruning (3.98 days) followed by moderate (4.44 days) and light (5.01 days) pruning.

Oliviera *et al.* (2015) noticed that maximum number of inflorescences were observed when tip pruning was used in Palmer mango tree than control.

Srilatha and Reddy (2015) reported that among the different pruning levels, removal of current season's growth recorded early flowering than the trees pruned to previous season's growth in mango cv. Raspuri.

Ghavale *et al.* (2016) observed that maximum days were taken in control for emergence of inflorescence (94.67 days) where as in pruned plants. It took only 21.33 days were pruning was carried in the first week of November and on the past season wood in mango cv. Alphonso.

Thirupathi and Ghosh (2016) stated that a significant response to shoot pruning was observed with regard to flowering of mango cv. Mallika. Early flowering initiation (17th January) was observed in control followed by 15th September pruned shoots (20th January) and very late i.e. 15th July pruned shoots treatment (3rd February). Shoot pruning trees registered late flower bud initiation and peak period of flowering while early pruning increased the production of new shoots, which were the source of auxins, required for induction of flowering. The late physiological maturity of these new shoots lead to late flowering.

Oliviera *et al.* (2017) reported that the different dosages of PBZ in conjunction with tip pruning produced significant flowering in Palmer mango. The greatest number of inflorescence was observed when tip pruning was used in Palmer mango trees. Branch tip pruning provided a higher percentage of flowering and a higher number of fruits per branch of 'Ubá' mango trees by more than 30 per cent.

Mahesha and Singh (2018) obtained maximum flower per branch (29.75) as compared to the control plants (26.5 flowers per branch) with shoot pruning in Assam lemon.

Pruning with 10 cm severity at 15th September was significantly superior with respect to flowers per meter shoot in acid lime (Patil *et al.*, 2018).

Sahu *et al.* (2018) noticed the treatment combination removal of terminal shoots followed by spraying of NAA @ 50 ppm produced highest flowering (19.48 kg/tree) and was the best among all other treatment in sapota cv. Cricket Ball.

Sarkhosh *et al.* (2018) investigated that, pruned trees produced more inflorescence when the axillary bud below cutting point received over 300 h chill cum $< 20^{\circ}\text{C}$ over the first three to four weeks after tip pruning in mango cvs. Honey Gold and Calyspo. The result indicated that the combination of cool weather ($< 20^{\circ}\text{C}$) and tip pruning is a promising alternative strategy for sustainable mango production in the region, when it is applied in May, June and the first two weeks of July.

Soudagar *et al.* (2018) reported that the minimum (60 days) number of the days required for emergence of flower panicles was in T₃ (tip pruning by retaining 2 leaves) compared with control (65 days) in mango cv. Alphonso.

Samant *et al.* (2019) recorded minimum number of days in smudging (78 days) for induction of flower panicle as compared to control (80 days) in mango cv. Alphonso.

Warang *et al.* (2019) found that minimum number of days (39.33 days) were required for emergence of flower panicle in T₄ (removal of new shoots on first fortnight of September) in mango cv. Alphonso.

Nachare (2020) studied the effect of girdling and removal of new shoots on induction of flowering in mango cv. Ratna and concluded that minimum number of days (42.67 days) were required for emergence of flower panicle in T₅ (Girdling on first fortnight of the October and removal of new shoots) in mango cv. Ratna.

2.2 Effect of girdling, tip pruning and smudging on sex ratio, fruit set and fruit retention.

2.2.1 Effect of girdling on sex ratio, fruit set and fruit retention in mango and other fruit crops.

The trials with 4-year-old mango seedling indicated that fruit set was better on the flowering trees which were girdled than on those without girdling in open pollinated seedlings of mango cv. Saigon (Gaskins, 1963).

Bonded *et al.* (1979) observed that fruit retention per panicle was higher in smudged trees but heavier fruiting per tree resulted from KNO_3 application, leading to smaller fruits than smudging in Carabao mango.

Oothuyse (1990) reported that girdling at the time of panicle emergence or before increased the number of fruits retained by the mango cv. Haden. Girdling, one or two months before panicle emergence, was most effective in improving set, the number of fruits retained per tree being 192 per cent greater, on average, than that of the control trees. When trees were girdled, three or four months before panicle emergence, set was improved by an average of 125 per cent. Girdling at the time of panicle emergence increased set by on average of 66 per cent, whereas girdling, one or two months after panicle emergence, had no apparent effect on the number of fruits retained.

All the girdling treatments recorded higher fruit retention compared to control, which was about 48 per cent per branch in Jambu fruit (*Syzgyium samarangense*) (Khandaker *et al.*, 2011).

Haldankar *et al.* (2014) noticed that girdling improved number of fruits per twig and yield in jamun. T₂ (Deep cut for tertiary branches) was the best treatment which contributed for

maximum number of fruits per twig and yield (kg/plant and t/ha).

Shinde *et al.* (2014) noticed that maximum hermaphrodite flowers (14.26%) were observed in T₁ (ringing during first fortnight of May). The minimum hermaphrodite flowers (10.46%) were observed in T₁₁ (control).

Mohamed (2015) observed that the effect of girdling and paclobutrazol foliar spray at 500 ppm and 1000 ppm enhanced fruit retention per cent as compared with the control treatment in off year (2012 and 2014). Girdling treatment was the most efficient treatment in 2012 and 2014 followed by paclobutrazol at 500 ppm. Moreover, treated Manzanillo olive trees in mid-November showed high fruit retention per cent than those treated in mid- June in off year (2012 and 2014).

Nabila *et al.* (2015) noticed that percentage of perfect flowers was significantly increased due to girdling treatments. The highest percentage of perfect flowers was obtained in girdling during February (84.66 and 92.33%) during 2009 and 2010 seasons respectively on olive cv. Manzanillo. Percentage of initial fruit set was significantly increased as a result of girdling treatments. The highest percentage of initial fruit set was obtained from girdling during February (11.94 and 15.09%) during 2009 and 2010 seasons respectively.

Ramano and Stanica (2015) noticed that girdling treatment had a significant effect on tree fruit set capacity of Chinese date. All the girdling treatments determined higher fruit set values compared to the control.

Ibrahim *et al.* (2016) observed that girdling branches and limbs significantly affected the initial number of fruitlets per

branches and fruit set percentage in Washington Navel Orange. The highest numbers of the fruitlets per branches (115.89 and 132.33 in the first and second seasons, respectively) were recorded for girdled branches, followed by girdled limbs (91.11 and 109.67). Control treatment exhibited the lowest numbers of fruitlets (57.04 and 62.04 for the control) in the first and second seasons, respectively.

Ghadage *et al.* (2017) found that fruit percentage at harvest stage was significantly greater. Minimum percentage of fruit set (1.00%) was seen in 0.75 cm girdling width treatment (W₃) treatment in mango cv. Alphonso. The girdling during 15th July (T₁) produced significantly highest percentage fruit set at harvest stage (1.40%). The girdling during 15th September (T₃) treatment produced significantly lowest fruit set (1.05%) at harvest in mango cv. Alphonso.

Malshe *et al.* (2021) found that highest hermaphrodite flower per cent (9.40%) by girdling in first fortnight of September in mango cv. Alphonso.

2.2.2 Effect of removal of new shoots and smudging on sex ratio, fruit set and fruit retention in mango and other fruit crops.

Bajpai *et al.* (1973) found highest fruit set during monsoon by shoot pruning 30 cm in guava cv. Allahabad safeda.

Thorp and Sedgley (1993) studied the tipping of terminal shoots in avocado cv. Hass and concluded that number of fruit set was highest in tipped apical bud (2.1) followed by control (1.9).

Kundu *et al.* (1994) observed that effect of time and severity of pruning on growth, flowering and fruiting in ber cv.

Umran and recorded maximum fruit retention on trees when pruned to 15 buds per primary branch on 30th May under Haryana condition.

Ingle *et al.* (1999) studied effect of severity of pruning on growth, yield and quality of old acid lime trees and recorded maximum sex ratio (Staminate and hermaphrodite flowers) in September pruned trees.

Nagao *et al.* (2000) observed that maximum fruit set occurred on 36 per cent of the tip pruned branches and 4 per cent of the non-pruned flushing terminals. The vegetative flushing during winter reduced flowering, while tip pruning of vegetative flushes offer the possibilities for obtaining increased bloom and fruit set in Kaimana' Lychee in Hawaii.

Yeshitela *et al.* (2003) studied the impact of panicle and shoot pruning on inflorescence and yield related developments in some mango cultivars and recorded rapid fruit development and more fruit per panicle by pruning in mango cvs. Keitt and Tommy Atkins.

Khan and Syamal (2004) noticed highest fruit set in 12 cm shoot pruned tree whereas minimum fruit set was registered in unpruned tree in Kagzi lime.

Raut and Diware (2005) evaluated the pruning severity based on shoot diameter i.e. removal of shoots at a point measuring 1 cm (light), 2 cm (moderate) and 3 cm (severe). The shoot length and diameter were significantly higher when pruned severely or moderately, while number of shoots and fruit set on pruned branches were significantly more in moderate pruning than on severe pruning and light pruning in ber cvs. Gola, Punjab Chhuara and Kadaka.

Gill and Bal (2006) found highest fruit set and retention with decrease in the pruning severity in ber cv. Umran. The fruit set and retention increased with the delay in pruning up to 9th and 23rd May, respectively.

Sharma and Singh (2006) recorded highest sex ratio (35.9) in panicles of un-pruned trees and lowest (26.6) in flowers of severely pruned trees. Flowers that appeared in panicles at tree top had comparatively lower sex ratio (27.7) than those, which appeared at lower canopy heights in mango cv. Amrapalli.

Waghmare and Joshi (2008) studied that the effect of response of mango (*Mangifera indica* L.) to light pruning for vegetative and flowering flushes and observed that pruning significantly improved sex ratio. The lowest sex ratio was found in moderately pruned trees (I₂) (7.41:1, 6.85:1) followed by severely pruned trees, which was attributed to the development of lower temperature regime in denser canopies. The highest sex ratio was found in un-pruned trees (I₀) (8.82:1, 8.39:1).

Shaban (2009) assessed moderate pruning and spraying with GA₃ @ 100 ppm and recorded the maximum number of panicles per shoot. The longest panicle resulted from moderate pruning and GA₃ at 100 ppm. Severe pruning treatment with either GA₃ concentrations was the most effective for increasing number of fruits set per tree in Zebda mango.

Shaban and Haseeb (2009) carried out an experiment entitled effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. Pronounced and significant increase in initial fruit set was found with moderate pruning.

Samra *et al.* (2010) suggested that combination of PGR with pinching were encouraging for mango to increase total number fruit set per panicle in “Zebda” mango.

Kaith *et al.* (2011) assessed different heading back intensities in apple cv. Starking Delicious and observed that thinning recorded the highest fruit set 21.6 per cent and 28.4 per cent in year 2007 and 2008 respectively.

Chauhan *et al.* (2013) assessed the different pruning intensities and recorded that tip pruning of frost affected shoots registered maximum fruit set (180 per plant) in mango cv. Mallika.

Gopu *et al.* (2014) studied canopy management in mango (*Mangifera indica* L.) cv. Alphonso with reference to flowering, yield and quality characters under ultra-high density planting in mango. The maximum per cent fruit set was found in the treatment T₅ (50 per cent removal of past season’s growth and tipping).

Kumar *et al.* (2014) assessed seven pruning treatments by heading back 10-60 per cent portion of past season’s growth along with unpruned control in ber cv. Banarasi Karaka. The number of emerged shoots and maximum fruit set were markedly promoted by the 30 per cent pruning intensity than rest of the treatments.

Zaeneldeen (2014) carried out an experiment entitled effect of urea, gibberellic acid foliar application and pinching early panicles on productivity of "Succary Abiad" mango trees under desert conditions. Pinching of early emerged panicles at 1 cm delayed flowering under Egyptian condition. With such delays, panicle emergence and flowering occur under warmer weather

conditions which improve activity of the pollinating insects, consequently pollination and fruit set.

Srilatha and Reddy (2015) found that removal of current season's growth recorded maximum fruit set per plant than the trees pruned to previous season's growth in mango cvs. Raspuri, Dashehari and Amrapalli.

Ghavale *et al.* (2016) concluded that pruning on the current season shoots (M₁ method) in the first and third week of October resulted in highest fruit set than unpruned trees in mango cv. Alphonso.

The branch tip pruning increased the number of fruits per branch (average of 3.46 fruits in the branch), while plants not treated with tip pruning showed 1.96 fruits per branch in Uba mango. The high number of panicles per branch observed in plants of tip pruning contributed to increase the number of fruits per branch (Oliviera *et al.*, 2017).

Rodge and Pujari (2017) studied that effect of pruning on reproductive shoots and yield of mango cv. Alphonso. The highest number of fruit set was recorded by removal of current season growth in first week of October.

Mahesha and Singh (2018) found that pruning of the current season shoot had a significant influence on number of flowers per branch as well as number of fruitlets per branch after the imposition of the treatments. The pooled data indicated that the highest number (31.35) of flowers per branch and fruitlets (6.90) per branch were obtained in 15 cm shoot pruning as compared to control i.e. 26.5 flowers per branch, 5.8 fruitlets in Assam lemon.

Patil *et al.* (2018) noticed that the severity of pruning significantly influenced on fruit set per cent in acid lime. The maximum fruit set (44.51%) was found in trees pruned at 10 cm severity followed by 15 cm pruning (39.57%). Minimum fruit set per cent (36.31%) was observed in 5 cm severity in Acid Lime.

Soudagar *et al.* (2018) recorded that higher per cent number of hermaphrodite flowers was produced in T₁ (tip pruning with two leaves) (19.98%) in mango cv. Alphonso. The highest percentage of fruit set was also observed in T₁ (tip pruning with two leaves) (5.87%). The maximum fruit retention at harvest stage was observed in T₂ (tip pruning by retaining 6 leaves) (0.95%).

Samant *et al.* (2019) found highest hermaphrodite flower (15.34%), fruit set (10.00) and fruit retention (0.29%) in T₆ (smudging) over control in mango cv. Alphonso.

Warang *et al.* (2019) observed that maximum fruit set (8.95) and maximum fruit retention (0.83) were found in T₆ (Girdling on first fortnight of the September and first fortnight of October and removal of new shoots) in mango cv. Alphonso.

Nachare (2020) recorded the highest per cent number of hermaphrodite flowers (13.12%) were recorded in T₅ (Girdling on first fortnight of the October and removal of new shoots) as compared to control (7.54%) in mango cv. Ratna.

2.3 Effect of girdling, tip pruning and smudging on fruit development and yield.

2.3.1 Effect of girdling on fruit development and yield of mango and other fruit crops.

Girdling, girdling + cytokinin and scoring advanced fruit ripening 2 to 4 days than control in peach trees (Powell and Howell, 1981).

Dann *et al.* (1984) observed stimulated fruit growth and development by girdling and found that fruit on girdled limbs ripened about a week earlier than on control limbs in peach tree (*Prunus persica* L.) Batsch.

Day and Dejong (1990) concluded that in early season Mayfire nectarine trees, girdling advanced fruit maturity when done on March 31st and percentage of fruit picked in 1st harvest were also greater. Total yield per tree was unaffected by girdling but the percentage of fruit picked in first harvest was significantly greater in all treatments as compared to control.

De Villiers *et al.* (1990) noticed the effect of girdling on fruit growth and internal quality of Culemborg peach and reported that fruits on girdled branches matured 5 days earlier than control.

Agenbag *et al.* (1992) noticed the influence of girdling on fruit quality of sunlite nectarine and they found that all girdling treatments showed earlier (about 3 days) ripening of fruits.

The yield was enhanced by all ringing treatments as compared to control when full bearing nectarine cv. May Gold was ringed 56, 59 or 63 days after full bloom in consecutive 2 years. (Agenbag and Toit, 1992).

Allan *et al.* (1993) noticed that pre and post stone hardening girdling treatment resulted earlier and shorter period i.e. 10 days as compared to control (24 days) in peach cv. Florida Prince.

Powell (1996) found increase in yield (1/4 to 1/2 bushel per tree) by girdling in peach trees.

Agusti *et al.* (1998) recorded that ringing advanced fruit ripening and percentage of fruits harvested on first picking was significant increased as compared to control in peaches and nectarines.

Beri (2003) stated that girdling and thinning done at 21 and 28 days after full bloom was found to advance fruit maturity by 10 to 14 days in peach. Girdling and thinning treatments done at full bloom stage gave the maximum yield in peach cv. Shan-A-Punjab.

Girdling at the beginning of pit-hardening stage greatly enhanced “MitGhamer” peach fruit quality and advanced fruit maturity (6-7 days) resulting in an increase in growers returns, since their fruits can arrive earlier to more demanding markets (Eliwa, 2003).

Chanana and Gill, (2006) assessed that thinning, girdling and their combination performed either at full bloom or 15 days after full bloom (DAFB) early fruit maturity by 4 to 14 days in Florida Prince peach.

In peach cvs. Florida Prince and Shan-i-Punjab, fruit maturity was advanced by 8 days in both the varieties when limb girdling was done 14 days after full bloom in Florida Prince and 28 days after full bloom in Shan-i-Punjab. Trunk girdling

advanced the maturity by 7 days in both the varieties (Kumar, 2007).

Haldankar *et al.* (2014) recorded that T₂ (Deep cut on tertiary branches) was the best treatment which contributed for maximum number of fruits per twig and yield (kg/plant and t/ha) in Jamun cv. Bahadoli.

Shinde *et al.* (2014) reported minimum days required for flowering to harvesting in T₁ (ringing during first fortnight of May) (101 days) as compared to control (114.11 days). The maximum number of fruits per plant were recorded in T₁ (ringing during first fortnight of May) (154.60) as compared to control (47.13) and in mango cv. Alphonso.

Mohamed (2015) noticed that girdling treatment had the highest production in Manzanillo olive trees as compared with control and paclobutrazol treatments in 'on' years (2011 and 2013) and 'off' years (2012 and 2014). Generally, trees treated in mid- June produced higher tree yield than those treated in mid-November in 'on' year (2013). Girdling treatment done in mid-November improve tree yield.

Ibrahim *et al.* (2016) reported that girdled branches increased number of harvested fruits/branch by (264.45 and 372.25) in relation to control in the 1st and 2nd seasons, respectively in Washington Navel Orange.

Ghadge *et al.* (2017) observed maximum yield (kg/plant) with 1.50cm of girdling with (97.42 kg/plant). The lowest yield was noted in 0.75cm of girdling width (81.75 kg/plant). Girdling on 15th July (T₁) produced significantly maximum yield (94.20 kg/plant). The minimum yield (kg/plant) was obtained in T₃ (girdling in 15th September) (81.57 kg/plant) which was at par

with T₂ (girdling in 15th August) treatment in mango cv. Alphonso.

Warang *et al.* (2019) found maximum number of fruits per tree in T₄ (girdling on first fortnight of the September and removal of new shoots) (148.33) with highest yield (30.64 kg/tree) as compared to control in mango cv. Alphonso.

Nachare (2020) found that treatment T₅- girdling on first fortnight of the October and tip pruning (removal of new shoots) had highest number of fruit per tree (143.33) and also higher yield (58.67 kg/tree) as compared to control.

Malshe *et al.* (2021) recorded the highest number of fruit (419.25) per tree and yield (32.68 kg tree⁻¹) by girdling in first fortnight of September in mango cv. Alphonso.

2.3.2 Effect of removal of new shoots and smudging on fruit development and yield of mango and other fruit crops.

Shinde *et al.* (2002) noticed that centre opening and thinning of branches resulted in the maximum fruit yield (43.3 kg/tree) followed by heading back of branches on alternate limbs (43.2 kg/tree) and heading back of branches on entire tree (39.9 kg/tree) over the control (13.5 kg/tree) in mango cv. Alphonso.

Sharma and Chauhan (2004) registered the highest fruit yield in lightly pruned trees where 25 per cent of current season's growth was removed followed by the moderate and severely pruned trees where 50 and 75 per cent of the current season's growth was removed, respectively in peach.

Dardeniz *et al.* (2008) noticed that shoot topping at 3 nodes beyond the last cluster on main shoot gave the highest yield (2.18 kg/ vine) in grapes cv. Karasakiz.

Bamini (2009) recorded that highest total number of fruits harvested per tree (122.50) in mango cv. Neelum during off season was registered in trees treated with light pruning and soil application of paclobutrazol @ 2.3g a.i. per tree. It was concluded that the treatment light pruning with addition of paclobutrazol registered the highest yield. In all the treatment the fruit yield was more in off season than main season.

Samira *et al.* (2011) concluded that heading back up to 1/3 branch gave the highest average yield (33.62 kg/tree) followed by tipping (31.47 kg/tree) than that of control tree (19.41 kg/tree) in plum cv. Sun Gold plum.

Kumar *et al.* (2014) assessed that days taken for sprouting, number of shoots emerged, number of retained shoots, shoot length, girth of shoots and fruit yield were markedly promoted by 30 per cent pruning intensity than rest of the treatments in Ber cv. Banarsi Karaka.

Abd El-Wadoud (2015) studied pinching intensities in grapes cv. Melissa and observed that the highest yield was obtained from pinching and maintaining laterals along with defoliation treatment (15.91 kg/vine). The pinching treatments increased the number of bunches per vine.

Bhagawati *et al.* (2015) reported that the fruit yield was highest in case of severe pruning (11.66 kg/ tree; 18.16 t/ha) followed by light pruning (9.60 kg/tree; 15.31 t/ha) and moderate (8.70 kg/tree; 13.98 t/ha) in guava. The yields were superior over that of no pruning (5.98 kg /tree; 9.01 t/ha).

Rani *et al.* (2018) observed that early half shoot pruning of tree after spring crop harvesting in October-November and paclobutrazol application @ 2.5 ml/tree in lemon gives high yield

per tree and advanced fruit harvest. The spring crop was regulated by early pruning and paclobutrazol application. The harvesting period was early i.e. May-June under Tarai condition of Uttarakhand by proper manipulation of early half shoot pruning and application of paclobutrazol.

Sahu *et al.* (2018) found that the treatment combination tip clipping of terminal shoots followed by spraying of NAA @ 50 ppm produced highest fruit yield (19.48 kg/tree) and was the best among all other treatments in sapota.

Warang *et al.* (2019) concluded that maximum number of fruits per tree was recorded in T₄ (girdling on first fortnight of the September and removal of new shoots) (148.33) with highest yield (30.64 kg/tree) as compared to control in mango cv. Alphonso.

Nachare (2020) found that girdling on first fortnight of the October and tip pruning (removal of new shoots) had highest number of fruit per tree (143.33) and also higher yield (58.67 kg/tree) as compared to control in mango cv. Ratna.

2.4 Effect of girdling, tip pruning and smudging on physical parameters and chemical composition of fruits.

2.4.1 Effect of girdling on physical parameters and chemical composition of mango and other fruit crops.

2.4.1.1 Effect of girdling on physical parameters of mango and other fruit crops.

Larue (1988) found that girdling in early season peaches and nectarines before pit hardening increased fruit size at harvest.

In Mayfire nectarines, girdling prior to stage II increased fruit weight by 22.5 per cent (Day and Dejong, 1990).

El-Sherbini (1992) observed that fruit diameter and size significantly increased by girdling at stage ii of peach cv. Riogrande.

Allan *et al.* (1993) noticed that girdling resulted in greater numbers of fruit of larger, desirable and marketable size (>90 g) than the control in peach cv. Florida Prince (Low chill cultivar).

Kubota *et al.* (1993) observed increase in fruit weight in peach cvs. Sanyo-Suimitsu and Shimizu-hakuta when girdling was performed on lateral bearing branches at stage 1 and 2 of fruit development.

Powell (1996) found that girdling of peach trees 3 to 4 weeks after full bloom increased fruit size by 1/8 to 1/4 inch diameter.

Deng *et al.* (1997) showed that in Chunlei peach, best time for girdling was 15 days after full bloom and it significantly increased average fruit weight by 44.98 per cent.

Agusti *et al.* (1998) observed significant increase in fruit weight by 10-15 per cent when girdling or ringing the branches of peach and nectarine cultivars was performed at pit hardening stage. In peach and nectarine fruits, ringing at pit hardening improved fruit colour.

Wilton (2000) recorded increased fruit size due to girdling and increase in fruit colour development due to girdling in apple cv. Pacific Rose.

Valentini and Arroyo (2002) registered a positive effect on fruit size by girdling in "Springcrest" peach.

William and Ayars (2005) noticed that trunk girdling and GA₃ application at berry set increased berry size of seedless grape cultivars.

Kumar (2007) observed that all girdling treatments significantly increased the fruit size in peach cvs. Florida Prince and Shan-A-Punjab. The maximum firmness recorded when limb and trunk girdling was done 14 days after full bloom in Florida Prince and 28 days after full bloom in Shan-A-Punjab.

Khalkho *et al.* (2015) studied effect of girdling and defoliation in litchi and concluded that girdling markedly improved fruit weight, fruit diameter, seed-pulp ratio and juice percentage.

Nabila *et al.* (2015) noticed that highest fruit weight resulted from girdling during April. Meanwhile, the lowest average fruit weight was produced from control in olive cv. Manzanillo.

Ramona and Stanica (2015) observed that the fruit weight on girdled branches was slightly higher than on control. Girdling was effective technique for improving fruit weight in Chinese date. It substantially improved some fruit characteristics (size and weight) beside fruit set percentage and ripening period. Girdling determined a fruit diameter increase by 3 to 5 mm, earlier harvest by 3 up to 10 days in Chinese date.

Ghadage *et al.* (2017) found that significantly maximum fruit weight was obtained with 1.50 cm of girdling width (301.66g). The minimum fruit weight was noted in 0.75 cm of girdling width (269.53 g) in mango cv. Alphonso.

Warang *et al.* (2019) stated that physical parameters of mango cv. Alphonso at harvest stage were non-significant which

indicated that girdling did not influence the physical parameters of the fruit.

Nachare (2020) indicated that the average weight of fruit at harvest stage was maximum in T₃ (Girdling on first fortnight of the September and October) (462.87g) as compared to control T₈ (373.33g).

2.4.1.2 Effect of girdling on chemical composition of mango and other fruit crops.

Weaver (1952) conducted an experiment to find suitable time of girdling in increasing the total soluble solids and reported that early girdling increased the percentage of total soluble solids than late or no girdling in grape cv. Red Malaga.

Bhujbal and Wavhal (1972) studied the effect of girdling on one year old grape vines and described that cane girdling resulted in higher total soluble solids in 'Gulabi' cultivar of grape. Cane girdling caused lower acidity in fruits of Gulabi cultivar of grape.

William *et al.* (1977) revealed that cane girdling treatments in grape cv. 'Red Malaga' were successful in reducing acidity in berries.

Girdling was also successful in reducing the acidity in Thompson seedless (Dabas *et al.*, 1980).

Reddy and Prakash (1989) reported that double girdling (4.8 mm + knife line) maximized accumulation of total soluble solids in grape cv. Gulabi.

De villers *et al.* (1990) experimented the effect of 6 mm branch girdling on 'Culemborg' peach and reported that total soluble solids (11.29%) were higher than control (10.03%).

Arakawa *et al.* (1997) studied the effect of girdling on fruits of apple cultivars and reported a significant increase in total soluble solids.

According to Goa (1997) in girdled extra early variety 'Chunlei' of peach total soluble solids content increased by 3.4-3.9 per cent.

Agusti *et al.* (1998) studied the effect of ringing on fruit quality and found that ringing significantly increased per cent total soluble solids content in some of the peaches and nectarine cultivars.

Ilha *et al.* (1999) reported that trunk girdling in Japanese plums significantly decreased both fruit firmness and titrable acidity.

Girdling done at 21 days after full bloom maximized TSS/acid ratio in peach cv. Shan-A-Punjab (Beri, 2003).

Eliwa (2003) concluded that fruit thinning and/or girdling treatments significantly affected fruit flesh thickness, TSS (°B) and acidity (%) in peach cv. MitGhamer.

Girdling plus thinning 15 days after full bloom decreased acidity by 19.15 per cent as compared to control in Florida Prince peach (Chanana and Gill, 2006).

Mostafa and Saleh (2006) found the highest values of TSS/acid ratio with girdling plus potassium nitrate treatments followed by girdling treatment alone in Balady mandarin.

Hossain *et al.* (2007) noted that effect of ringing on trees can bring about an increase in the size and sugar content of fruits and cause them to mature a few days to a week earlier in peach trees.

Shinde *et al.* (2014) noticed that the different girdling times had non-significant effect on chemical composition of fruits of mango cv. Alphonso.

Khalkho *et al.* (2015) concluded effect of girdling and defoliation in litchi and concluded that girdling remarkably improved TSS of litchi fruits.

Ghadage *et al.* (2016) noted that the different girdling times had a non-significant effect on acidity, ascorbic acid, reducing sugars and total sugars of fruits of mango cv. Alphonso.

Soudagar *et al.* (2018) concluded that the variation observed for fruit length due to tip pruning was found to be non-significant at marble, egg and harvest stage. The fruit weight did not vary due to tip pruning treatments. However, the average weight was found to be higher in fruits obtained from pruned trees in comparison with unpruned trees.

Warang *et al.* (2019) reported that the chemical composition of mango cv. Alphonso at harvest stage were non-significant which indicated that girdling did not influence the chemical compositions of the fruit.

Nachare (2020) observed that chemical composition of mango cv. Ratna at harvest stage were non-significant which showed that girdling did not influence the chemical compositions of the fruit.

2.4.2 Effect of removal of new shoots and smudging on physical parameters and chemical composition of mango and other fruit crop.

2.4.2.1 Effect of Removal of new shoots and smudging on physical parameters of mango and other fruit crop.

Sundararajan and Muthuswamy (1996) studied pruning in guava cvs. Nagpur seedless and smooth green by removing 10 to 15 cm terminal portion of shoot growth and resulted in increase in fruit weight.

Bound and Summers (2001) observed that severely pruned trees of Apple 'Fuji' produced heavier and large sized fruits with a higher percentage of fruit in 80 mm diameter of large category.

Bruno and Evelyn (2001) showed that shoot tipping in cherimoya at 10 buds and its combination with bark girdling resulted in an increase of 25 per cent in fruit weight.

Singh (2007) concluded that mean fruit weight was significantly influenced by pruning intensity and was highest in the lightly pruned trees (194 g and 186 g in 2006 and 2007, respectively). However, average fruit weight decreased in the 'on' year due to increase in the number of fruits per tree. Number of fruits per tree were highest in the moderately pruned trees in mango cvs. Amrapalli, Mallika and Dashehari.

Bhanupratap *et al.* (2009) investigated the effect of pruning on physico-chemical properties of mango cv. Amrapali under high density orchard and found that the pulp to stone ratio was maximum in severely pruned trees during first and second year than that of in control.

Torres *et al.* (2009) studied the pre-bloom shoot tipping of mango on yield, fruit size and quality in cultivars Kensington,

Kent and Keitt. It was found that mean fruit size on Kensington was not affected. Kent showed positive correlation with pruning while in Keitt pruning reduced mean fruit size from 547 to 389 g.

Singh *et al.* (2010) observed the effect of pruning on fruit quality of mango cultivars (*Mangifera indica* L.) under high density planting. It was reported that in moderate pruning had the highest pulp: stone ratio in mango cv. Amrapalli.

Mohamed *et al.* (2011) registered that the highest magnitude of weight, size, length, diameter, shape and flesh thickness were recorded by shortening 1/3 branches level followed by shortening 1/2 branches level, tipping than control trees in both seasons in Plum.

Asrey *et al.* (2013) reported that pruning affects fruit yield and post-harvest quality in mango (*Mangifera indica* L.) cv. Amrapali. The average weight was found higher in fruits obtained from pruned trees in comparison with un-pruned trees. On an average 15 per cent higher weight was recorded in fruits obtained from pruned trees compared with control.

Chauhan *et al.* (2013) assessed the different pruning intensities and noticed that tip pruning of frost affected shoots gave maximum fruit weight (486 g) in mango cv. Mallika.

Gopu *et al.* (2014) registered highest pulp to stone ratio in heavy pruned trees followed by T₂ (light pruning) as compared to control in mango cv. Alphonso.

Abd El-Wadoud (2015) concluded that pinching and maintaining laterals along with defoliation in grapes cv. Melissa produced highest average bunch weight (696.83 g and 685.75 g), highest average bunch length (25.94 and 25.40 cm) and highest

average bunch width (17.36 and 16.65 cm) in year 2013 and 2014 respectively.

Adhikari and Kandel (2015) observed that pruning in mid-May at 30 cm tip pruning from terminal portion gave large fruit size of better quality in rainy and winter season in guava.

Ashraf *et al.* (2015) assessed the effect of paclobutrazol and summer pruning on yield and fruit quality of apple cv. 'Red Delicious'. Results indicated that pruning significantly improved fruit size (53.15 cm) and weight (188.19 g).

Bhagawati *et al.* (2015) conducted an experiment on effect of pruning intensities on the performance of guava under mid-hill conditions of eastern Himalayas and reported that pruning was found to had significant impact on increase in the fruit diameter compared to no pruning. The result indicated that the fruit diameter at the time of harvest was maximum with severe pruning (7.15 cm) which was significantly more than that of moderate pruning (6.45 cm) and light pruning (6.15 cm).

Gupta and Gill (2015) indicated that the pulp percentage and pulp to stone ratio were maximum in the fruits of the trees pruned at 8th bud level in ber cv. Umran.

Soudagar *et al.* (2018) observed that effect of tip pruning on mango cv. Alphonso and concluded that the variation observed for fruit length due to tip pruning was found to be non-significant at marble, egg and harvest stage. The fruit weight did not vary due to tip pruning treatments. However the average weight was found to be higher in fruits obtained from pruned trees in comparison with unpruned trees.

2.4.2.2 Effect of Removal of new shoots and smudging on chemical composition of mango and other fruit crop.

Chadha and Kumar (1970) reported that the total soluble solids and reducing sugars increased with the severity of pruning in grapes cv. Perellete.

Sonali *et al.* (2001) concluded that 5 levels of pruning in litchi trees increased total sugars and TSS content as compared to control.

Bamini (2009) noticed that the severe pruning treatments recorded higher fruit quality in terms of TSS, total sugars, reducing and non-reducing sugars ascorbic acid and carotenoid content in mango tree cv. Neelum. It was concluded that the treatment with severe pruning with addition of paclobutrazol had registered the best fruit quality.

Samira *et al.* (2011) observed that heading back of branches up to 1/3 in plum cv. Sun Gold gave highest TSS.

Asrey *et al.* (2013) concluded that TSS of mature green un-pruned trees was maximum (11.9 °B) while that of pruned trees was (10.3 °B). In ripe stage of pruned trees the TSS observed was maximum in un-pruned trees (25.9 °B) while that of pruned trees it was (22.8 °B). The titratable acidity of mature green un-pruned tree was minimum (0.56%) whereas that of pruned tress was 0.70 per cent. At ripe stage the titratable acidity observed was minimum in un-pruned trees 0.11 per cent while in that of pruned trees it was 0.17 per cent in mango cv. Amrapali.

Gopu *et al.* (2014) assessed the various pruning levels in mango cv. Alphonso. The highest total soluble solids, total sugars and non-reducing sugars of the fruit were observed in T₆

(total removal of past season's growth) whereas highest reducing sugars was noticed in T₄ (heavy pruning).

Abd El-Wadoud (2015) recorded the highest TSS in pinching and maintaining laterals along with defoliation treatment in grapes cv. Melissa.

Adhikari and Kandel (2015) concluded that 20 cm tip removal in early May enhanced yield with quality improvement of fruits in guava.

Ashraf *et al.* (2015) noticed that acidity (0.23%) was reduced in comparison to control after pruning in apple "Red delicious".

Gupta and Gill (2015) found that TSS content was maximum in the fruits pruned at 8th bud level followed by 10th and 12th bud levels and minimum under control in apple cv. 'Red delicious'.

Srilatha and Reddy (2015) observed that pruning of current season's growth and paclobutrazol application were vital for induction of early flowering and advancing fruit harvest in mango. Such beneficial effects of treatments mediated through increase in phenolic and flavonoids contents in mango cv. Raspuri.

Mustafa *et al.* (2016) revealed that tipping of shoots at pre-blooming stage reduced the total acidity of berries in grapes cv. Kamali.

Total soluble solids (26.1 Brix) and vitamin C pruned (36.6 mg 100 g) were high in the 15th June shoot pruned trees while lowest TSS (22.90 Brix) and ascorbic acid content (24.7 mg 100g) were recorded from unpruned trees mango cv. Mallika. Minimum

acidity content was recorded on 15th August shoot pruned trees (0.32%) and highest (0.53%) on the 15th September shoot pruned trees (T₄) (Thirupathi and Ghosh, 2016).

Soudagar *et al.* (2018) reported that tip pruning does not have a markedly effect on chemical composition of mango fruits at harvest and ripe stage cv. Alphonso.

Samant *et al.* (2019) evaluated that chemical composition at harvest stage in cv. Alphonso were non-significant which showed that smudging did not influence the chemical compositions of the fruit.

Warang *et al.* (2019) noticed that the chemical composition of mango cv. Alphonso at harvest and ripe stage were non-significant which indicated that removal of new shoots did not influence the quality parameters of the fruit.

Nachare (2020) found that the chemical composition of mango cv. Ratna at harvest and ripe stage were non-significant which indicated that removal of new shoots did not influence the quality parameters of the fruit.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was undertaken at College of Horticulture, Dapoli (M.S.) during 2020-2021.

3.1 Experimental site

The experiment was conducted in the mango orchard of cv. Ratna Nursery No.14, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) India, pin- 415 712. The soil of Experimental plot was red lateritic with uniform depth and good drainage conditions.

3.2 Place and Weather conditions

Dapoli represents more and less tropical climate having average humidity 78% throughout the year. The average minimum and maximum temperature are 18.4°C and 32.7°C, respectively with an average precipitation of 4,129 mm distributed mainly during four months from June to September. The Konkan region lies on west coast of Maharashtra at 17°45' N latitude and 73°12' E longitude. It has an altitude of 240 m from the MSL. The soil is lateritic, sandy clay loam and acidic in reaction having pH ranging from 5.6 to 6.5. The detailed information about weather parameters during experimentation is given in Annexure-II.

3.3 Experimental details

The experimental details are as given under

Experiment design	: Randomized block design (RBD)
No. of replications	: Three
No. of treatments	: Ten
No. of trees/ treatment/replication	: Two
Total no. of trees	: Sixty
Age of tree	: 30 years
Spacing	: 5 X 5 m

Treatment details

- T₁** : Girdling on first fortnight of October
- T₂** : Girdling on first fortnight of November
- T₃** : Girdling on first fortnight of October and first fortnight of November
- T₄** : Girdling on first fortnight of October and tip pruning (removal of new shoots)
- T₅** : Girdling on first fortnight of November and tip pruning (removal of new shoots)
- T₆** : Girdling on first fortnight of October and first fortnight of November and tip pruning (removal of new shoots)
- T₇** : Tip pruning (removal of new shoots) in November
- T₈** : Removal of new shoots below old shoot
- T₉** : Smudging
- T₁₀** : Control

3.4 Package of Practices followed:

For all experimental plants the manures and fertilizers were applied in trenches of 30 cm width and at 15 cm depth. The trench was dug at half of the canopy diameter of the tree away from the trunk. The application was made in the month of July. A recommended dose of 1.5 kg N, 0.5 kg P₂O₅, 1.0 kg K₂O and 50 kg FYM was applied per plant. The selected plants were applied with Paclobutrazol @ 3 ml/meter of canopy diameter during the month of July.

The girdling was done in the month of October and November. At that time, the circular portion of bark is cut with the help of girdling knife and the cut was deep enough sap comes from this portion when girdling was done.

The new shoots were allowed to grow fully till their growth ceased. At this stage, the colour of these new shoots was light green. Removal of new and old shoots was performed on these shoots according to treatments. Total 200 shoots were tip pruned per experimental plant.

The smudging was done in month of December. During smudging, the colour of newly emerged shoots was light green. Smudging was done early in the morning. In the previous day the material like rice bran, dry residues of plant was collected at the base of plant canopy. Then next day early in the morning smudging was done for about 2 hours. The entire process of smudging was performed four times at four days interval.

3.5 Observations recorded

3.5.1 Observations of panicle

3.5.1.1 Number of days required for panicle emergence

Days taken for emergence of flowering on trees from date of treatment exposure were counted and recorded.

3.5.1.2 Flowering intensity (%)

Flowering intensity was measured by calculating per cent flowered shoots from total shoots of the trees.

For recording of following observations four panicles from all sides were randomly selected on each experimental plant.

3.5.1.3 Length of panicle (cm)

The length of panicle was measured with the help of scale. The average length of selected panicles was calculated and expressed in centimeters (cm).

3.5.1.4 Width of panicle (cm)

The width of panicle was measured with the help of scale. The average width of selected panicles was calculated and expressed in centimeters (cm).

3.5.1.5 Number of rachis/panicle

The number of rachis on all randomly selected panicle were measured and the average number of rachis per panicle were calculated.

3.5.1.6 Percentage of hermaphrodite flowers per panicle (%)

The percentage of hermaphrodite flowers was calculated by using the given formula:

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

3.5.1.7 Fruit set per panicle (%)

Fruit set at pea stage was recorded on randomly selected panicles and per panicle fruit set was calculated and expressed in per cent.

3.5.1.8 Fruit retention per panicle (%)

Fruit retention at harvesting stage was recorded on same randomly selected panicles. The per panicle fruit retention at harvesting stage was recorded and expressed in per cent.

3.5.2 Observations of fruit

3.5.2.1 Physical characteristics of mango fruits

For this study, five fruits were randomly selected per treatment. The observations were recorded on various physical parameters at harvest stage.

Following physical parameters were recorded

3.5.2.1.1 Length of fruit (cm)

The length of fruit from stalk end to apex was measured with the help of Vernier caliper and expressed in centimeters (cm).

3.5.2.1.2 Diameter of fruit (cm)

The diameter of fruit was measured with help of Vernier caliper and expressed in centimeters (cm).

3.5.2.1.3 Fresh fruit weight (g)

The weight of fruit was recorded by monopan electronic balance and expressed in grams (g).

3.5.2.1.4 Pulp weight (g)

The pulp weight of fruit was recorded separately by monopan electronic balance and expressed in grams (g).

3.5.2.1.5 Pulp to stone ratio

Mango fruit and stone of fruit were separated and their weight was recorded in grams (g) and ratio of pulp weight to stone weight was calculated.

3.5.2.2 Chemical composition of fruits

Randomly selected fruits from each treatment per replication was used for estimating the following chemical constituents of the fruit at harvest stage and ripe stage.

3.5.2.2.1 Total soluble solids (°B)

Total soluble solids were estimated with the help of Hand Refractometer (Erma Japan, 0 to 32° B) and value was corrected at 20°C with help of temperature correction chart (A.O.A.C., 1975).

3.5.2.2.2. Reducing sugars (%)

The reducing sugar were estimated by using Lane and Eynon (1923) method with modification suggested by Ranganna (1977). A known weight (5g) of sample was blended with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to delead the solution. This lead-free extract was used to estimate reducing sugars by titrating against standard Fehling's mixture (Fehling's A and B) using methylene blue as an indicator to a brick red point.

3.5.2.2.3 Total sugar (%)

The total sugar was estimated by the same procedure of reducing sugar after acid hydrolysis of an aliquot of delead sample with 35 per cent hydrochloride acid, followed by neutralization with sodium hydroxide (40%). This filter was used for titration against standard Fehling's mixture (Fehling's A and B)

using methylene blue as an indicator to brick red end point (Ranganna, 1977).

3.5.2.2.4 Titratable acidity (%)

A known quantity of liquid sample pulp was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. In case of solid sample, a known sample was blended in mortar and pestle with 20-25 ml of distilled water. It was then transferred to 100 ml volumetric flask, made up volume and filtered. A known volume of aliquot (10ml) was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The results were expressed as per cent anhydrous citric acid (A.O.A.C., 1975).

3.5.2.2.5 Ascorbic acid (mg/100g of fruit pulp)

Ascorbic acid content of sample was determined by 2,6-dichlorophenol indophenols titration method described by Rao and Deshpande (2006). 5 ml of the ascorbic acid working standard (500 µg/5ml) and 10 ml of 4 % oxalic acid were pipette out into 100 ml conical flask. The contents in the flask were titrated against the dye solution (V1) until the appearance of pale pink colour that persisted for few minutes. 5 ml of the rest sample was similarly titrated against the dye solution (V2). Ascorbic acid content was expressed in mg/100g.

3.5.2.2.6 pH

The pH of the mango pulp is measured with the help of pH meter at room temperature and the values are recorded.

3.5.3 Yield parameters

3.5.3.1 Yield (kg/tree)

Yield of mango fruit per tree in kg was recorded by weighing number of fruits harvested.

3.5.3.2 Yield (No. of fruits/tree)

Yield of each tree was recorded by counting total number of fruits per tree.

3.5.3.3 Number of days required harvesting after flowering

The number of days required for harvest from date of flowering was recorded.

3.5.4 Statistical analysis

The data obtained was analyzed statistically as per the method suggested by Panse and Sukhatme (1995). The standard error of mean (S.E) was worked out and the critical difference (C.D) at 5 per cent was calculated whenever the results were found significant.

3.5.5 Economics

Net return were calculated by given formula:

$$\text{Net return} = \text{Gross income} - \text{Cost of cultivation}$$

Benefit cost ratio was calculated by given formula:

$$\text{Benefit Cost Ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

CHAPTER IV

RESULT AND DISCUSSION

The research project entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was carried out during the year 2020-2021 at college of Horticulture, Dapoli (M.S.). The results obtained during the present study were statistically analyzed and are presented under appropriate heads as well as discussed with the help of relevant literature available on the topic of mango and other fruit crops.

4.1 Effect of girdling, tip pruning and smudging on days required for induction of flowering in mango cv. Ratna from exposure of the treatment.

The data on effect of girdling, tip pruning and smudging on days required for induction of flowering in mango cv. Ratna from exposure of the treatment are presented in Table 1 and illustrated with figure 1.

The perusal of data presented in Table 1 revealed that the minimum days (40.83 days) required for induction of flowering were recorded by treatment removal of new shoots (T₇) which was at par with T₈ (removal of new shoots below old shoot) (42.33 days) and T₅ (girdling on first fortnight of November and removal of new shoots) (49.83 days) and significantly superior over all other treatments under the study. Treatment T₄ (girdling on first fortnight of October and removal of new shoots) (64.83 days) whereas treatment T₉ (smudging) (65.50 days) were at par with each other. In control T₁₀, it took 131.33 days for induction of flowering followed by T₃ (girdling on first fortnight of October and November) (94.17 days) and T₁ girdling on first fortnight of October (91.33 days).

Table 1. Effect of girdling, tip pruning and smudging on number of days required for induction of flowering from treatment exposure in mango cv. Ratna.

Treatments	Days required for induction of flowering
T₁ (Girdling on first fortnight of October)	91.33
T₂ (Girdling on first fortnight of November)	76.33
T₃ (Girdling on first fortnight of October and November.)	94.17
T₄ (Girdling on first fortnight of October and removal of new shoots)	64.83
T₅ (Girdling on first fortnight of November and removal of new shoots)	44.67
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	77.33
T₇ (Removal of new shoots)	40.83
T₈ (Removal of new shoots below old shoots)	42.33
T₉ (Smudging)	65.50
T₁₀ (Control)	131.33
Range	40.83-131.33
Mean	73.87
SE_m±	2.23
CD @ 5%	6.63

The pattern of variation in different treatments:

$$\underline{T_7} < \underline{T_8} < \underline{T_5} < \underline{T_4} < \underline{T_9} < \underline{T_2} < \underline{T_6} < \underline{T_1} < \underline{T_3} < \underline{T_{10}}$$

Thus, it was observed that girdling, removal of new shoots and smudging were beneficial for induction of early flowering in mango cv. Ratna as compared to control. The earliest induction of flowering was found in T₇ (removal of new shoots). Shoot pruning reduces the auxin synthesis at the apex of the branches, directing the transport of assimilates and cytokinin's to the axillary buds of branches, creating favourable condition for flowering (Taiz and Zeiger, 2012). Gopu *et al.* (2014) assessed various pruning levels and reported that minimum days (169 days) were required in pruned tree as compared to control (198 days) and showed uniform flowering per panicle in mango cv. Alphonso. Srilatha and Reddy (2015) proved that among the different pruning levels, removal of current season's growth recorded earliest flowering than the trees pruned to previous season's growth in mango cv. Raspuri. Soudagar *et al.* (2018) studied the effect of tip pruning in mango cv. Alphonso and concluded that the minimum number of days (59.60 days) were required for emergence of panicles in T₃ (tip pruning by keeping 2 leaves).

Girdling improved leaf N content, C/N ratio and carbohydrate which improve flowering and fruit set in fruit crops (Shao *et al.*, 1998). According to Kraus and Kraybill (1918) high ratio of carbohydrates to nitrogen as major factor governing fruit bud formation and fruit bearing play a dominating role for a long time. Singh (1961) stated that nitrogen and carbohydrate reserves play useful role in flower- bud- initiation though they did not form the primary cause and that the accumulation of these compounds might create a congenial condition for the production and action of the substances those are actually responsible for flower initiation in mango. Sen, (1943) reported that the terminal bud in mango was considered to inhibit the formation of axillary flower

bud since the removal of terminal buds helped in producing inflorescence from axillary buds in the 'Haden' mango. Shinde *et al.* (2014) also recorded earliest flowering in ringing done during 1st fortnight of May which was followed by ringing during second fortnight of May. It was further observed that delay in ringing also delayed the emergence of flowering in mango cv. Alphonso. The minimum number of days (39.33 days) for induction of flowering in mango cv. Alphonso were also reported in plant where removal of new shoots done in first fortnight of September (Warang *et al.* 2019). Nachare, (2020) found minimum number of days (42.67 days) were required for emergence of flower panicle by girdling during first fortnight of the October and removal of new shoots.

4.2 Effect of girdling, tip pruning and smudging on flowering intensity in mango cv. Ratna.

The data on effect of girdling, tip pruning and smudging on flowering intensity in mango cv. Ratna are presented in Table 2 and illustrated with Figure 2.

The maximum flowering intensity (62.27%) was observed in girdling on first fortnight of November and removal of new shoots (T₅) which was at par with T₆ (60.83%) and T₄ (59.17%) followed by treatment T₇ (52.50%). Treatment T₂ (43.33%), T₈ (42.50%), T₃ (41.67%) and T₁ (38.33%) were at par with each other. The minimum flowering intensity (26.67%) was recorded in control (T₁₀).

All treatments improved flowering intensity over control. Among the treatments girdling on first fortnight during November and tip pruning was beneficial for highest flowering intensity in mango cv. Ratna. Girdling on first fortnight during October and

November and tip pruning during November was also beneficial for improving flowering intensity in mango cv. Ratna.

Table 2. Effect of girdling, tip pruning and smudging on flowering intensity in mango cv. Ratna.

Treatments	Flowering intensity (%)
T₁ (Girdling on first fortnight of October)	38.33
T₂ (Girdling on first fortnight of November)	43.33
T₃ (Girdling on first fortnight of October and November.)	41.67
T₄ (Girdling on first fortnight of October and removal of new shoots)	59.17
T₅ (Girdling on first fortnight of November and removal of new shoots)	62.27
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	60.83
T₇ (Removal of new shoots)	52.50
T₈ (Removal of new shoots below old shoot)	42.50
T₉ (Smudging)	32.50
T₁₀ (Control)	26.67
Range	26.67-62.27
Mean	46.98
SEm±	2.25
C.D. @ 5%	6.70

The pattern of variation in different treatments:

$$\underline{\mathbf{T_5}} > \underline{\mathbf{T_6}} > \underline{\mathbf{T_4}} > \underline{\mathbf{T_7}} > \underline{\mathbf{T_2}} > \underline{\mathbf{T_8}} > \underline{\mathbf{T_3}} > \underline{\mathbf{T_1}} > \underline{\mathbf{T_9}} > \underline{\mathbf{T_{10}}}$$

Girdling is one of the ways to improve the earliness and intensity of flowering in mango cv. Cogshall (Urban *et al.*, 2009). Lal and Mishra (2007) studied the effect of pruning on growth and

bearing behaviour of mango cv. Chausa. Under pruning treatments, the highest flowering (58.40%) was observed in trees which received second order pruning and thinning out of central leader with 42.62 and 44.78 per cent flowering respectively. In unpruned trees, only 36.14 per cent flowering was noticed. Ibrahim *et al.* (2016) suggested that number of flowers per branch of Washington Navel Orange tree was significantly affected by the girdling treatments in two seasons. Oliveira *et al.* (2017) reported that branch tip pruning provided a higher percentage of flowering and a higher number of fruits per branch of 'Ubá' mango trees by more than 30 per cent. The different dosages of paclobutrazol in conjunction with tip pruning produced significant flowering in Palmer mango. The greatest number of inflorescence was observed when tip pruning was performed in Palmer mango trees. Warang *et al.* (2019) recorded that maximum flowering intensity was observed by girdling in first fortnight of the September and removal of new shoots (65.67 %) as compared to control T₈ (27.33 %) in mango cv. Alphonso. According to Nachare (2020) highest flowering intensity was observed by girdling on first fortnight of the October and removal of new shoots (61.17%) as compared to control T₈ (33.67%) in mango cv. Ratna.

4.3 Effect of girdling tip pruning and smudging on length of panicle, width of panicle and number of rachis per panicle in mango cv. Ratna.

The data on effect of girdling, tip pruning and smudging on length of panicle, width of panicle and number of rachis per panicle in mango cv. Ratna are given in Table 3 and illustrated with Figure 3.

There was significant difference among treatments for length of panicle, width of panicle and number of rachis per panicle. The data on length of panicle were showed that girdling on first fortnight of November and removal of new shoots (T₅) registered

Table 3. Effect of girdling, tip pruning and smudging on length of panicle, width of panicle and number of rachis per panicle in mango cv. Ratna

Treatments	Length of panicle (cm)	Width of panicle (cm)	Number of rachis/panicle
T₁ (Girdling on first fortnight of October)	26.30	20.87	25.30
T₂ (Girdling on first fortnight of November)	24.13	19.97	28.33
T₃ (Girdling on first fortnight of October and November)	25.10	23.67	28.97
T₄ (Girdling on first fortnight of October and removal of new shoots)	25.20	22.97	29.77
T₅ (Girdling on first fortnight of November and removal of new shoots)	30.20	24.63	30.63
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	28.83	21.57	29.77
T₇ (Removal of new shoots)	27.67	19.67	26.73
T₈ (Removal of new shoots below old shoot)	29.20	19.97	31.57
T₉ (Smudging)	27.47	20.40	27.67
T₁₀ (Control)	25.57	17.27	26.20
Range	24.13-30.20	17.27-24.63	25.30-31.57
Mean	26.97	21.10	28.49
SEm ±	0.65	0.92	0.91
C.D. @ 5%	1.92	2.73	2.72

The pattern of variation in different treatments:

Length of panicle: T₅>T₈>T₆>T₇>T₉>T₁>T₁₀>T₄ T₃>T₂

Width of panicle : T₅>T₃>T₄>T₆>T₁>T₉>T₈=T₂>T₇>T₁₀

Rachis per panicle : T₈>T₅>T₄=T₆>T₃>T₂>T₉>T₇ T₁₀>T₁

longest panicle (30.20 cm) which was at par with T₈ (29.20 cm) and T₆ (28.83 cm) and significantly superior over all other treatments. It was followed by T₇ (27.67 cm), T₉ (27.47 cm) and T₁ (26.30 cm). The shortest panicle (24.13 cm) was found in treatment girdling on first fortnight of November (T₂) which was at par with T₃ (25.10 cm), T₄ (25.20 cm) and T₁₀ (25.57 cm).

The data on width of panicle revealed that the maximum panicle width (24.63 cm) was observed in treatment girdling on first fortnight of November and removal of new shoots (T₅) and it was at par with T₃ (23.67cm) and T₄ (22.97 cm) and significantly superior over all other treatments. Treatments T₆ (21.57 cm), T₁ (20.87 cm), T₉ (20.40 cm), T₈ (19.97 cm), T₂ (19.97 cm), and T₇ (19.67 cm) were at par with each other. The minimum panicle width (17.27 cm) was found in control (T₁₀).

The highest number of rachis per panicle (31.57) were noted in treatment removal of new shoots below old shoot (T₈) which was at par with T₅ (30.63), T₄ (29.77), T₆ (29.77), T₃ (28.97). Treatments T₂ (28.33), T₉ (27.67), T₇ (26.73) and T₁₀ (26.20) were at par with each other. The lowest number rachis per panicle (25.30) were recorded in girdling on first fortnight of October (T₁).

There was increase in length and width of panicle as well as number of rachis per panicle by girdling on first fortnight of November and tip pruning (removal of new shoots). It may be due to availability of more sugars and auxins in branches. Nachare

(2020) observed the longest length of panicle in girdling on first fortnight of September (31.37cm) in mango cv. Ratna. Shoot pruning was significantly effective in increasing the length and width of panicle. Removal of new shoots leads to formation of longer panicle length due to gross changes in endogenous hormonal levels (Singh *et al.*, 2010). Thinning of terminal shoot clusters and young growth flushes would bring an optimum cytokinin/ gibberellin balance required for proper growth of panicle (Rao and Khader, 1980). Shaban (2009) found moderate pruning and spraying with GA₃ at 100ppm, was promising for mango as it increased flowering panicles and length of panicle in variety Zebda.

4.4 Effect of girdling, tip pruning and smudging on hermaphrodite flowers (%) in mango cv. Ratna

The data on effect of girdling, tip pruning and smudging on hermaphrodite flowers (%) in mango cv. Ratna are presented in Table 4 and graphically illustrated with Figure 4.

Percentage of hermaphrodite flowers per panicle had direct relationship with fruit set and fruit yield. The highest per cent of hermaphrodite flowers (15.01 %) were recorded in treatment girdling on first fortnight of November and removal of new shoots (T₅) which was at par with T₆ (14.75 %) and T₄ (14.50 %) and significantly superior over all other treatments. Treatment T₇ (13.30 %), T₁ (12.43 %), T₂ (12.17 %), T₈ (12.10 %) and T₃ (12.07%) were at par with each other. The lowest per cent of hermaphrodite flowers (10.98 %) were observed in control (T₁₀).

These investigation proves that girdling removal of new shoots and smudging treatments may have induced maximum number of hermaphrodite flowers in mango cv. Ratna. The

increase in hermaphrodite flowers due to girdling and tip pruning in mango cv. Alphonso was also observed by Shinde *et al.* (2014).

Table 4. Effect of girdling, tip pruning and smudging on hermaphrodite flower (%) per panicle of mango cv. Ratna

Treatments	Hermaphrodite flower (%)
T₁ (Girdling on first fortnight of October)	12.43
T₂ (Girdling on first fortnight of November)	12.17
T₃ (Girdling on first fortnight of October and November.)	12.07
T₄ (Girdling on first fortnight of October and removal of new shoots)	14.50
T₅ (Girdling on first fortnight of November and removal of new shoots)	15.01
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	14.75
T₇ (Removal of new shoots)	13.30
T₈ (Removal of new shoots below old shoot)	12.10
T₉ (Smudging)	11.31
T₁₀ (Control)	10.98
Range	10.98-15.01
Mean	12.86
SEm ±	0.51
C.D. @ 5%	1.50

The pattern of variation in different treatments:

$$\underline{\mathbf{T_5 > T_6 > T_4 > T_7 > T_1 > T_2 > T_8 > T_3 > T_9 > T_{10}}}$$

According to Waghmare and Joshi, (2008) highest percentage of hermaphrodite flower per panicle in the pruned trees was due to removal of excess shoots. It leads to more light interception and

movement of assimilates to fewer growing points. The highest number of hermaphrodite flowers (%) due to removal of new shoots reported in the earlier studies of mango cv. Alphonso by Gopu *et al.* (2014). Soudagar *et al.* (2018) showed that higher per cent number of hermaphrodite flowers were produced in T₁ (tip pruning with two leaves) (19.98%) in mango cv. Alphonso. Singh *et al.*, (2010) reported that light pruning in mango resulted highest hermaphrodite flowers (%) than un-pruned trees whereas lowest per cent of hermaphrodite flowers were found in un-pruned trees due to the development of lower temperature regime in denser canopies. Nabila *et al.* (2015) found that percentage of perfect flowers was significantly increased due to girdling treatments. The highest percentage of perfect flowers was obtained in girdling during February (84.66 and 92.33% during 2009 and 2010 seasons respectively) in olive cv. Manzanillo. December pruning slightly increased the hermaphrodite flowers in Dasherri mango (Mohan *et al.*, 2001). Warang *et al.* (2019) noticed that higher per cent number of hermaphrodite flowers were produced by girdling during first fortnight of the September and removal of new shoots (16.87%) in mango cv. Alphonso. Nachare (2020) observed that highest percentage number of hermaphrodite flowers (13.12 %) produced by girdling in first fortnight of October and tip pruning in mango cv. Ratna.

4.5 Effect of girdling, tip pruning and smudging on fruit set and fruit retention per panicle in mango cv. Ratna

The data on effect of girdling, tip pruning and smudging on fruit set per panicle in mango cv. Ratna are given in Table 5 and graphically presented with Figure 5a and 5b.

There was significant difference among treatments for fruit set per panicle in mango cv. Ratna. The data on fruit set per panicle revealed that treatment girdling on first fortnight of November and removal of new shoots (T₅) had maximum fruit set per panicle (8.53) which was at par with T₆ (8.23) and significantly superior over other treatments. Treatments T₁ (6.30), T₂ (6.00) and T₈ (5.97) were at par among themselves. The minimum fruit set (5.03) was noted in control (T₁₀) which was inferior to all other treatments.

The highest fruit retention per panicle (0.95) was observed in treatment girdling on first fortnight of November and removal of new shoots (T₅) which was significantly superior over other treatments and it was followed by T₆ (0.87 %). Treatment T₄ (0.77 %) and T₇ (0.72 %) were at par with each other. Treatment T₈ and T₃ had the same number of fruits retained per panicle (0.57 %) and were at par with T₉ (0.55 %). The lowest fruit retention (0.50%) was noted in control (T₁₀) which was inferior to all other treatments.

From the present study it was observed that girdling, removal of new shoots significantly increased fruit set and fruit retention in mango cv. Ratna. Gaskins (1963) found in trial with 4-year-old mango seedlings that fruit set was better on the flowering trees which were girdled than on those which flowered without girdling in open pollinated seedlings of Saigon mango.

Table 5. Effect of girdling, tip pruning and smudging on fruit set and fruit retention per panicle in mango cv. Ratna

Treatments	Fruit set (%)	Fruit retention (%)
T₁ (Girdling on first fortnight of October)	6.30	0.64
T₂ (Girdling on first fortnight of November)	6.00	0.59
T₃ (Girdling on first fortnight of October and November.)	5.73	0.57
T₄ (Girdling on first fortnight of October and removal of new shoots)	7.30	0.77
T₅ (Girdling on first fortnight of November and removal of new shoots)	8.53	0.95
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	8.23	0.87
T₇ (Removal of new shoots)	6.70	0.72
T₈ (Removal of new shoots below old shoot)	5.97	0.57
T₉ (Smudging)	5.42	0.55
T₁₀ (Control)	5.03	0.50
Range	5.03-8.53	0.50-0.95
Mean	6.52	0.67
SEm ±	0.11	0.02
CD @ 5%	0.33	0.06

The pattern of variation in different treatments.

Fruit set : T₅>T₆>T₄>T₇>T₁>T₂>T₈>T₃>T₉>T₁₀

Fruit retention : T₅>T₆>T₄>T₇>T₁>T₂>T₈=T₃>T₉>T₁₀

According to Chauhan *et al.* (2013), tip pruning had highest fruit set in mango cv. Mallika. Murneek (1938) showed that branch ringing increased fruit set to 94 per cent and 33.7 per cent in Rome and Ingram apple cultivars. Ibrahim *et al.* (2016) observed that girdling branches and limbs significantly affected the initial number of fruitlets per branch and fruit set percentage in Washington Navel Orange. Thorp and Sedgley (1993) concluded that number of fruit set was highest in tipped off apical bud (2.1) followed by control in avocado cv. Hass. Soudagar *et al.* (2017) recorded the highest percentage of fruit set by tip pruning with two leaves in mango cv. Alphonso. Warang *et al.*, (2019) recorded maximum fruit set (8.95 %) and maximum fruit retention (0.83 %) in girdling on first fortnight of the September and first fortnight of October and removal of new shoots in mango cv. Alphonso.

There was no influence of smudging on fruit set and fruit retention it may be due to stimulating effect on growth, but nature of growth, vegetative or reproductive depends on other climatic factors concluded that smudging can induce flowering, if shoot is in condition to flower (Sen and Mallik, 1947). Instead of flowering smudging stimulated vegetative growth. Smudging was less effective in producing panicles (Bondad *et al.*, 1979).

4.6 Effect of girdling, tip pruning and smudging on physical parameters of fruits at harvest stage in mango cv. Ratna

4.6.1 Effect of girdling, tip pruning and smudging on fruit weight, fruit length and fruit diameter at harvest stage of fruits in mango cv. Ratna

The data on weight, length and diameter of fruit at harvest stage are presented in Table 6 and illustrated with Figure 6a and 6b.

The maximum average weight (448.27g) of mango fruit at harvest was observed in treatment girdling on first fortnight of October and November and removal of new shoots (T₆) which was at par with T₅ (446.53g) and T₈ (445.43g) and significantly superior over other treatments. It was followed by T₇ (437.17g) and T₄ (425.10g). Treatment T₃ (408.63g), T₂ (407.90g) and T₁ (405.23g) were at par with each other. The minimum average weight of fruit (374.27g) was seen in control (T₁₀).

The treatment girdling on first fortnight of October and November and removal of new shoots (T₆) registered maximum fruit length (12.93 cm) which was at par with T₅ (12.60 cm) and T₈ (12.43 cm) and significantly superior over other treatments. It was followed by T₇ (12.18). Treatment T₃ (11.41 cm), T₇ (11.33 cm) and T₂ (10.72 cm) were at par with each other. It was followed by T₉ (10.34 cm) and T₁ (10.22 cm). The minimum length of fruit (9.53 cm) was found in control (T₁₀).

The maximum fruit diameter (9.55cm) was found in girdling on first fortnight of October and November and removal of new shoots (T₆) and it was at par with T₈ (9.38cm) and T₅ (9.30cm) and significantly superior over other treatments. Treatment T₄ (9.21cm) and T₃ (9.15cm) were at par with each other. It was followed by T₄ (9.21cm) and T₃ (9.15cm). The minimum fruit diameter (7.96cm) was recorded in control (T₁₀) was at par with T₉ (8.16cm), T₁ (8.24cm) and T₂ (8.25cm).

Ghadage *et al.* (2017) reported significantly maximum fruit weight (301.66g) with 1.50cm of girdling width. The girdling

during 15th July (T₁) produced significant maximum fruit weight (293.49g) in mango cv. Alphonso. Nabila *et al.* (2015) found

Table 6. Effect of girdling, tip pruning and smudging on fruit weight, fruit length and fruit diameter at harvest stage in mango cv. Ratna

Treatments	Average fruit weight at harvest (g)	Fruit length (cm)	Fruit diameter (cm)
T₁ (Girdling on first fortnight of October)	405.23	10.22	8.24
T₂ (Girdling on first fortnight of November)	407.90	10.72	8.25
T₃ (Girdling on first fortnight of October and November.)	408.63	11.41	9.15
T₄ (Girdling on first fortnight of October and removal of new shoots)	425.10	11.33	9.21
T₅ (Girdling on first fortnight of November and removal of new shoots)	446.53	12.60	9.30
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	448.27	12.93	9.55
T₇ (Removal of new shoots)	437.17	12.18	8.79
T₈ (Removal of new shoots below old shoot)	445.43	12.43	9.38
T₉ (Smudging)	403.87	10.34	8.16
T₁₀ (Control)	374.27	9.53	7.90
Range	374.27-448.27	9.53-12.93	7.90-9.55
Mean	420.24	11.37	8.79
SEm ±	1.15	0.24	0.10
CD @ 5%	3.42	0.72	0.31

The pattern of variation in different treatments.

Average fruit weight : T₆>T₅>T₈>T₇>T₄>T₃>T₂>T₁>T₉>T₁₀

Fruit length : T₆>T₈>T₅>T₇>T₃>T₄>T₂>T₉>T₁>T₁₀

Fruit diameter : T₆>T₈>T₅>T₄>T₃>T₇>T₂>T₁>T₉>T₁₀

highest fruit length (2.63 and 2.80) during 2009 and 2010 respectively as a result of girdling during April in both seasons of the study. According to Deng *et al.* (1997) found that in chunlei peach, best time for girdling was 15 days after full bloom which significantly increased average fruit weight by 44.98 per cent. Improvement in fruit size due to pruning was observed in mango by Fivaz and Stassen, (1997) in mango cv. Sensation. El- sherbini (1992) concluded that fruit diameter and size significantly increased by girdling at stage II of peach cv. Riogrande. Nachare (2020) found that the maximum average fruit weight (462.87g) in girdling on first fortnight of September and October in mango cv. Ratna.

The girdling in first fortnight of October did not improved average fruit weight, fruit length and fruit diameter may be due to excess of shoots on tree it may cause lower interception of sunlight inside the canopy which results lower photosynthesis rate and lower supply of photosynthate to fruit. According to E. Lahav *et al.* (1972) due to girdling fruit weight decreases (265g) as compared to control (326g) in 'Ettinger' cultivar of avocado. Also smudging treatment did not influence on fruit weight, length and diameter of mango cv. Ratna. Smudging practice could be location specific and induces flowers only if shoot is in condition to flower. This inferences indicate that this technique could not work under changing climatic condition of Konkan region.

4.6.2 Effect of girdling, tip pruning and smudging on pulp weight and pulp to stone ratio of fruits at harvest in mango cv. Ratna

The data on effect of girdling, tip pruning and smudging on pulp weight (g) and pulp stone ratio in mango cv. Ratna are given in Table 7 and graphically presented with Figure 7a and 7b.

At harvest stage, the highest pulp weight (341.03g) was seen in treatment girdling on first fortnight of November and removal of new shoots (T₅) which was at par with T₆ (337.03g) and significantly superior over other treatments. It was followed by T₈ (323.60g). Treatment T₇ (308.20g) and T₄ (307.20g) were at par with each other. It was followed by treatment T₂ (280.33g) T₃ (279.37g) and T₁ (270.67g). The lowest pulp weight (243.21g) was noticed in control (T₁₀) which at par with T₉ (249.20g).

The data on pulp stone ratio indicated that there was significant difference among treatments. The data on pulp stone ratio showed that treatment girdling on first fortnight of November and removal of new shoots (T₅) had maximum pulp stone ratio (6.24) and it was at par with T₆ (6.08) and significantly superior over other treatments. Treatment T₈ (5.65) and T₇ (5.54) were at par with each other. It was followed by T₂ (4.87), T₄ (4.68) and T₃ (4.67). The minimum pulp stone ratio (3.95) was seen in control (T₁₀) and it was at par with T₉ (4.06).

Ghadage *et al.* (2017) reported significantly maximum volume of pulp (190.55 ml) was obtained with 1.50 cm of girdling width. The girdling on 15th July (T₁) produced significantly maximum pulp volume (184.73ml) in mango cv. Alphonso. Nabila *et al.* (2015) found that girdling during April resulted in highest and significant pulp/seed ratio (88.66%) during 2009 and 2010

Table 7. Effect of girdling, tip pruning and smudging on pulp weight and pulp to stone ratio of fruit at harvest stage in mango cv. Ratna

Treatments	Pulp weight (g)	Pulp to stone ratio
T₁ (Girdling on first fortnight of October)	270.67	4.49
T₂ (Girdling on first fortnight of November)	280.33	4.87
T₃ (Girdling on first fortnight of October and November.)	279.37	4.67
T₄ (Girdling on first fortnight of October and removal of new shoots)	307.20	4.68
T₅ (Girdling on first fortnight of November and removal of new shoots)	341.03	6.24
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	337.03	6.08
T₇ (Removal of new shoots)	308.20	5.54
T₈ (Removal of new shoots below old shoot)	323.60	5.65
T₉ (Smudging)	249.20	4.06
T₁₀ (Control)	243.21	3.95
Range	243.21-341.03	3.95-6.24
Mean	293.98	5.02
SEm ±	3.66	0.12
CD @ 5%	10.87	0.35

The pattern of variation in different treatments:

Pulp weight at harvest : T₅>T₆>T₈>T₇>T₄>T₂>T₃>T₁>T₉>T₁₀

Pulp to stone ratio at harvest : T₅>T₆>T₈>T₇>T₂>T₄>T₃>T₁>T₉>T₁₀

seasons respectively in Olive cv. Manzanillo. Khalkho *et al.* (2015) concluded that removal of shoot and girdling markedly improved seed-pulp ratio and juice percentage in litchi cv. Shahi. Similar results with respect to pulp weight (g) and pulp stone ratio were also reported by Bhanupratap *et al.* (2009) in mango cv. Amrapali. Nachare (2020) found maximum weight of pulp (346.40g) in girdling on first fortnight of the September and tip pruning (removal of new shoots) in mango cv. Ratna. However, Soudagar *et al.* (2019) reported that the pulp weight and pulp to stone ratio did not vary due to tip pruning treatments.

The lower pulp weight and pulp to stone ratio by girdling in first fortnight of October and smudging can be attributed to minimum fruit size and maximum stone weight.

4.7 Effect of girdling, tip pruning and smudging on physical parameters of fruit at ripe stage in mango cv. Ratna

The data on effect of girdling, tip pruning and smudging on fruit weight (g), pulp weight (g) and pulp stone ratio in mango cv. Ratna are given in Table 8 and graphically presented with Figure 8a and 8b.

The variation recorded for all treatments at ripe stage for fruit weight (g) was found significant. The maximum fruit weight (418.60 g) was obtained from treatment girdling on first fortnight of October and November and removal of new shoots (T₆) was at par with T₅ (414.77g) and T₈ (411.43g) and significantly superior

over other treatments. Treatment T₇ (407.43g) and T₄ (404.73g) were at par with each other. It was followed by T₃ (392.73g) T₂ (389.37g) and T₁ (387.63g). The minimum fruit weight (341.43g) was noticed in control (T₁₀) followed by T₉ (362.63g).

The highest pulp weight (325.13g) was seen in treatment girdling on first fortnight of October and November and removal of new shoots (T₆) and significantly superior over all other treatments. It was followed by T₅ (308.17g) and T₈ (307.63g). Treatment T₄ (290.43g) and T₇ (290.30g) were at par with each other. It was followed by T₂ (258.93g), T₃ (257.87g) and T₁ (254.93g). The lowest pulp weight (217.20g) was found in smudging (T₉) followed by T₁₀ (220.93g).

The data on pulp to stone ratio showed that treatment girdling on first fortnight of November and removal of new shoots (T₅) had maximum pulp stone ratio (6.11) and significantly superior over remaining treatments. It was followed by T₆ (5.71). Treatment T₇ (5.22) and T₈ (5.13) were at par with each other. It was followed by T₂ (4.47), T₃ (4.42) and T₄ (4.35). The minimum pulp to stone ratio (3.74) was seen in control (T₁₀).

There was increase in weight of fruit (g), pulp weight (g) and pulp stone ratio of mango cv. Ratna due to effect of girdling and tip pruning (removal of new shoots). The higher fruit weight, fruit length and diameter in pruned trees might be due to improvement in microclimate and higher photosynthetic rate which helps more accumulation partitioning towards the fruit development (Kumar *et al.*, 2014). According to Gupta and Gill (2015) the fruit size in terms of fruit length and fruit diameter increased with the increase in intensity of pruning in ber cv. Umran.

Table 8. Effect of girdling, tip pruning and smudging on physical parameters of fruit at ripe stage in mango cv. Ratna

Treatments	Fruit weight (g)	Pulp weight (g)	Pulp to stone ratio
T₁ (Girdling on first fortnight of October)	387.63	254.80	4.10
T₂ (Girdling on first fortnight of November)	389.37	258.93	4.47
T₃ (Girdling on first fortnight of October and November.)	392.73	257.87	4.42
T₄ (Girdling on first fortnight of October and removal of new shoots)	404.73	290.43	4.35
T₅ (Girdling on first fortnight of November and removal of new shoots)	414.77	308.17	6.11
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	418.60	325.13	5.71
T₇ (Removal of new shoots)	407.43	290.30	5.22
T₈ (Removal of new shoots below old shoot)	411.43	307.63	5.13
T₉ (Smudging)	362.63	217.20	3.97
T₁₀ (Control)	341.43	220.93	3.74
Range	341.43-418.60	217.20-325.13	3.74-6.11
Mean	393.08	273.14	4.72
SEm ±	3.62	2.34	0.08
CD @ 5%	10.75	6.96	0.23

The pattern of variation in different treatments:

Fruit weight at ripe stage	: <u>T₆</u> > <u>T₅</u> > <u>T₈</u> > <u>T₇</u> > <u>T₄</u> > <u>T₃</u> > <u>T₂</u> > <u>T₁</u> > <u>T₉</u> > <u>T₁₀</u>
Pulp weight at ripe stage	: <u>T₆</u> > <u>T₅</u> > <u>T₈</u> > <u>T₄</u> > <u>T₇</u> > <u>T₂</u> > <u>T₃</u> > <u>T₁</u> > <u>T₁₀</u> > <u>T₉</u>
Pulp to stone ratio at ripe stage	: <u>T₅</u> > <u>T₆</u> > <u>T₇</u> > <u>T₈</u> > <u>T₂</u> > <u>T₃</u> > <u>T₄</u> > <u>T₁</u> > <u>T₉</u> > <u>T₁₀</u>

Nabila *et al.* (2015) found that highest fruit weight (5.60 and 5.70g) resulted from girdling during April. Girdling during April resulted in the highest significant pulp/seed ratio (88.66%) during 2009 and 2010 seasons respectively. Khalkho *et al.* (2015) concluded that removal of shoot and girdling markedly improved seed-pulp ratio and juice percentage in litchi cv. Shahi. The results in the present investigation are in confirmation with findings of Gopu *et al.* (2014) in mango cv. Alphonso; Warang *et al.* (2019) in mango cv. Alphonso; Nachare *et al.* (2020) in mango cv. Ratna. However, Soudagar *et al.* (2018) reported non-significant effect of tip pruning on mango on fruit length and diameter cv. Alphonso.

The lower pulp weight and pulp to stone ratio by girdling in first fortnight of October and smudging can be attributed to minimum fruit size and maximum stone weight.

4.8 Effect of girdling, tip pruning and smudging on chemical composition of fruit at harvest stage in mango cv. Ratna

4.8.1 Effect of girdling, tip pruning and smudging on TSS, reducing and total sugars of fruit at harvest stage in mango cv. Ratna

The data on effect of girdling, tip pruning (removal of new shoots) and smudging on TSS (°B), reducing sugars (%) and total

sugars (%) of mango cv. Ratna at harvest stage are presented in Table 9 and depicted in Figures 9a, 9b and 9c.

The data regarding TSS (°B) at harvest stage found non-significant differences among various treatments. The highest TSS (10.70°B) obtained from treatment removal of new shoots (T₇) which was followed by T₄ (10.67 °B), T₈ (10.63°B), T₃ (10.50 °B), T₅ (10.37 °B), T₉ (10.35 °B), T₁ (10.27 °B), T₁₀ (10.23 °B) and T₆ (10.20 °B). The lowest TSS (9.83°B) was observed in girdling first fortnight of November (T₂).

The data on reducing sugars (%) in mango cv. Ratna had non-significant trend. The maximum reducing sugars (%) were obtained in treatment T₆ (1.90 %) which was followed by T₈ (1.83 %), T₇ (1.75 %), T₉ (1.66 %), T₂ (1.61 %), T₅ (1.55 %), T₃ (1.49 %), T₁ (1.43 %), and T₁₀ (1.36 %). The minimum reducing sugars (1.25%) were found in girdling on first fortnight of October and removal of new shoots (T₄).

The effect of various treatments on total sugars (%) was non-significant. Treatment T₅ had the maximum total sugars (3.41 %) which was followed by T₆ and T₈ (3.40 %), T₇ (3.35 %), T₁ (3.33 %), T₄ (3.31 %), T₉ (3.30 %), T₃ (3.28 %), and T₁₀ (3.17 %). The minimum total sugars (3.15 %) were noted in girdling on first fortnight of November (T₂).

Girdling, removal of new shoots and smudging does not have much effect on TSS, reducing and total sugars of fruit at harvest stage. Soudagar *et al.* (2018) stated that tip pruning had non-significant effect on TSS, reducing sugar and total sugars of fruits in mango cv. Alphonso, also Warang *et al.* (2019) in Alphonso and Nachare, (2020) in Ratna found girdling and removal of new shoot

doesn't have any significant effect on TSS, reducing sugar and total sugar of mango at harvest stage. Ram *et al.* (2012) reported

Table 9. Effect of girdling, tip pruning and smudging on TSS reducing and total sugars of fruit at harvest stage in mango cv. Ratna.

Treatments	TSS (°B)	Reducing sugar (%)	Total sugars (%)
T₁ (Girdling on first fortnight of October)	10.27	1.43	3.33
T₂ (Girdling on first fortnight of November)	9.83	1.61	3.15
T₃ (Girdling on first fortnight of October and November.)	10.50	1.49	3.28
T₄ (Girdling on first fortnight of October and removal of new shoots)	10.67	1.25	3.31
T₅ (Girdling on first fortnight of November and removal of new shoots)	10.37	1.55	3.41
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	10.20	1.90	3.40
T₇ (Removal of new shoots)	10.70	1.75	3.35
T₈ (Removal of new shoots below old shoot)	10.63	1.83	3.40
T₉ (Smudging)	10.35	1.66	3.30
T₁₀ (Control)	10.23	1.36	3.17
Range	9.83-10.70	1.25-1.90	3.15-3.41
Mean	10.38	1.58	3.31
SEm ±	0.23	0.14	0.13
CD @ 5%	NS	NS	NS

The pattern of variation in different treatments:

TSS at harvest stage (° B)	:	<u>T₇>T₄>T₈>T₃>T₅>T₉>T₁>T₁₀>T₆>T₂</u>
Reducing sugar at harvest stage (%)	:	<u>T₆>T₈>T₇>T₉>T₂>T₅>T₃>T₁>T₁₀>T₄</u>
Total sugars at harvest (%)	:	<u>T₅>T₆=T₈>T₇>T₁>T₄>T₉>T₃>T₁₀>T₂</u>

that relatively higher degree of TSS was recorded both in matured green and ripened fruits harvested from unpruned trees of mango cv. Amrapali. Gopu *et al.* (2014) reported that highest total soluble solids, total sugars and non-reducing sugars of the fruit were observed in total removal of past season's growth compared to control in mango cv. Alphonso. According to Martinez de Toda and Sancha, (1998) effect of various methods of pruning did not influence on TSS in Grenache vines.

4.8.2 Effect girdling, tip pruning and smudging on acidity, pH and ascorbic acid of fruit at harvest stage in mango cv. Ratna

The data on effect of girdling, tip pruning (removal of new shoots) and smudging on acidity (%) pH and ascorbic acid (mg/100g) of mango cv. Ratna at harvest stage are presented in Table 10 and depicted in Figure 10a, 10b and 10c.

The data on effect of girdling, tip pruning (removal of new shoots) and smudging on acidity (%) pH and ascorbic acid (mg/100g) of mango cv. Ratna showed non-significant results among different treatments. The lowest titratable acidity (2.65 %) was recorded in treatment girdling on first fortnight of October (T₁) which was followed by T₃ (2.77 %), T₄ (2.96 %), T₉ (3.17 %), T₆ (3.20 %), T₈ (3.23 %), T₁₀ (3.24 %), T₂ (3.25 %), and T₅ (3.27 %). The highest titratable acidity (3.53 %) was found in removal of new shoots (T₇).

The maximum pH (2.93) was found in girdling on first fortnight of October (T₁). It was followed by T₄ (2.92), T₇ (2.80), T₁₀ (2.77), T₃ (2.73), T₆ (2.63), T₅ (2.60), T₈ (2.60) and T₉ (2.60). The minimum pH (2.43) was found in girdling on first fortnight of November (T₂).

The maximum ascorbic acid was seen in treatment T₅ (76.27 mg/100g) which was followed by T₆ (74.57 mg/100g), T₁₀ (71.87 mg/100g), T₉ (70.87 mg/100g), T₃ (68.87 mg/100g), T₈ (66.63 mg/100g), T₁ (66.40 mg/100g), T₇ (65.50 mg/100g) and T₄ (65.33 mg/100g). The minimum ascorbic acid (65.30 mg/100g) was found girdling on first fortnight of November (T₂).

Effect of girdling, tip pruning and smudging showed non-significant variation with respect to titratable acidity, pH and ascorbic acid of mango fruit at the harvest stage. Shinde *et al.* (2014) reported that the different girdling times had non-significant effect on chemical composition of fruits in mango cv. Alphonso. Ghadage *et al.* (2016) reported that the different girdling time had non-significant effect on chemical composition of fruits in mango cv. Alphonso. Soudagar *et al.* (2018) concluded that tip pruning has non-significant effect on acidity, pH and ascorbic acid of fruits in mango cv. Alphonso. Warang *et al.* (2019) found that effect of girdling and removal of new shoot had non-significant effect on acidity, pH and ascorbic acid of fruits in mango cv. Alphonso. Nachare (2020) reported that effect of girdling and tip pruning had non-significant effect on acidity, pH and ascorbic acid of fruits in mango cv. Ratna.

Table 10. Effect of girdling, tip pruning and smudging on acidity, pH and ascorbic acid of fruit at harvest stage in mango cv. Ratna

Treatments	Acidity (%)	pH	Ascorbic acid (mg/100g)
T₁ (Girdling on first fortnight of October)	2.65	2.93	66.40
T₂ (Girdling on first fortnight of November)	3.25	2.43	65.30
T₃ (Girdling on first fortnight of October and November.)	2.77	2.73	68.87
T₄ (Girdling on first fortnight of October and removal of new shoots)	2.96	2.92	65.33
T₅ (Girdling on first fortnight of November and removal of new shoots)	3.27	2.60	76.27
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	3.20	2.63	74.57
T₇ (Removal of new shoots)	3.53	2.80	65.50
T₈ (Removal of new shoots below old shoot)	3.23	2.60	66.63
T₉ (Smudging)	3.17	2.60	70.87
T₁₀ (Control)	3.24	2.77	71.87
Range	2.65-3.53	2.60-2.93	65.30-76.27
Mean	3.13	2.70	69.16
SEm ±	0.18	0.14	2.93
CD @ 5%	NS	NS	NS

The pattern of variation in different treatments:

Titrateable acidity (%)	:	<u>$T_1 < T_3 < T_4 < T_9 < T_6 < T_8 < T_{10} < T_2 < T_5 < T_7$</u>
pH	:	<u>$T_1 > T_4 > T_7 > T_{10} > T_3 > T_6 > T_5 = T_8 = T_9 > T_2$</u>
Ascorbic acid (mg/100g)	:	<u>$T_5 > T_6 > T_{10} > T_9 > T_3 > T_8 > T_1 > T_7 > T_4 > T_2$</u>

4.9 Effect of girdling, tip pruning and smudging on chemical composition of fruit at ripe stage in mango cv. Ratna

The data on effect of girdling, tip pruning (removal of new shoots) and smudging on TSS ($^{\circ}$ B), reducing and total sugar (%), acidity (%), pH and ascorbic acid (mg/100g) of mango cv. Ratna at ripe stage are presented in Table 11 and depicted in Figures 12a, 12b, 12c, 12d 12e and 12f. The variation between all treatments at ripe stage for all chemical parameters was non-significant.

The treatment T_7 had highest TSS (22.54 $^{\circ}$ B) which was followed by T_4 (22.47 $^{\circ}$ B), T_8 (22.39 $^{\circ}$ B), T_2 (21.88 $^{\circ}$ B), T_5 (21.81 $^{\circ}$ B), T_9 (21.78 $^{\circ}$ B), T_{10} (21.51 $^{\circ}$ B), T_6 (21.44 $^{\circ}$ B) and T_1 (21.17 $^{\circ}$ B). The lowest TSS was seen in T_3 (20.79 $^{\circ}$ B).

The maximum reducing sugars (%) were estimated in treatment T_2 (4.13 %) followed by T_5 (4.10 %), T_6 (3.37 %), T_3 (3.29%), T_7 (3.27 %), T_1 (3.15 %), T_8 (3.05 %), T_4 (2.75 %) and T_{10} (2.70%). The minimum reducing sugars were detected in control T_9 (2.57 %).

The highest total sugars (%) were detected in T_6 (14.83 %) and it was followed by T_7 (14.30 %), T_2 (14.20 %), T_8 13.90 %, T_5 (13.80 %), T_4 (12.87 %), T_3 (12.63 %), and T_{10} (12.53 %). The lowest total sugars were found in T_9 (12.47%).

Table 11. Effect of girdling, tip pruning and smudging on chemical composition of fruits at ripe stage in mango cv. Ratna

Treatments	TSS (°Brix)	Sugars		Titratable Acidity (%)	pH	Ascorbic Acid (mg/100g)
		Reducing sugars (%)	Total sugars (%)			
T₁	21.17	3.15	12.53	0.22	4.50	50.65
T₂	21.88	4.13	14.20	0.18	4.80	56.16
T₃	20.79	3.29	12.63	0.19	4.13	59.07
T₄	22.47	2.75	12.87	0.23	4.37	57.19
T₅	21.81	4.10	13.80	0.18	4.53	51.33
T₆	21.44	3.37	14.83	0.19	4.90	52.47
T₇	22.54	3.27	14.30	0.20	4.60	53.70
T₈	22.39	3.05	13.90	0.20	4.33	54.83
T₉	21.78	2.57	12.47	0.21	4.07	56.20
T₁₀	21.51	2.70	12.53	0.22	4.23	47.47
Range	20.79-22.54	2.57-4.13	12.47-14.83	0.18-0.23	4.07-4.90	47.47-59.07
Mean	21.78	3.24	13.41	0.20	4.45	53.91
SEm ±	0.44	0.30	0.68	0.03	0.20	3.14
CD @ 5%	NS	NS	NS	NS	NS	NS

The pattern of variation in different treatments:

TSS (°Brix)	: <u>T₇>T₄>T₈>T₂>T₅>T₉>T₁₀>T₆>T₁>T₃</u>
Reducing sugar (%)	: <u>T₂>T₅>T₆>T₃>T₇>T₁>T₈>T₄>T₁₀>T₉</u>
Total sugar (%)	: <u>T₆>T₇>T₂>T₈>T₅>T₄>T₃>T₁=T₁₀>T₉</u>
Acidity (%)	: <u>T₂=T₅<T₃=T₆<T₇=T₈<T₉<T₁=T₁₀<T₄</u>
pH of pulp	: <u>T₆>T₂>T₇>T₅>T₁>T₄>T₈>T₁₀>T₃>T₉</u>
Ascorbic acid (mg/100g)	: <u>T₃>T₄>T₉>T₂>T₈>T₇>T₆>T₅>T₁>T₁₀</u>

The minimum titratable acidity was found in treatment T₂ and T₅ (0.18). It was followed by T₃ and T₆ (0.19), T₇ and T₈ (0.20), T₉ (0.21), T₁ and T₁₀ (0.22). The maximum acidity (0.23) was noted in T₄.

The maximum pH magnitude was found in treatment T₆ (4.90). It was followed by T₂ (4.80), T₇ (4.60), T₅ (4.53), T₁ (4.50), T₄ (4.37), T₈ (4.33), T₁₀ (4.23) and T₃ (4.13). The minimum pH was noticed in T₉ (4.07).

The ascorbic acid content at ripe stage was non-significant among treatments. The maximum ascorbic acid was detected in treatment T₃ (59.07 mg/100g). It was followed by T₄ (57.19 mg/100g), T₉ (56.20 mg/100g), T₂ (56.16 mg/100g), T₈ (54.83 mg/100g), T₇ (53.70 mg/100g), T₆ (52.47 mg/100g), T₅ (51.33 mg/100g) and T₁ (50.65 mg/100g). The minimum ascorbic acid (47.47 mg/100g) observed in control (T₁₀).

Removal of new shoots, girdling and smudging did not affected TSS, reducing and total sugars of fruit at ripe stage. Shinde *et al.* (2014) also reported that the different girdling time had non-significant effect on TSS, titratable acidity, reducing

sugar, total sugars, and ascorbic acid of fruits in mango cv. Alphonso. Sunil *et al.* (2002) recorded that different pruning levels in ber didn't influenced ascorbic acid content in fruit. Sharma (2014), exhibited that heading back of branches in apple cv. Starking delicious didn't had significant difference in relation to acidity of fruits. Warang *et al.* (2019) stated that effect of girdling and removal of new shoots had non-significant effect on TSS, titratable acidity, reducing sugars, total sugars, pH and ascorbic acid of fruits in mango cv. Alphonso. Tip pruning had non-significant effect on TSS, titratable acidity, reducing sugars, total sugars and ascorbic acid of fruits in mango cv. Alphonso (Soudagar *et al.*, 2018). Ghadage *et al.* (2016) found the different girdling time had non-significant effect on titratable acidity, reducing sugars, total sugars and ascorbic acid of fruits in mango cv. Alphonso. The results in present investigation are in similar lines found by Nachare (2020) in mango cv. Ratna.

4.10 Effect of girdling, tip pruning and smudging on days required for flowering to harvesting in mango cv. Ratna

The data on effect of girdling, removal of new shoots and smudging on days required for harvesting from flowering in mango cv. Ratna are presented in Table 12 and graphically depicted with Figure 12.

The various treatments significantly influenced the days required from flowering to harvesting. The minimum days required for harvesting (134.87 days) were seen in removal of new shoots (T₇) which was at par with T₅ (141.07 days) and T₈ (141.67 days) and significantly superior over remaining treatments. Treatment T₄ (147.5 days), T₉ (149.33 days), T₂ (149.67) and T₁ (150.33) were at par with each other. The maximum number of

days required for harvesting (165.00 days) were observed in control (T₁₀) was followed by T₃ (156.33 days) and T₆ (155.73 days).

Table 12. Effect of girdling, tip pruning and smudging on days required from flowering to harvesting of mango cv. Ratna

Treatments	Days required from flowering to harvesting
T₁ (Girdling on first fortnight of October)	150.33
T₂ (Girdling on first fortnight of November)	149.67
T₃ (Girdling on first fortnight of October and November.)	156.33
T₄ (Girdling on first fortnight of October and removal of new shoots)	147.50
T₅ (Girdling on first fortnight of November and removal of new shoots)	141.07
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	155.73
T₇ (Removal of new shoots)	134.87
T₈ (Removal of new shoots below old shoot)	141.67
T₉ (Smudging)	149.33
T₁₀ (Control)	165.00
Range	134.87-165.00
Mean	149.15
SEm ±	2.41
CD @ 5%	7.16

The pattern of variation in different treatments:

$$\underline{T_7} < \underline{T_5} < \underline{T_8} < \underline{T_4} < \underline{T_9} < \underline{T_2} < \underline{T_1} < \underline{T_6} < \underline{T_3} < \underline{T_{10}}$$

The tip pruning facilitated early flowering and harvesting in mango cv. Ratna. Girdling and tip pruning also facilitated early harvesting in mango. Pruning increases photosynthate translocation to flower buds which result in earlier fruit set which lead to early harvest than control (Lal *et al.*, 2000). Srilatha and Reddy (2015) reported that pruning of current season growth and application of paclobutrazol recorded early harvesting of fruits in mango cv. Raspuri. Shinde *et al.* (2014) concluded that the minimum days were required for flowering to harvesting in T₁ (ringing during first fortnight of May). Soudagar *et al.* (2018) exhibited that the minimum number of days required for harvesting in tip pruning by retaining 2 leaves.

Fruit growth and development by girdling and found that fruit on girdled limbs ripened about a week earlier than on control limbs in peach tree (*Prunus persica* L.) Batsch (Dann *et al.*, 1984). Warang *et al.* (2019) noticed that the minimum days required for harvesting was in T₄ (girdling on first fortnight of September and removal of new shoots). According to Nachare (2020) the minimum days required for flowering to harvesting by girdling in first fortnight of September and removal of new shoots (115 days) in mango cv. Ratna. These results indicate that removal of new shoots and girdling has contributed vital role for accumulation of photosynthates and enable earlier flowering which may have attributed to earlier fruit set and ultimately minimum days for harvesting of fruits in cv. Ratna.

4.11 Effect of girdling, tip pruning and smudging on number of fruits per tree and yield in mango cv. Ratna

The data on effect of girdling, removal of new shoots and smudging on number of fruits per tree in mango cv. Ratna are presented in Table 13 and graphically illustrated with Figure 13.

Table 13. Effect of girdling, tip pruning and smudging on number of fruits and yield of mango cv. Ratna

Treatments	No. of fruits per tree	Yield (kg/tree)
T₁ (Girdling on first fortnight of October)	106.67	43.08
T₂ (Girdling on first fortnight of November)	102.50	41.81
T₃ (Girdling on first fortnight of October and November.)	101.50	41.48
T₄ (Girdling on first fortnight of October and removal of new shoots)	116.33	49.45
T₅ (Girdling on first fortnight of November and removal of new shoots)	145.00	61.58
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	134.67	58.10
T₇ (Removal of new shoots)	126.33	55.23
T₈ (Removal of new shoots below old shoot)	108.50	48.45
T₉ (Smudging)	100.00	40.52
T₁₀ (Control)	88.33	29.47
Range	88.33-145.00	29.47-61.58
Mean	112.98	46.92
SEm ±	2.66	1.11
CD @ 5%	7.89	3.30

The pattern of variation in different treatments:

Number of fruits per tree : T₅>T₆>T₇>T₄>T₈>T₁>T₂>T₃>T₉>T₁₀

Yield (kg/tree) : T₅>T₆>T₇>T₄>T₈>T₁>T₂>T₃>T₉>T₁₀

The maximum number of fruits per tree (145.00) were exhibited by treatment girdling on first fortnight of November and removal of new shoots (T₅) which was significantly superior over all other treatments under the study. It was followed by T₆ (134.67) and T₇ (126.33). Treatment T₁ (106.67), T₂ (102.50) and T₃ (101.50) which were at par with each other. The minimum number of fruits per tree (88.33) was recorded in control (T₁₀).

The maximum yield per tree (61.58 kg/tree) was recorded in girdling on first fortnight of November and removal of new shoots (T₅) It was followed by T₆ (58.10 kg/tree) and T₇ (55.23 kg/tree). Treatments T₁ (43.08 kg/tree), T₂ (41.81 kg/tree) and T₃ (41.48 kg/tree) which were at par with each other. The lowest yield per tree (29.47 kg/tree) was obtained in treatment control (T₁₀).

Girdling can improve carbohydrate availability to fruits and as a consequent lead to an increased fruit set percentage with decreased bud drop due to branch girdling it also leads to increase maximum number of fruit per shoots and maximum fruit weight which help to increased fruit yield kg per plant and fruit yield kg per hectare (Goren *et al.*, 2003). Shinde *et al.* (2014) noticed the highest number of fruits per plant in T₁ (ringing during first fortnight of May) in cv. Alphonso. Warang *et al.* (2019) reported that girdling on first fortnight of the September and removal of new shoots increased the yield. According to Ghadage *et al.* (2017) girdling on 15th July produced significantly maximum yield

(94.20kg/plant) in mango cv. Alphonso. Ibrahim *et al.* (2016) concluded that the highest numbers of the harvested fruits (18.22 and 22.67/ branch in the two seasons) came from girdling branches in Washington Navel Orange. Remarkable response to shoot pruning was observed in mango cv. Mallika. Highest fruit yield (69.20 kg tree) was recorded in 15th June shoot pruned trees (Thirupathi and Ghosh, 2016). Yeshitela *et al.* (2003) noticed highest fruit number (68.8) on trees by post-harvest pruning where terminal shoots were cut back to a suitable node in mango cv. Tommy Atkins. Soudagar *et al.* (2017) concluded that tip pruning by retaining two leaves increased the yield in mango cv. Alphonso. Mahesha and Singh (2018) reported that the highest yield (10.45t/ha) by summer and winter season shoot pruning as compared to the control plant yield is 9.43mt/ha was obtained in Assam lemon. Shaban (2005) reported that heading back of shoots in mango tree cv. Hindi-Bi-Sinnara helped to produced highest number of fruits per tree. Adhikari and Kandel (2015) reported that 20 cm tip removal in guava enhanced the yield. Nachare (2020) recorded highest yield in mango cv. Ratna by girdling in first fortnight of the September and tip pruning (52.63 kg/tree).

These investigation indicates that treatment girdling in first fortnight of November and removal of new shoots was found promising among various treatment with respect to fruit yield. This may be due to girdling which improved carbohydrates availability to earlier development of fruit and even removal of new shoots may have stop the translocation of food to new vegetative growth.

4.12 Effect of girdling, tip pruning and smudging on yield pattern of mango cv. Ratna

The data on girdling, removal of new shoots and smudging on yield pattern in mango cv. Alphonso are presented in Table 14.

The harvesting of T₇, T₅ and T₈ were started in 4th week of May and ended in 2nd week of June. The harvesting of T₁, T₄ and T₆ was commenced in 1st week of June and completed in 3rd week of June. The harvesting of T₂, T₃, T₉ and T₁₀ was started in 2nd week of June and ended in 3rd week of June.

The prevailing trend of rate per kg of market indicated that during last week of May the raw mango fruits were sold @ RS. 50 per kg which reduced to RS. 20 per kg during 1st week to 3rd week of June. The girdling and tip pruning treatments helped to induce early flowering which further leads to early harvesting which gave better returns.

Table 14. Effect of girdling, tip pruning and smudging on yield pattern in mango cv. Ratna

Treatments	Weekly interval Harvest (Kg/tree)				
	4 th week of May	1 st week of June	2 nd week of June	3 rd week of June	Total
T ₁	-	10.5	18.08	14.5	43.08
T ₂	-	-	20	21.81	41.81
T ₃	-	-	23.18	18.8	41.48
T ₄	-	5.8	31.5	12.15	49.45
T ₅	17.7	18.68	25.2	-	61.58
T ₆	-	21.2	28.5	10.67	60.37
T ₇	11.2 3	17.53	26.47	-	55.23
T ₈	10.6	24.4	16.45	-	48.45
T ₉	-	-	23.6	16.92	40.52
T ₁₀	-	-	24.2	8.86	33.06
				Total	475.03
Rate of fruits (Rs. / kg)	50	20	20	20	

4.13 Effect of girdling, tip pruning and smudging on production economics (B:C ratio) of mango cv. Ratna

The data on girdling, removal of new shoots and smudging on production economics (B:C ratio) in mango cv. Ratna are presented in Table 15. The treatment girdling on first fortnight of November (T₅) had the highest gross return (Rs. 212451) as well as maximum net profit (Rs. 133281.70) with highest B:C ratio (2.68). It was followed by T₆ (2.40), T₇ (2.37), T₈ (2.13), T₄ (1.96), T₁ (1.72), T₃ (1.67), T₂ (1.58) and T₉ (1.44). The lowest B:C ratio (1.19) was noticed in control (T₁₀). The results in present investigation are in similar lines with findings of Warang *et al.* (2019) in mango cv. Alphonso and Nachare (2020) in mango cv. Ratna.

Table 15. Effect of girdling, tip pruning and smudging on production economics (B:C ratio) in mango cv. Ratna

Treatment	Yield (t/ha)	Expenditure Incurred (Rs. /ha)	Gross return (Rs. /t)	Net. Profit	B:C ratio
T₁ (Girdling on first fortnight of October)	4.31	56435.8	96930	40494.20	1.72
T₂ (Girdling on first fortnight of November)	4.18	54635.57	86128.6	31493.03	1.58
T₃ (Girdling on first fortnight of October and November.)	4.15	58183.10	96973.8	38790.70	1.67
T₄ (Girdling on first fortnight of October and removal of new shoots)	4.95	62377.72	122141.5	59763.78	1.96
T₅ (Girdling on first fortnight of November and removal of new shoots)	6.16	79169.30	212451	133281.7 0	2.68
T₆ (Girdling on first fortnight of October and November and removal of new shoots)	6.04	73020.13	175555.9 6	102535.8 3	2.40
T₇ (Removal of new shoots)	5.52	66515.05	157405.5	90890.45	2.37
T₈ (Removal of new shoots below old shoot)	4.84	62447.18	132998.2 5	70551.08	2.13
T₉ (Smudging)	4.05	55243.83	79338.16	24094.33	1.44
T₁₀ (Control)	3.31	47775.55	57028.5	9252.95	1.19

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled “Studies on effect of special horticultural practices on induction of flowering in mango (*Mangifera indica* L.) cv. Ratna” was undertaken at College of Horticulture, Dapoli during the year 2020-21. During the course of study, the morphological, yield parameters, physical and chemical parameters at harvest and ripe stages were studied. The data obtained regarding all the parameters were analyzed statistically as per the method prescribed by Panse and Sukhatme (1995). The method of experimentation and the respective findings of investigation for data are summarized and concluded below.

5.1 Days required for panicle emergence

The least days (40.83 days) for induction of flowering were recorded by treatment removal of new shoots (T₇) which was at par with T₈ (removal of new shoots below old shoot) (42.33 days) and T₅ (girdling on first fortnight of November and removal of new shoots) (49.83 days) and significantly superior over all other treatments under the study. Treatment T₄ (girdling on first fortnight of October and removal of new shoots) (64.83 days) whereas treatment T₉ (smudging) (65.50 days) were at par with each other. In control T₁₀, it took 131.33 days for induction of flowering followed by T₃ (girdling on first fortnight of October and November) (94.17 days) and T₁ girdling on first fortnight of October (91.33 days).

5.2 Flowering intensity (%)

The maximum flowering intensity (62.27%) was observed in girdling on first fortnight of November and removal of new shoots

(T₅) which was at par with T₆ (60.83%) and T₄ (59.17%) followed by treatment T₇ (52.50%). Treatment T₂ (43.33%), T₈ (42.50%), T₃ (41.67%) and T₁ (38.33%) were at par with each other. The minimum flowering intensity (26.67%) was recorded in control.

5.3 Morphological parameters

5.3.1 Length of panicle (cm)

The data on length of panicle were showed that girdling on first fortnight of November and removal of new shoots (T₅) registered longest panicle (30.20 cm) which was at par with T₈ (29.20 cm) and T₆ (28.83 cm) and significantly superior over all other treatments. It was followed by T₇ (27.67 cm), T₉ (27.47 cm) and T₁ (26.30 cm). The shortest panicle (24.13 cm) was found in treatment girdling on first fortnight of November (T₂) which was at par with T₃ (25.10 cm), T₄ (25.20 cm) and T₁₀ (25.57 cm).

5.3.2 Width of panicle (cm)

The data on width of panicle revealed that the maximum panicle width (24.63 cm) was observed in treatment girdling on first fortnight of November and removal of new shoots (T₅) and it was at par with T₃ (23.67cm) and T₄ (22.97 cm) and significantly superior over all other treatments. Treatments T₆ (21.57 cm), T₁ (20.87 cm), T₉ (20.40 cm), T₈ (19.97 cm), T₂ (19.97 cm), and T₇ (19.67 cm) were at par with each other. The minimum panicle width (17.27 cm) was found in control (T₁₀).

5.3.3 Number of rachis per panicle

The highest number of rachis per panicle (31.57) were noted in treatment removal of new shoots below old shoot (T₈) which was at par with T₅ (30.63), T₄ (29.77), T₆ (29.77), T₃ (28.97). Treatment T₂ (28.33), T₉ (27.67), T₇ (26.73) and T₁₀ (26.20) were at par with

each other. The lowest number rachis per panicle (25.30) were recorded in girdling on first fortnight of October (T₁).

5.3.4 Hermaphrodite flowers (%)

The highest per cent of hermaphrodite flowers (15.01 %) were recorded in treatment girdling on first fortnight of November and removal of new shoots (T₅) which was at par with T₆ (14.75 %) and T₄ (14.50 %) and significantly superior over all other treatments. Treatments T₇ (13.30 %), T₁ (12.43 %), T₂ (12.17 %), T₈ (12.10 %) and T₃ (12.07%) were at par with each other. The lowest per cent of hermaphrodite flowers (10.98 %) were observed in control (T₁₀).

5.3.5 Fruit set

There was significant difference among treatments for fruit set per panicle in mango cv. Ratna. The treatment girdling on first fortnight of November and removal of new shoot (T₅) had maximum fruit set per panicle (8.53) which was at par with T₆ (8.23) and significantly superior over other treatments. Treatment T₁ (6.30), T₂ (6.00) and T₈ (5.97) were at par among themselves. The minimum fruit set (5.03) was noted in control (T₁₀) which was inferior to all other treatments.

5.3.6 Fruit retention (%)

The highest fruit retention per panicle (0.95) was observed in treatment girdling on first fortnight of November and removal of new shoots (T₅) which was significantly superior over other treatments and it was followed by T₆ (0.87 %). The lowest fruit retention (0.50%) was noted in control (T₁₀) which was inferior to all other treatments.

5.4 Physical parameters at harvest stage

5.4.1 Average fruit weight (g)

The maximum average weight (448.27g) of mango fruit at harvest was observed in treatment girdling on first fortnight of October and November and removal of new shoots (T₆) which was at par with T₅ (446.53g) and T₈ (445.43g) and significantly superior over other treatments. It was followed by T₇ (437.17g) and T₄ (425.10g). Treatment T₃ (408.63g), T₂ (407.90g) and T₁ (405.23g) were at par with each other. The minimum average weight of fruit (374.27g) was seen in control (T₁₀).

5.4.2 Length and diameter of fruit (cm)

The treatment girdling on first fortnight of October and November and removal of new shoots (T₆) registered maximum fruit length (12.93 cm) which was at par with T₅ (12.60 cm) and T₈ (12.43 cm) and significantly superior over other treatments. It was followed by T₇ (12.18). Treatment T₃ (11.41 cm), T₇ (11.33 cm) and T₂ (10.72 cm) were at par with each other. It was followed by T₉ (10.34 cm) and T₁ (10.22 cm). The minimum length (9.53 cm) of fruit was found in control (T₁₀).

The maximum fruit diameter (9.55cm) was found in girdling on first fortnight of October and November and removal of new shoots (T₆) and it was at par with T₈ (9.38cm) and T₅ (9.30cm) and significantly superior over other treatments. Treatment T₄ (9.21cm) and T₃ (9.15cm) were at par with each other. It was followed by T₄ (9.21cm) and T₃ (9.15cm).The minimum fruit diameter (7.96cm) was seen in control (T₁₀).

5.4.3 Pulp weight (g)

At harvest stage, the highest pulp weight (341.03g) was seen in treatment girdling on first fortnight of November and removal

of new shoots (T₅) which was at par with T₆ (337.03g) and significantly superior over other treatments. It was followed by T₈ (323.60g). Treatment T₇ (308.20g) and T₄ (307.20g) were at par with each other. It was followed by treatment T₂ (280.33g) T₃ (279.37g) and T₁ (270.67g). The lowest pulp weight (243.21g) was noticed in control (T₁₀) which at par with T₉ (249.20g).

5.4.4 Pulp to stone ratio

The data on pulp stone ratio indicated that there was significant difference among treatments. The treatment girdling on first fortnight of November and removal of new shoots (T₅) had maximum pulp stone ratio (6.24) and it was at par with T₆ (6.08) and significantly superior over other treatments. Treatment T₈ (5.65) and T₇ (5.54) were at par with each other. It was followed by T₂ (4.87), T₄ (4.68) and T₃ (4.67). The minimum pulp stone ratio (3.95) was seen in control (T₁₀) and it was at par with T₉ (4.06).

5.5 Physical parameters at ripe stage

5.5.1 Average fruit weight (g)

The variation recorded for all treatments at ripe stage for fruit weight (g) was found significant. The maximum fruit weight (418.60 g) was obtained from treatment girdling on first fortnight of October and November and removal of new shoots (T₆) was at par with T₅ (414.77g) and T₈ (411.43g) and significantly superior over other treatments. Treatment T₇ (407.43g) and T₄ (404.73g) were at par with each other. It was followed by T₃ (392.73g) T₂ (389.37g) and T₁ (387.63g). The minimum fruit weight (341.43g) was noticed in control (T₁₀) followed by T₉ (362.63g).

5.5.2 Pulp weight (g)

The highest pulp weight (325.13g) was seen in treatment girdling on first fortnight of October and November and removal of new shoots (T₆) and significantly superior over all other treatments. It was followed by T₅ (308.17g) and T₈ (307.63g). Treatment T₄ (290.43g) and T₇ (290.30g) were at par with each other. It was followed by T₂ (258.93g), T₃ (257.87g) and T₁ (254.93g). The lowest pulp weight (217.20g) was found in smudging (T₉) followed by T₁₀ (220.93g).

5.5.3 Pulp to stone ratio

The treatment girdling on first fortnight of November and removal of new shoots (T₅) had maximum pulp stone ratio (6.11) and significantly superior over remaining treatments. It was followed by T₆ (5.71). Treatment T₇ (5.22) and T₈ (5.13) were at par with each other. The minimum pulp to stone ratio (3.74) was seen in control (T₁₀).

5.6 Chemical parameters at harvest stage

5.6.1 TSS (°B)

The data regarding TSS (°B) at harvest stage found non-significant differences among various treatments. The TSS ranges from (9.83°B) to (10.70°B) and the mean TSS was (10.38°B).

5.6.2 Reducing sugars (%)

The data on reducing sugars (%) in mango cv. Ratna had non-significant trend. The reducing sugars ranges from (1.25%) to (1.90%) and average reducing sugars was (1.58%).

5.6.3 Total sugars (%)

The effect of various treatments on total sugars (%) was non-significant. The total sugars ranging from (3.15%) to (3.41%) with mean (3.31%).

5.6.4 Titratable acidity (%)

The effect of various treatments on titratable acidity (%) was non-significant. The titratable acidity ranging from (2.65%) to (3.53%) with mean (3.13%).

5.6.5 pH

The data on pH in mango cv. Ratna had non-significant trend. The pH ranges from 2.60 to 2.93 with an average 2.70.

5.6.6 Ascorbic acid (mg/100g)

The data on ascorbic acid in mango cv. Ratna had non-significant trend. It ranges from 65.30 mg/100g to 76.27 mg/100g.

5.7 Chemical parameters at ripe stage

5.7.1 TSS (°B)

The data regarding TSS (°B) at ripe stage found non-significant differences among various treatments. The TSS ranges from (20.79°B) to (22.54°B) and the mean TSS was (21.78°B).

5.7.2 Reducing sugars (%)

The data on reducing sugars (%) in mango cv. Ratna had non-significant trend. The reducing sugars ranges from (2.57%) to (4.13%) and average reducing sugars was (3.24%).

5.7.3 Total sugars (%)

The effect of various treatments on total sugars (%) was non-significant. The total sugars ranging from (12.47%) to (14.83%) with mean (13.41%).

5.7.4 Titratable acidity (%)

The effect of various treatments on titratable acidity (%) was non-significant. The titratable acidity ranging from (0.18%) to (0.23%) with mean (0.20%).

5.7.5 pH

The data on pH in mango cv. Ratna had non-significant trend. The pH ranges from 4.07 to 4.90 with an average 4.45.

5.7.6 Ascorbic acid (mg/100g)

The data on ascorbic acid in mango cv. Ratna had non-significant trend. It ranges from 47.47 mg/100g to 59.07 mg/100g.

5.8 Days required from flowering to harvesting

The various treatments significantly influenced the days required from flowering to harvesting. The minimum days required for harvesting (134.87 days) were seen in removal of new shoots (T₇) which was at par with T₅ (141.07 days) and T₈ (141.67 days) and significantly superior over remaining treatments. Treatment T₄ (147.5 days), T₉ (149.33 days), T₂ (149.67) and T₁ (150.33) were at par with each other. The maximum number of days required for harvesting (165.00 days) were observed in control (T₁₀) was followed by T₃ (156.33 days) and T₆ (155.73 days).

5.9 Number of fruits per tree

The maximum number of fruits per tree (145.00) were exhibited by treatment girdling on first fortnight of November and removal of new shoots (T₅) which was significantly superior over all other treatments under the study. It was followed by T₆ (134.67) and T₇ (126.33). Treatment T₁ (106.67), T₂ (102.50) and T₃ (101.50) which were at par with each other. The minimum number of fruits per tree (88.33) was recorded in control (T₁₀).

5.10 Yield (kg/tree)

The maximum yield per tree (61.58 kg/tree) was recorded in girdling on first fortnight of November and removal of new shoots (T₅). It was followed by T₆ (58.10 kg/tree) and T₇ (55.23 kg/tree). Treatment T₁ (43.08 kg/tree), T₂ (41.81 kg/tree) and T₃ (41.48 kg/tree) which were at par with each other. The lowest yield per tree (29.47 kg/tree) was obtained in treatment control (T₁₀).

5.11 Yield pattern

The harvesting of T₇, T₅ and T₈ were started in 4th week of May and ended in 2nd week of June. The harvesting of T₁, T₄ and T₆ was commenced in 1st week of June and completed in 3rd week of June. The harvesting of T₂, T₃, T₉ and T₁₀ was started in 2nd week of June and ended in 3rd week of June.

The prevailing trend of rate per kg of market indicated that during last week of May the raw mango fruits were sold @ RS. 50 per kg which reduced to RS. 20 per kg during 1st week to 3rd week of June. The girdling and tip pruning treatments helped to induce early flowering which further leads to early harvesting which gave better returns.

5.12 Production economics (B:C ratio)

The data treatment, T₅ had the highest gross return (Rs. 212451) as well as maximum net profit (Rs. 133281.70) with highest B:C ratio (2.68). It was followed by T₆ (2.40), T₇ (2.37), T₈ (2.13), T₄ (1.96), T₁ (1.72), T₃ (1.67), T₂ (1.58) and T₉ (1.44). The lowest B:C ratio (1.19) was noticed in control (T₁₀).

Conclusion

From the present findings, it can be concluded that girdling, tip pruning (removal of new shoots) and smudging in mango cv. Ratna are beneficial for early induction of flowering and early harvesting. The treatment T₇ (tip pruning) was the best for early induction of flowering with early harvesting. The treatment T₅ (girdling on first fortnight of November and tip pruning) had contributed for highest yield. Girdling, tip pruning and smudging did not influence the chemical composition of mango fruits. As this is only one year study, to observe the consistency of results a continues research for another few seasons is essential for confirmation of results.

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APPENDIX I

ABBREVIATIONS USED

%	:	per cent
&	:	and
/	:	per
@	:	At the rate
°B	:	degree Brix
°C	:	degree Celsius
µg	:	microgram
Anon.	:	Anonymous
BSS	:	Bright sunshine
C.D.	:	critical difference
cm	:	Centimeter (s)
cv.	:	cultivar
Dr.	:	doctor
Epan	:	Evaporation pan
<i>et al.</i>	:	and others
fig.	:	figure
FYM	:	Farm Yard Manure
g	:	gram
GA ₃	:	Gibberellic acid
ha	:	hectare
hrs.	:	hours
i.e.	:	Id est “that is”
K ₂ O	:	Potassium oxide
kg	:	Kilogram (s)
Kmph	:	Kilometer per hour
KNO ₃	:	Potassium nitrate
L.	:	Linnaeus
m	:	Meter (s)

M.S.	:	Maharashtra
Max.	:	Maximum
mg	:	Milligram (s)
Min.	:	Minimum
ml	:	Milliliter (s)
mm	:	Millimeter (s)
MSL	:	Mean sea level
MT	:	Metric tone
N	:	Nitrogen
no.	:	Number
NS	:	Non-significant
P ₂ O ₅	:	Phosphorous pentoxide
ppm	:	Parts per million
R.H.	:	Relative humidity
RD	:	Rainy day
S.E.	:	Standard error
t	:	tone (s)
TSS	:	Total soluble solids
var.	:	variety
viz.	:	Namely

APPENDIX II

Weekly weather data during the period of study at Dapoli (October 2020 to June 2021)

Period	MW	Tmax	Tmin	RH-I	RH-II	Wind speed	Rain	RD	BSS	Epan
		(°C)	(°C)	(%)	(%)	(Kmph)	(mm)	(day)	(hrs.)	(mm)
01.10 - 07.10	40	30.1	22.7	95.4	81.7	2.6	3.5	0.0	3.8	3.1
08.10 - 14.10	41	31.4	23.1	94.4	84.1	2.5	3.9	0.0	4.3	3.0
15.10 - 21.10	42	29.6	22.7	94.6	83.3	4.5	15.3	0.0	2.8	2.5
22.10 - 28.10	43	31.3	22.5	94.6	77.4	2.6	1.4	0.0	5.6	3.0
29.10 - 04.11	44	33.1	19.1	90.1	54.1	2.1	0.0	0.0	9.4	3.4
05.11 - 11.11	45	32.9	15.4	85.1	46.1	2.2	0.0	0.0	9.8	3.6
12.11 - 18.11	46	33.3	17.4	88.6	51.1	2.3	0.0	0.0	10.4	3.7
19.11 - 25.11	47	33.4	18.8	89.7	57.4	2.4	0.0	0.0	9.3	3.5
26.11 - 02.12	48	32.6	17.6	83.6	48.4	2.9	0.0	0.0	8.5	3.3
03.12 - 09.12	49	33.3	13.1	86.4	48.6	2.2	0.0	0.0	9.2	3.3
10.12 - 16.12	50	31.2	19.4	94.4	73.4	1.8	1.1	0.0	4.6	2.4
17.12 - 23.12	51	32.4	12.7	93.4	71.1	2.3	0.0	0.0	8.6	3.1
24.12 - 31.12	52	32.4	13.1	95.3	78.0	2.1	0.0	0.0	8.5	3.0
01.01 - 07.01	1	32.0	18.5	95.6	65.6	2.5	0.0	0.0	5.3	2.9
08.01 - 14.01	2	32.7	19.3	94.4	60.7	2.6	2.3	0.3	5.9	2.9
15.01 - 21.01	3	32.4	15.6	93.9	54.1	2.7	0.0	0.0	7.8	3.2
22.01 - 28.01	4	31.5	12.9	94.3	48.7	2.8	0.0	0.0	8.4	3.3
29.01 - 04.02	5	32.7	12.8	91.0	47.1	3.1	0.0	0.0	8.6	3.5
05.02 - 11.02	6	33.4	11.2	88.1	54.3	3.3	0.0	0.0	9.3	4.2
12.02 - 18.02	7	31.5	14.1	92.4	65.3	3.5	0.0	0.0	8.3	3.9
19.02 - 25.02	8	33.3	15.2	88.1	55.0	3.4	0.1	0.0	7.3	4.0
26.02 - 04.03	9	35.8	15.0	85.9	51.0	3.5	0.0	0.0	9.8	4.7
05.03 - 11.03	10	35.0	14.9	90.6	48.4	3.5	0.0	0.0	9.4	4.7
12.03 - 18.03	11	34.3	16.2	87.3	49.4	3.6	0.0	0.0	9.0	4.8
19.03 - 25.03	12	34.4	17.2	85.9	46.3	4.0	0.0	0.0	8.1	5.1
26.03 - 01.04	13	36.2	17.4	84.3	53.0	4.2	0.0	0.0	9.2	5.9
02.04 - 08.04	14	33.1	18.8	88.1	60.4	4.3	0.0	0.0	8.9	5.5
09.04 - 15.04	15	34.3	20.1	87.4	61.7	4.3	0.0	0.0	7.9	5.2
16.04 - 22.04	16	33.6	19.9	88.7	64.9	5.1	0.0	0.0	10.1	5.6
23.04 - 29.04	17	34.0	20.6	86.0	60.3	4.8	0.0	0.0	9.2	5.4
30.04 - 06.05	18	34.7	22.3	80.4	58.6	4.8	0.0	0.0	9.6	5.4
07.05 - 13.05	19	34.2	22.2	81.1	59.9	4.9	0.0	0.0	10.0	5.4
14.05 - 20.05	20	33.2	23.6	83.7	66.3	9.3	205.6	5.0	3.2	4.1
21.05 - 27.05	21	32.6	23.7	84.3	65.3	5.5	0.0	0.0	8.2	4.4
28.05 - 03.06	22	32.9	23.9	88.6	69.6	5.2	92.6	2.0	7.2	3.7
04.06 - 10.06	23	30.8	22.4	95.3	79.6	3.7	279.8	5.0	4.6	2.0
11.06 - 17.06	24	28.3	22.3	96.1	88.4	5.6	581.6	7.0	1.0	0.8
18.06 - 24.06	25	29.7	22.6	92.7	85.9	7.3	332.6	7.0	2.2	2.1

5.	Interest on working capital (@ 6% for 12 months)	1447.8	1447.8	1537.8	1537.8	1627.8	1627.8	1447.8	1447.8	1537.8	1357.8
6.	Interest on fixed capital	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7.	Rental value of land (1/6 th of the gross value - land revenue)	16155.00	14354.77	16162.30	20356.92	35408.50	29259.33	26234.25	22166.38	13223.03	9504.75
8.	Supervision charges (@10 % input cost)	2413	2413	2563	2563	2713	2713	2413	2413	2563	2263
9.	Amortization value	9740	9740	9740	9740	9740	9740	9740	9740	9740	9470
	Total Cost	56435.80	54635.57	58183.10	62377.72	79169.30	73020.13	66515.05	62447.18	55243.83	47775.55
10.	Yield and gross returns										
	Main Product	4308	4181	4198	4945	6158	6037	5523	5145	4052	3306
	Gross return	96930	86128.6	96973.8	122141.5	212451	175555.96	157405.5	132998.25	79338.16	57028.5
11.	Net return at:										
	1. Input cost	72800	61998.6	71343.8	96511.5	185321	148425.96	133275.5	108868.3	53708.16	34398.5
	2. Total cost	40494.20	31493.03	38790.70	59763.78	133281.70	102535.83	90890.45	70551.08	24094.33	9252.95
12.	Input output ratio	4.02	3.57	3.78	4.77	7.83	6.47	6.52	5.51	3.10	2.52
13.	Cost benefit ratio	1.72	1.58	1.67	1.96	2.68	2.40	2.37	2.13	1.44	1.19
14.	Cost per kg	22.50	20.60	23.10	24.70	34.50	29.08	28.50	25.85	19.58	17.25



Plate 1: Girdling on first fortnight of October



Plate 2: Girdling on first fortnight of November



Plate 3: Girdling on first fortnight of October and November

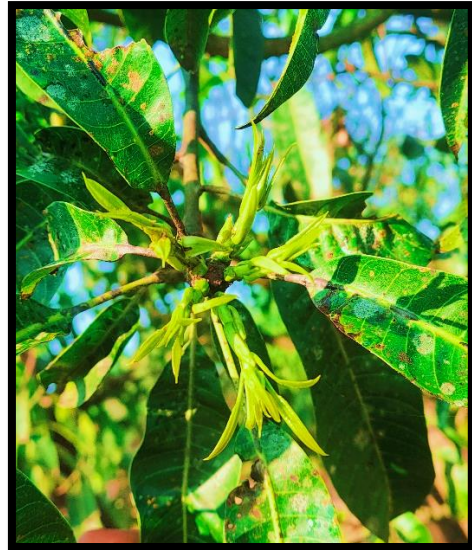


Plate 4: Tip Pruning

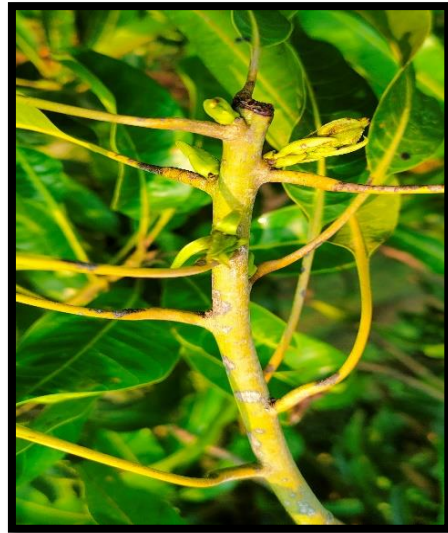
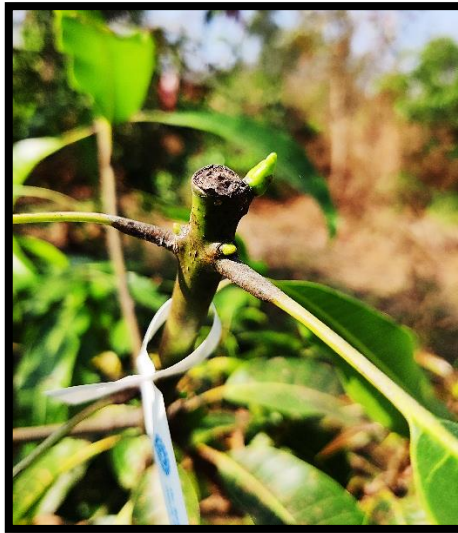
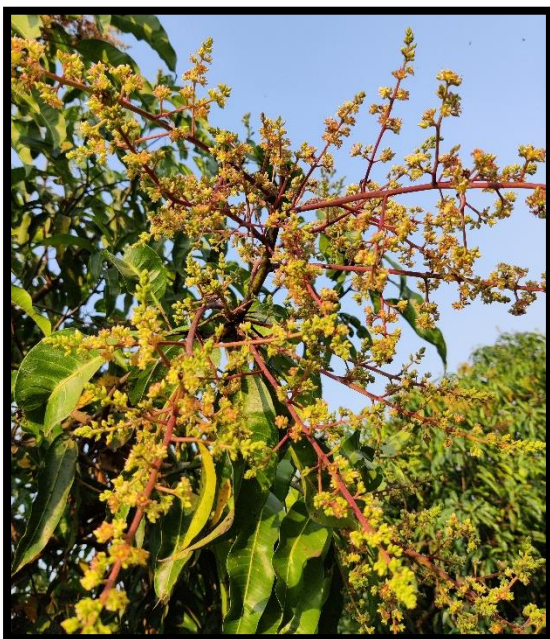


Plate 5: Removal of new shoots below old shoot



Plate 6: Smudging



Flowering



Fruit Set

Plate 7: Best treatment: T₅ (Girdling on first fortnight of November and tip pruning)

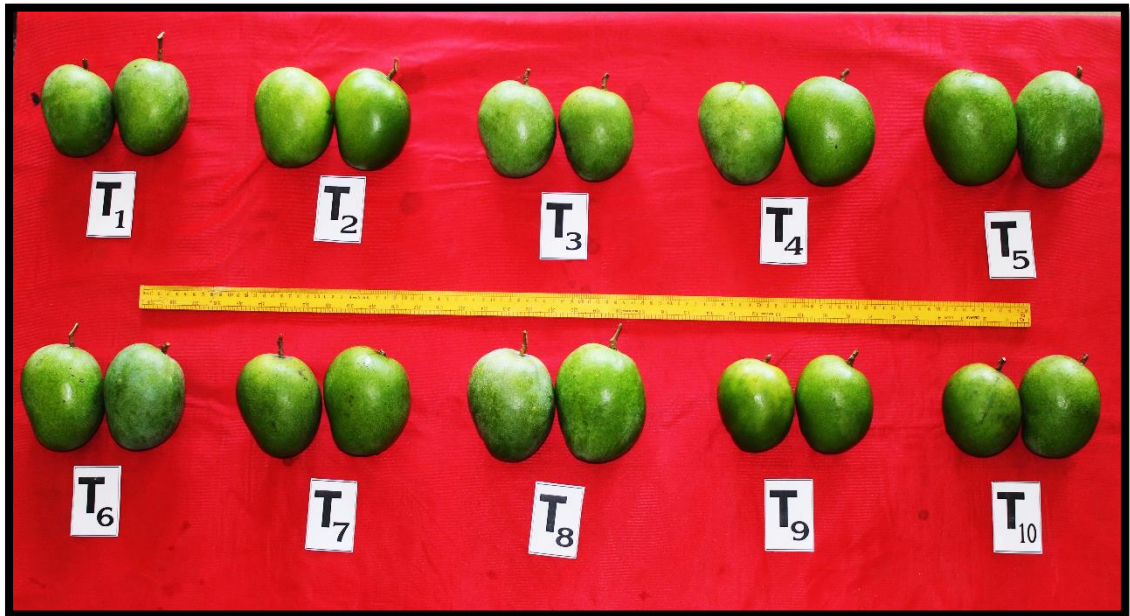


Plate 8: Fruits at harvest stage

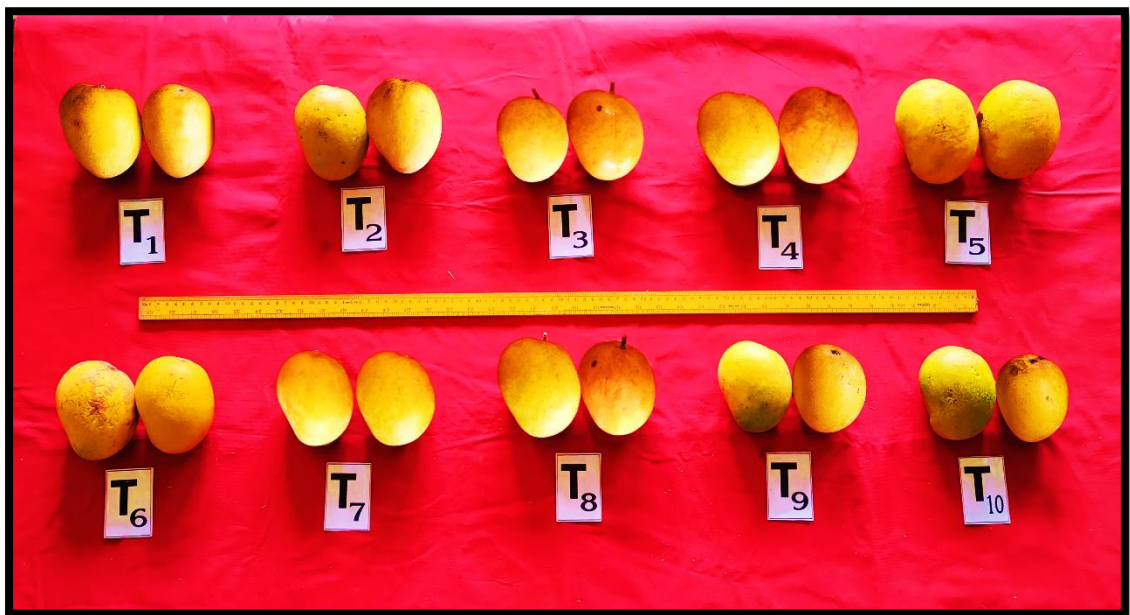


Plate 9: Fruits at ripe stage

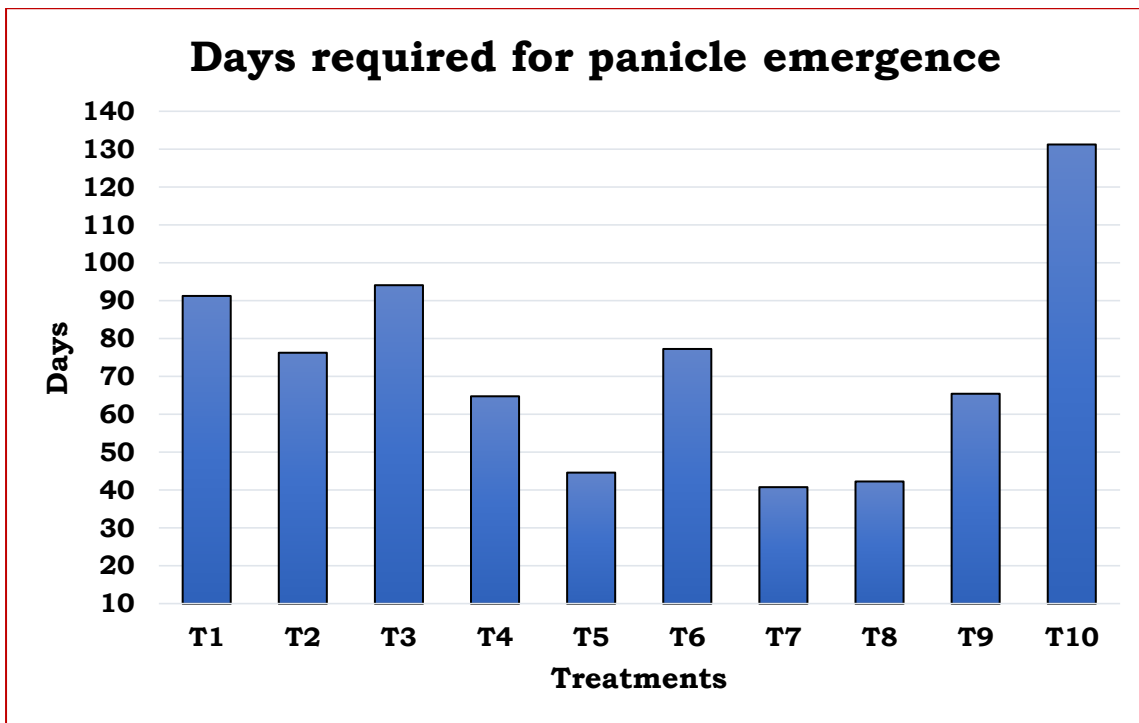


Fig. 1. Effect of girdling, tip pruning and smudging on number of days required for panicle emergence in mango cv. Ratna from treatment exposure

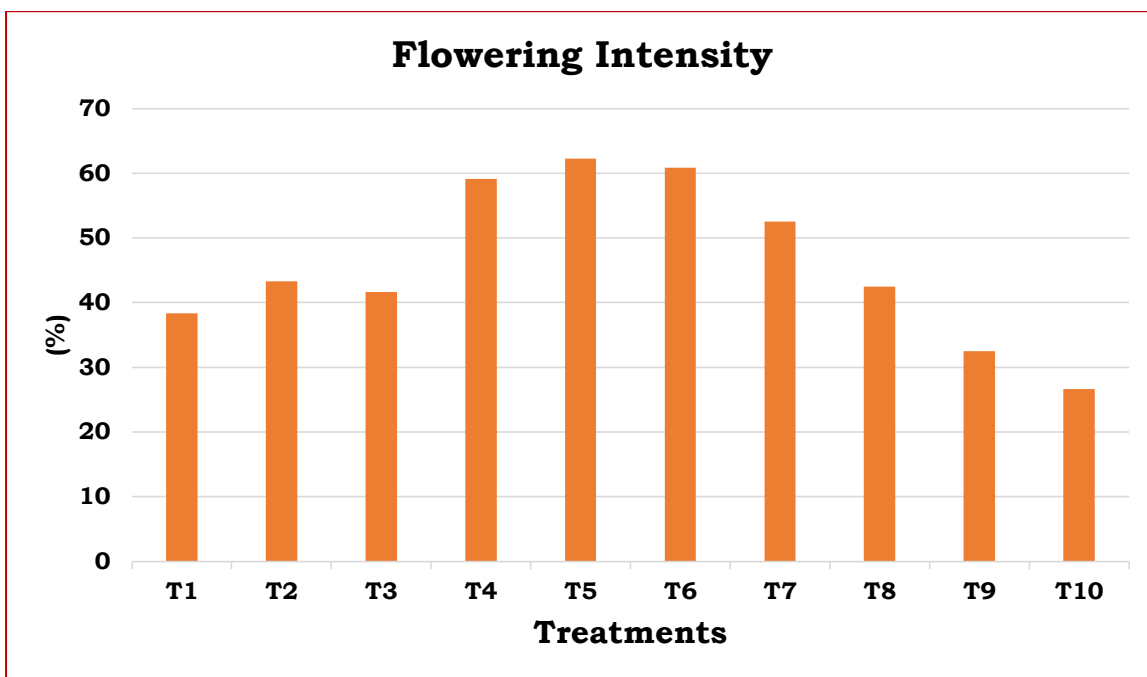


Fig. 2. Effect of girdling, tip pruning and smudging on flowering intensity in mango cv. Ratna.

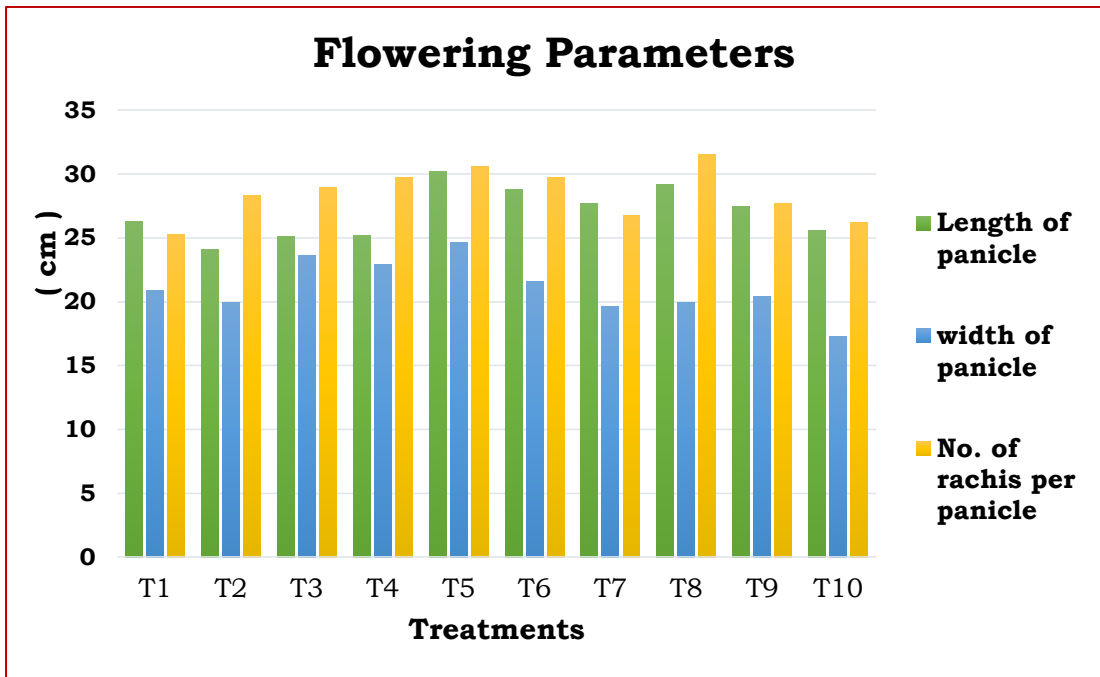


Fig. 3. Effect of girdling, tip pruning and smudging on length of panicle, width of panicle and rachis per panicle in mango cv. Ratna.

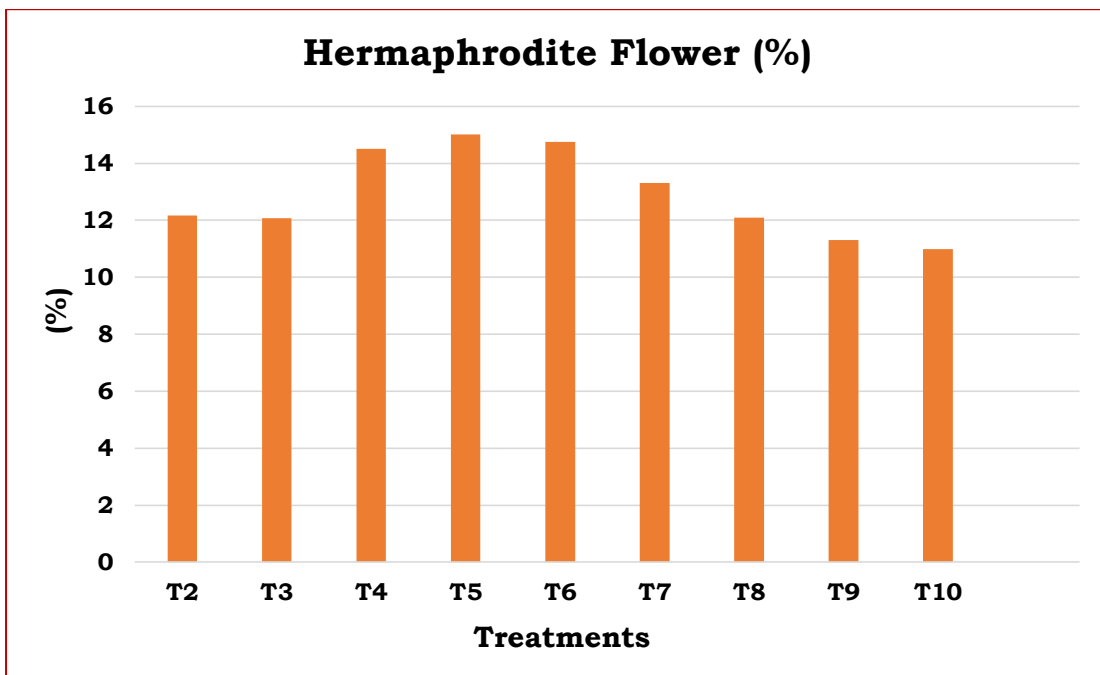


Fig. 4. Effect of girdling, tip pruning and smudging on hermaphrodite flower in mango cv. Ratna.

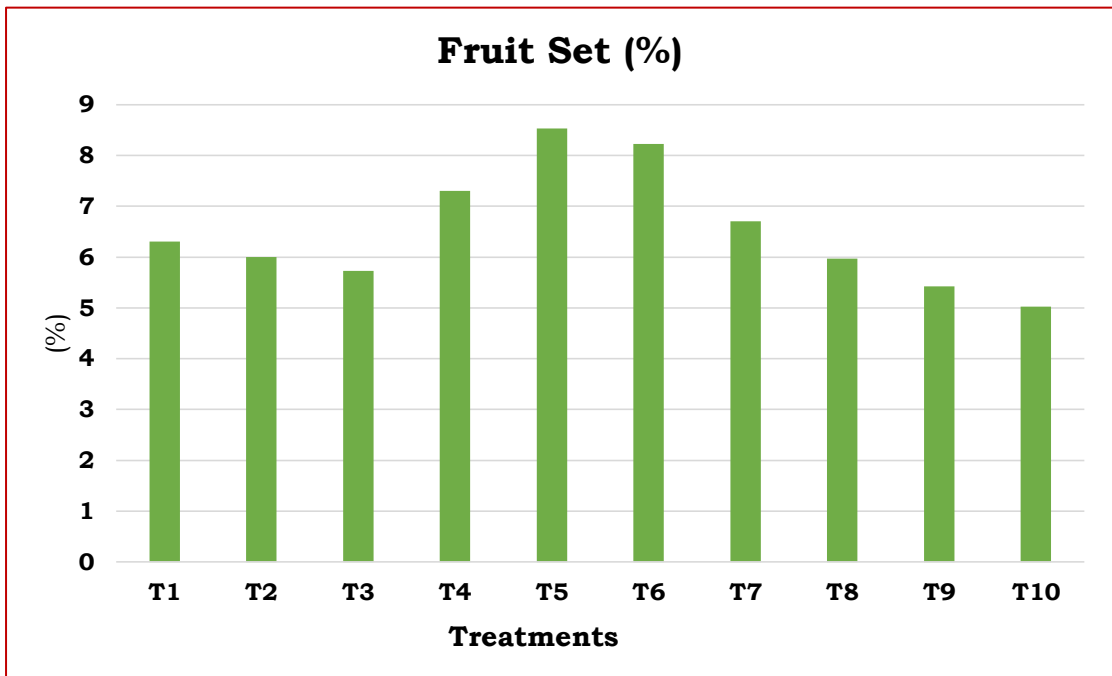


Fig. 5a. Effect of girdling, tip pruning and smudging on fruit set per panicle in mango cv. Ratna.

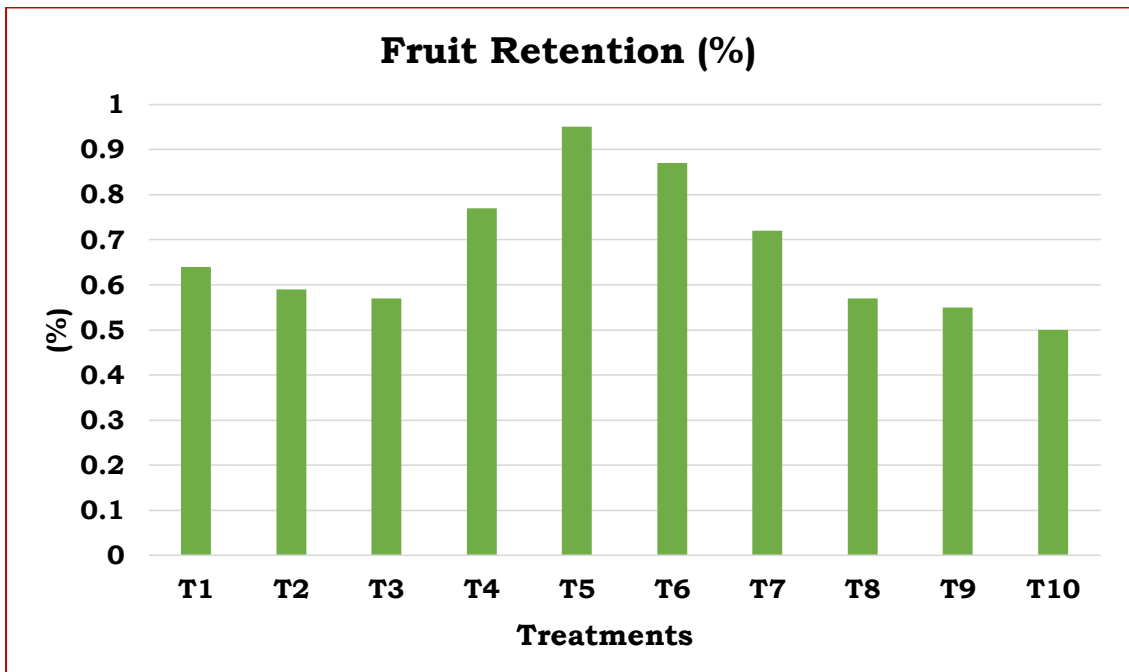


Fig. 5b. Effect of girdling, tip pruning and smudging on fruit retention per panicle in mango cv. Ratna.

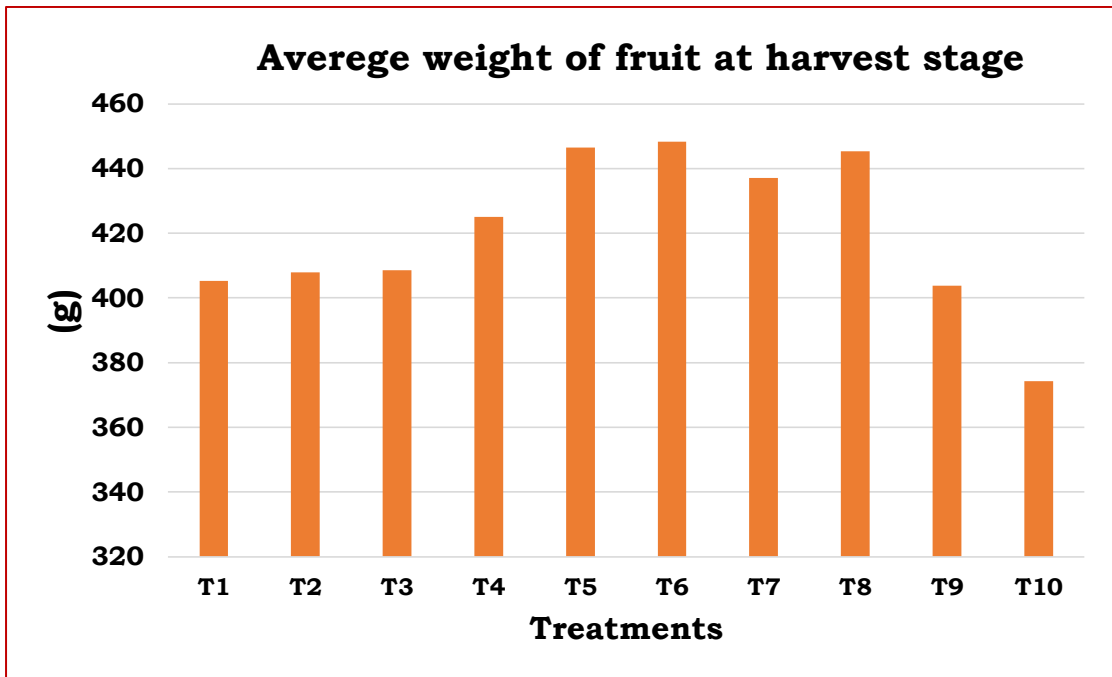


Fig. 6a. Effect of girdling, tip pruning and smudging on average weight of fruit in mango cv. Ratna.

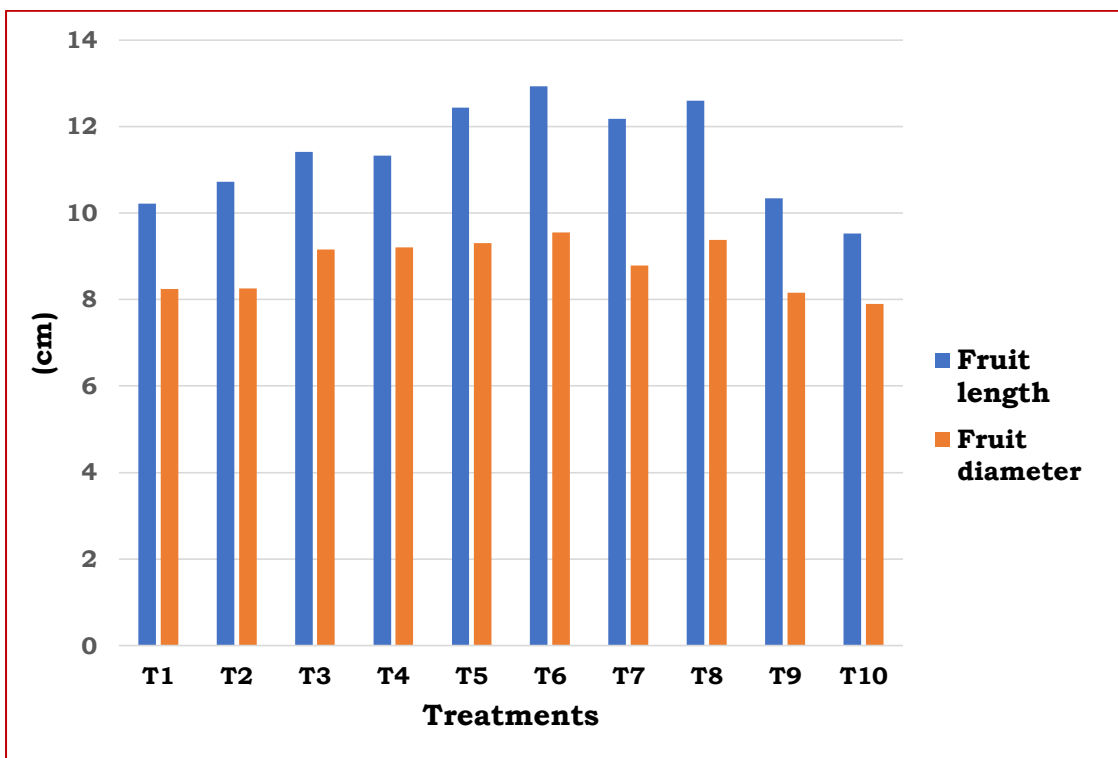


Fig. 6b. Effect of girdling, tip pruning and smudging on fruit length and diameter of fruit in mango cv. Ratna.

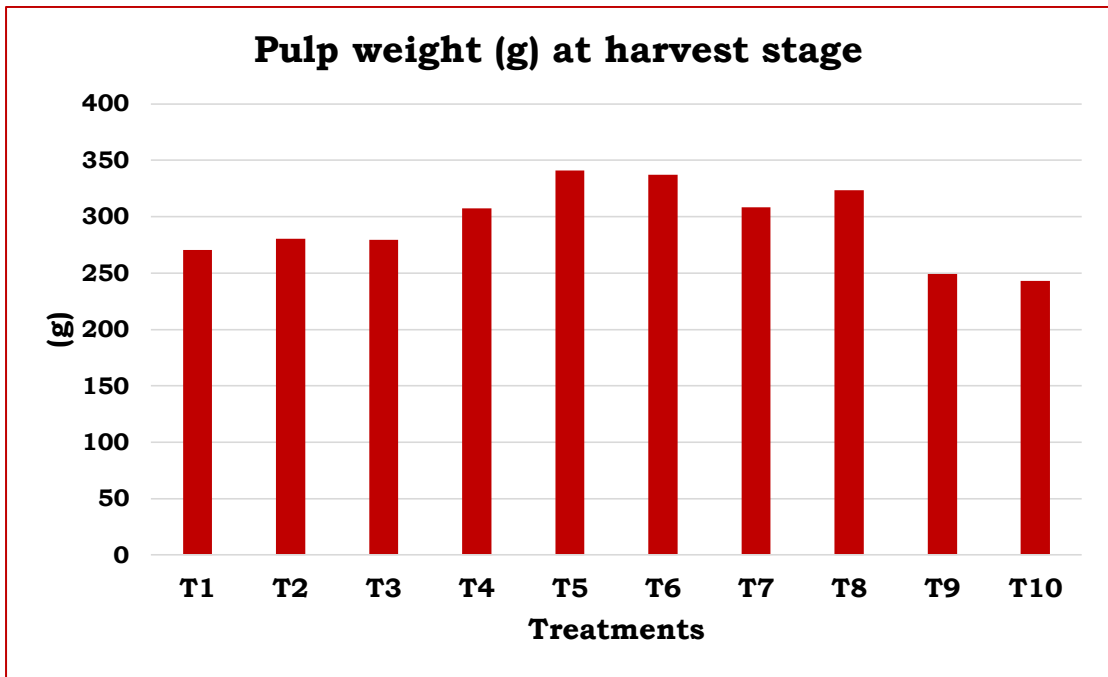


Fig. 7a. Effect of girdling, tip pruning and smudging on pulp weight of fruit at harvest in mango cv. Ratna.

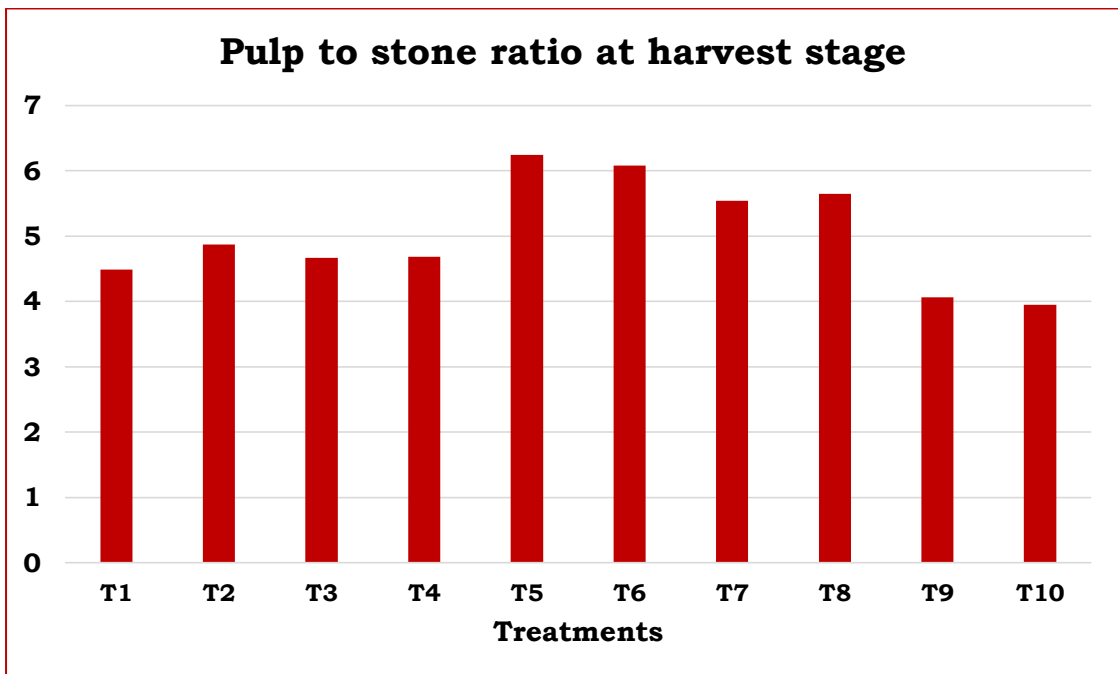


Fig. 7b. Effect of girdling, tip pruning and smudging on pulp to stone ratio of fruit at harvest stage in mango cv. Ratna.

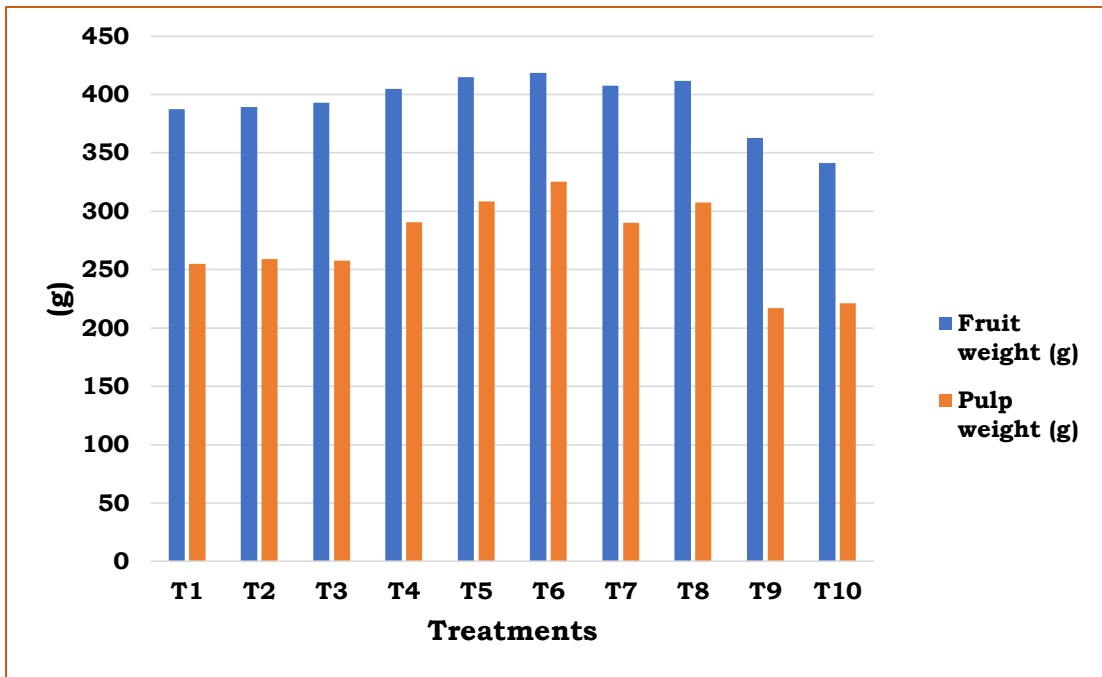


Fig. 8a. Effect of girdling, tip pruning and smudging on fruit weight and pulp weight at ripe stage in mango cv. Ratna.

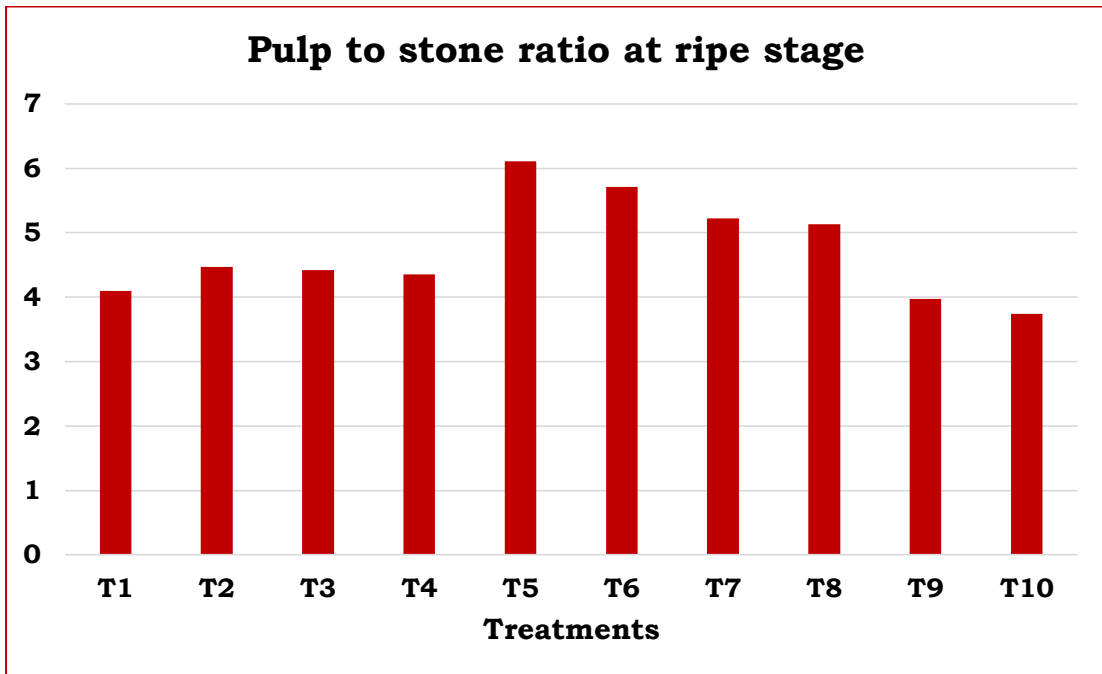


Fig. 8b. Effect of girdling, tip pruning and smudging on pulp to stone ratio of fruit at ripe stage in mango cv. Ratna.

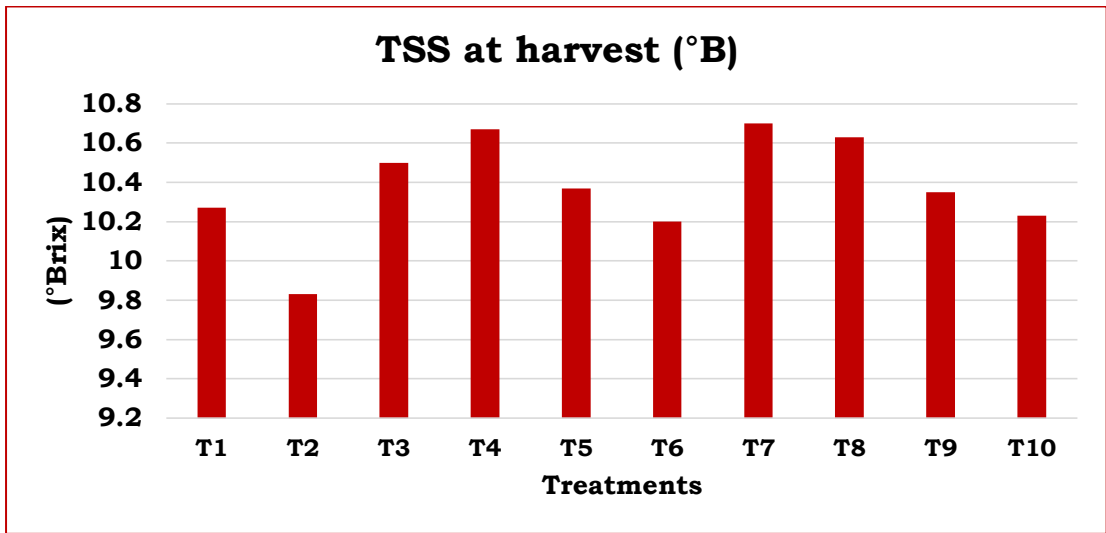


Fig. 9a. Effect of girdling, tip pruning and smudging on TSS (°B) of fruit at harvest stage in mango cv. Ratna.

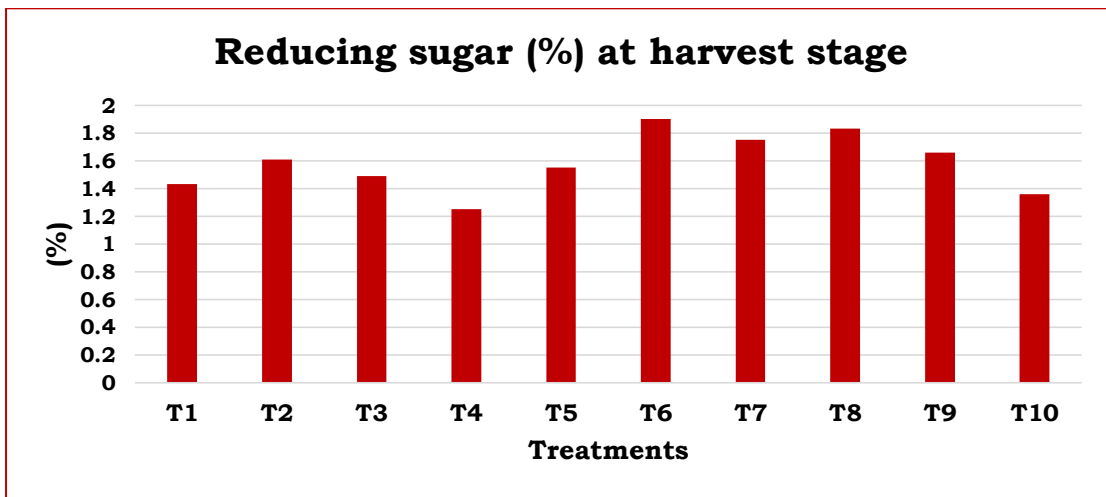


Fig. 9b. Effect of girdling, tip pruning and smudging on reducing sugars (%) of fruit at harvest stage in mango cv. Ratna.

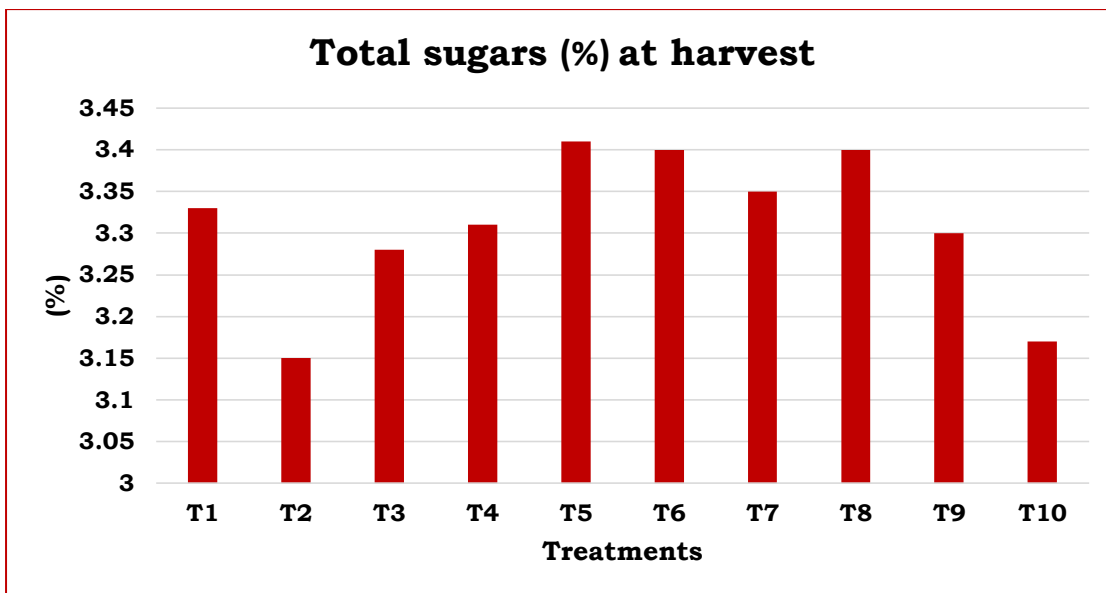


Fig. 9c. Effect of girdling, tip pruning and smudging on total sugars (%) of fruit at harvest stage in mango cv. Ratna.

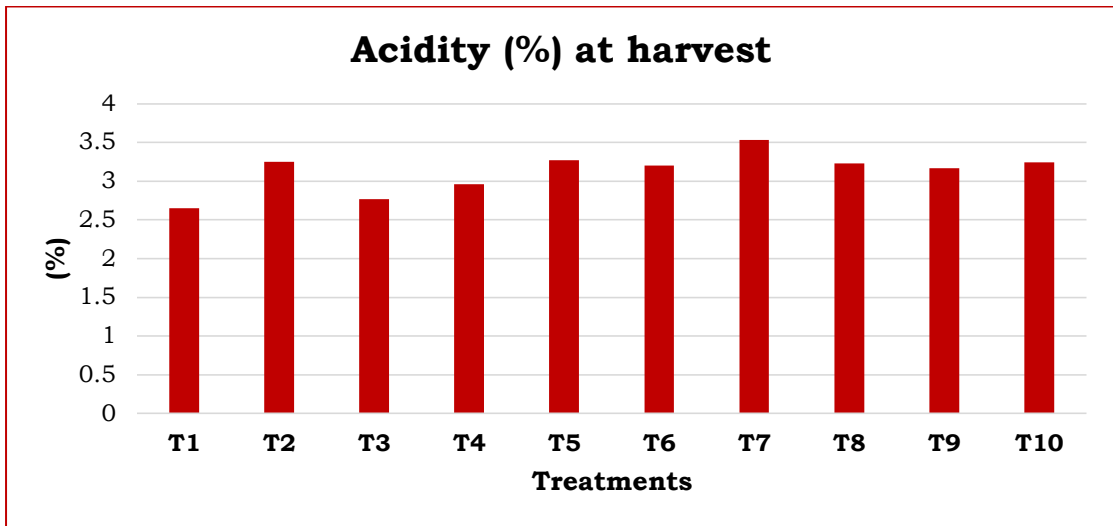


Fig. 10a. Effect of girdling, tip pruning and smudging on acidity (%) of fruit at harvest stage in mango cv. Ratna.

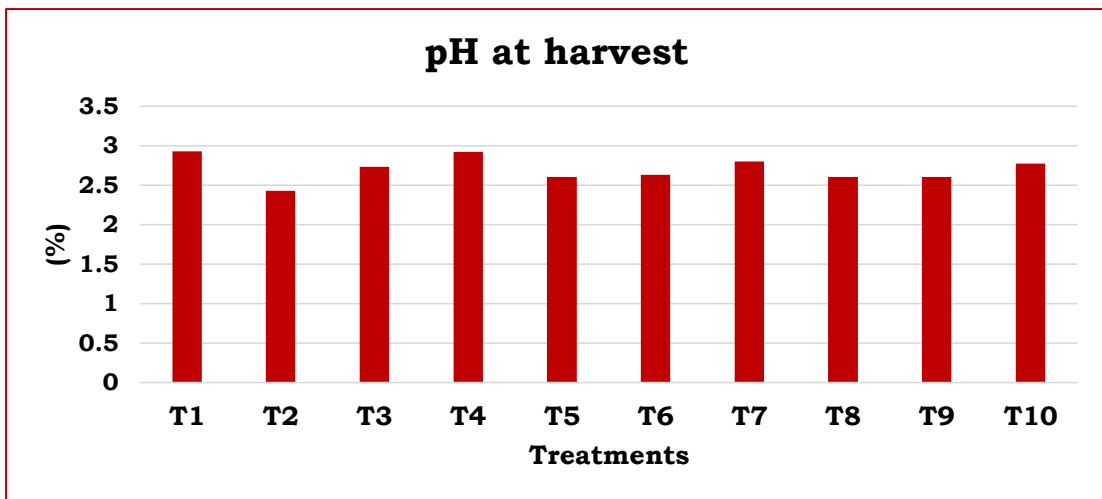


Fig. 10b. Effect of girdling, tip pruning and smudging on pH of fruit at harvest stage in mango cv. Ratna.

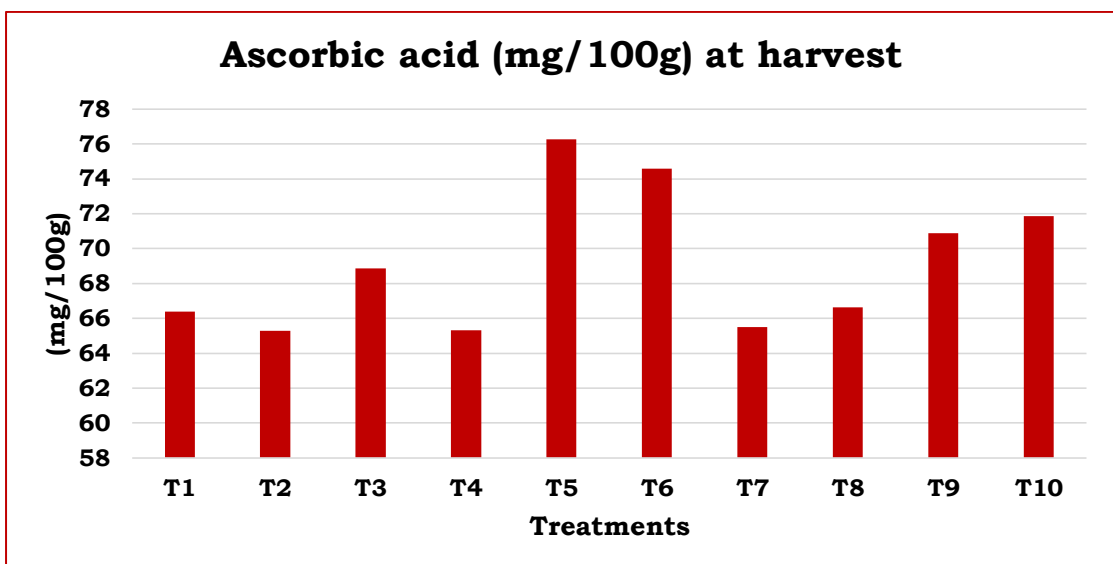


Fig. 10c. Effect of girdling, tip pruning and smudging on ascorbic acid (mg/100g) of fruit at harvest stage in mango cv. Ratna.

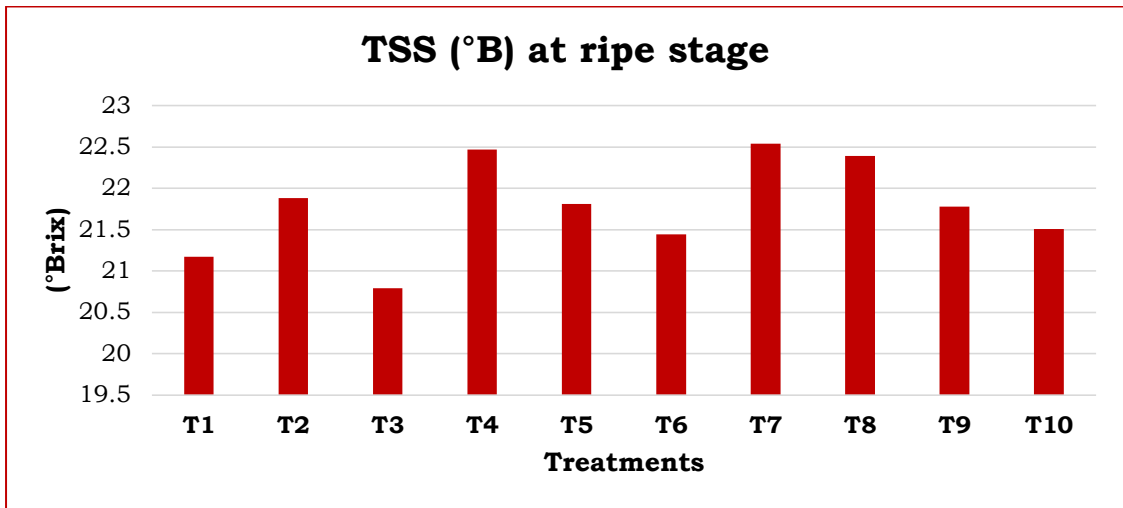


Fig. 11a. Effect of girdling, tip pruning and smudging on TSS (°B) of fruit at ripe stage in mango cv. Ratna.

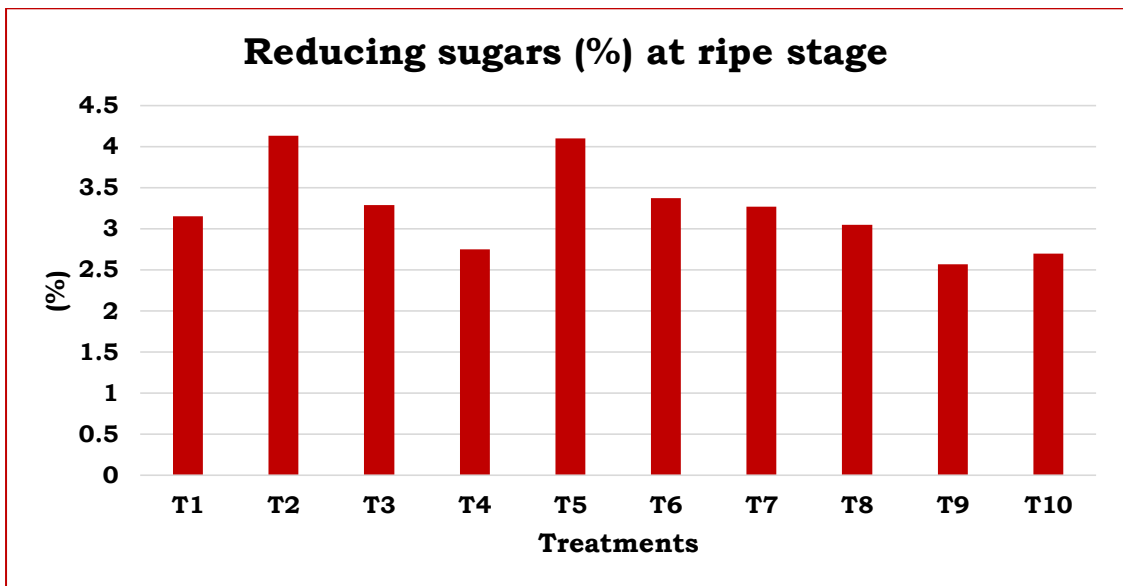


Fig. 11b. Effect of girdling, tip pruning and smudging on reducing sugars (%) of fruit at ripe stage in mango cv. Ratna.

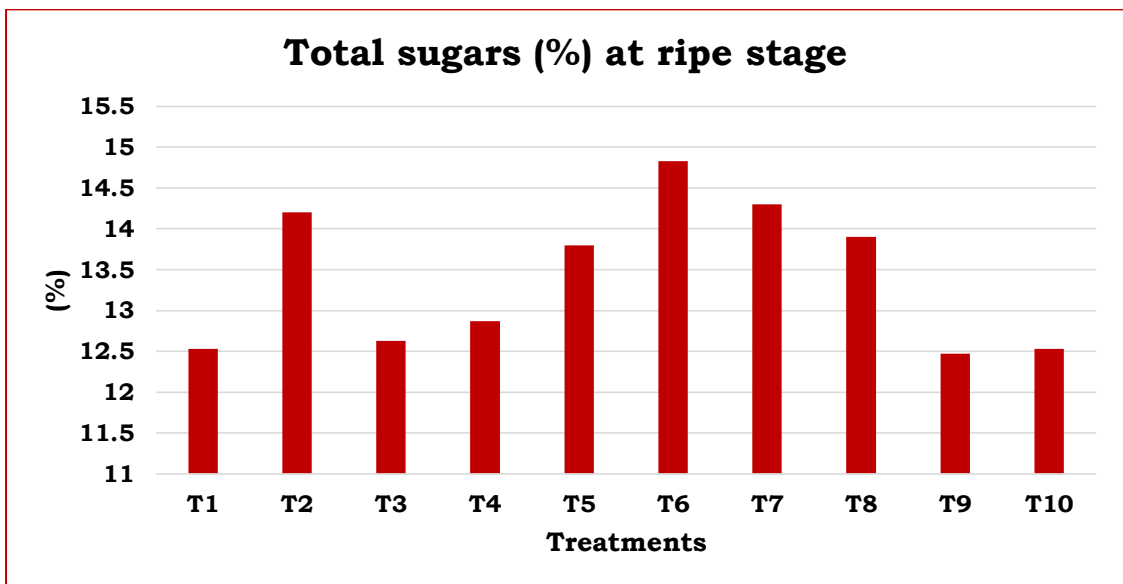


Fig. 11c. Effect of girdling, tip pruning and smudging on total sugars (%) of fruit at ripe stage in mango cv. Ratna.

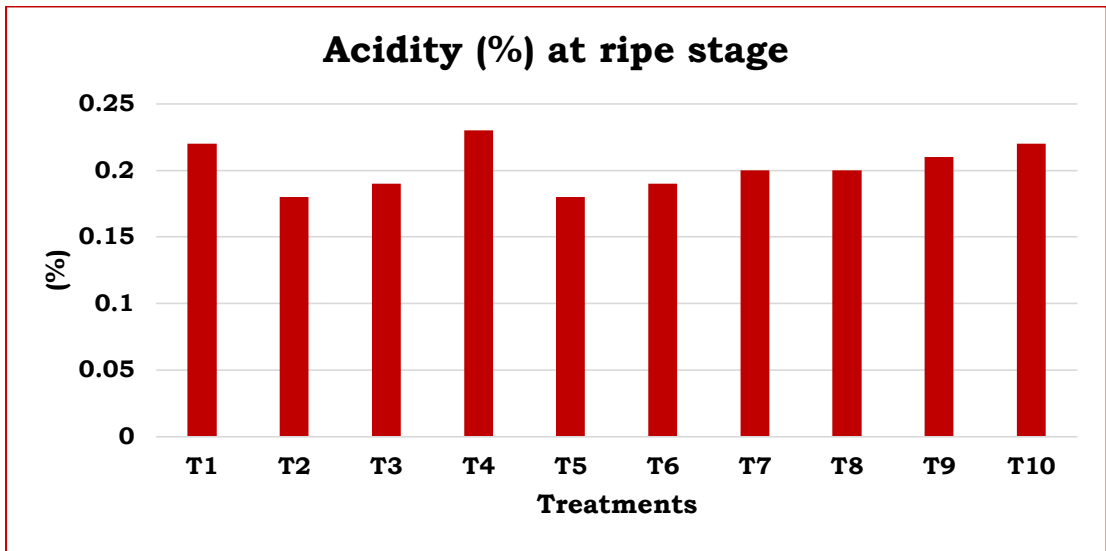


Fig. 11d. Effect of girdling, tip pruning and smudging on acidity (%) of fruit at ripe stage in mango cv. Ratna.

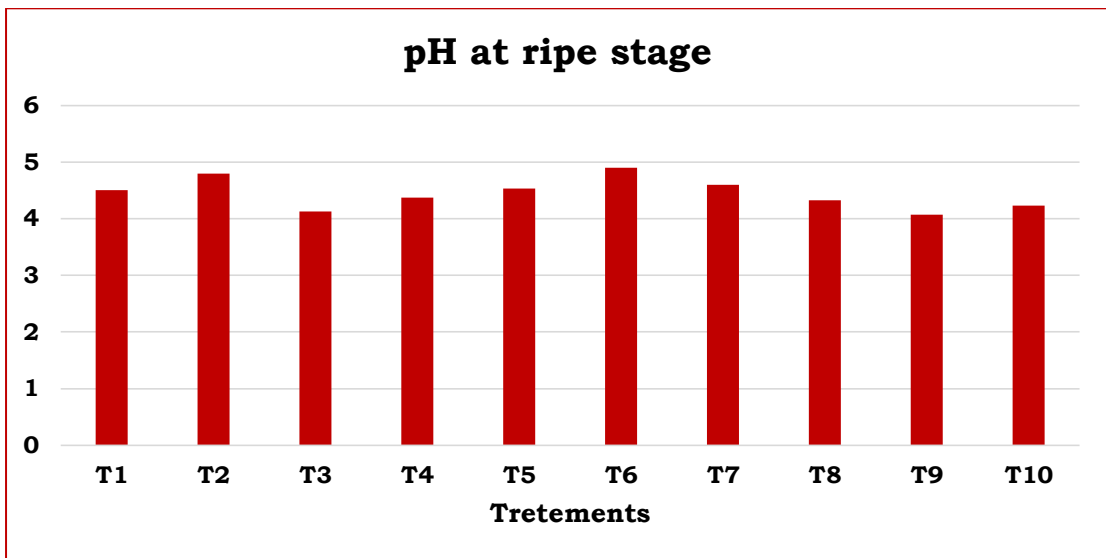


Fig. 11e. Effect of girdling, tip pruning and smudging on pH of fruit at ripe stage in mango cv. Ratna.

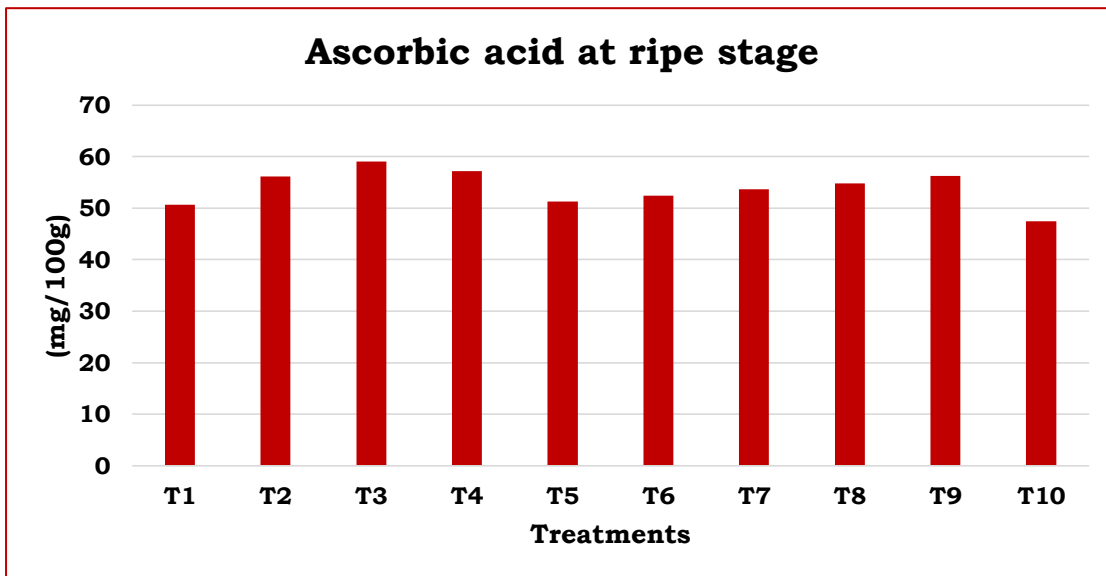


Fig. 11f. Effect of girdling, tip pruning and smudging on ascorbic acid (mg/100g) of fruit at ripe stage in mango cv. Ratna.

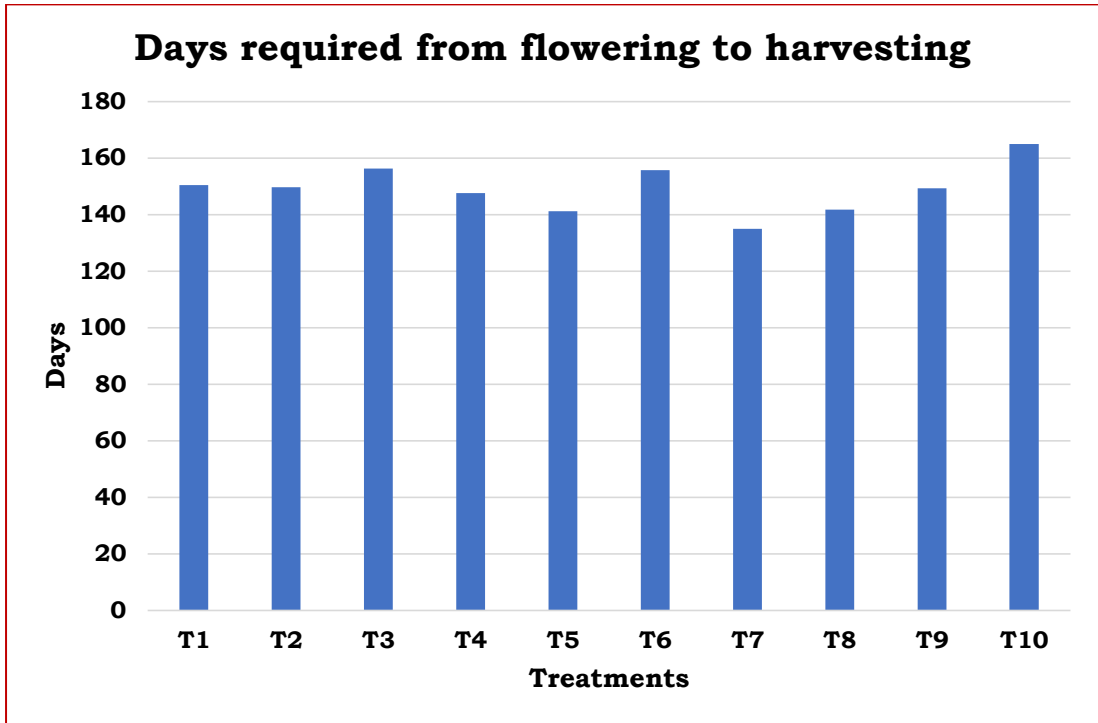


Fig. 12. Effect of girdling, tip pruning and smudging on number of days required for flowering to harvesting in mango cv. Ratna.

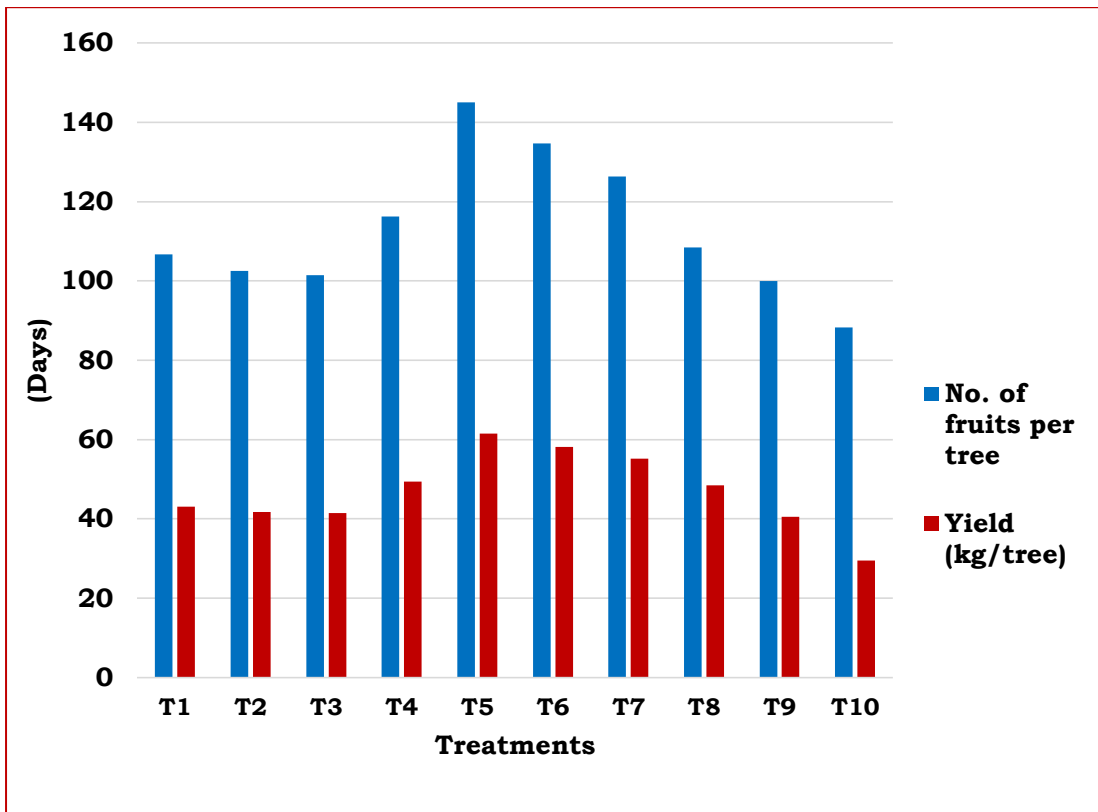


Fig. 13. Effect of girdling, tip pruning and smudging on number of fruit per tree and yield (kg/tree) in mango cv. Ratna.