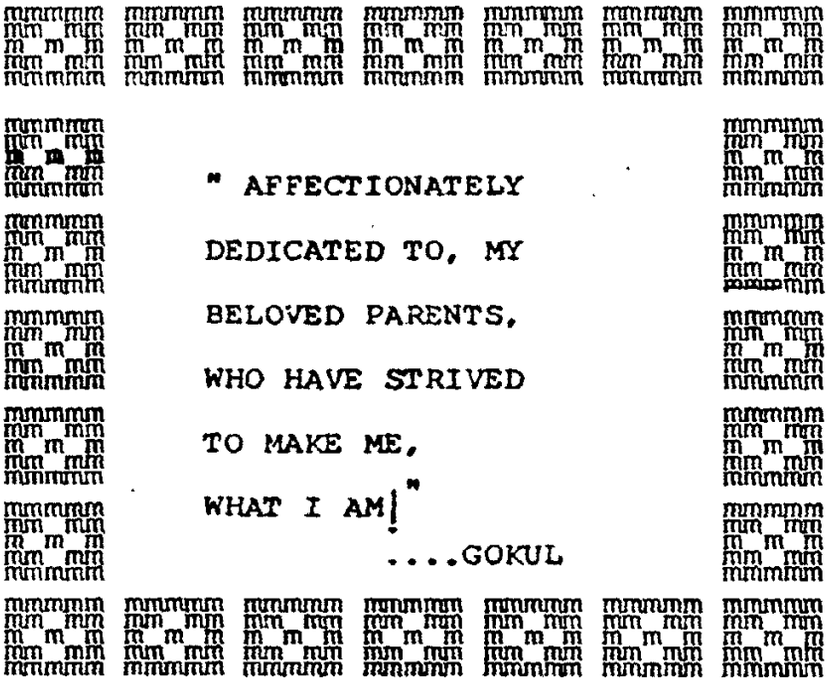
" AFFECTIONATELY
DEDICATED TO, MY
BELOVED PARENTS,
WHO HAVE STRIVED
TO MAKE ME,
WHAT I AM! "
....GOKUL

# STUDIES TO CONTROL LATE SEASON FLOWER PRODUCTION IN POMEGRANATE (Punica granatum, L.)

By

**Gokul Zipru Ahire**
B. Sc. (Agri) First Class

A Thesis Submitted to the
MAHATMA PHULE AGRICULTURAL UNIVERSITY
RAHURI, DIST-Ahmednagar
Maharashtra State (India)

In partial fulfilment of the requirements for the degree

of

## MASTER OF SCIENCE (AGRICULTURE)

in

## HORTICULTURE

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Approved

Dr.U.T. Desai
Major Professor

Dr.P.N. Kale
Committee Member

Prof.B.G. Keskar
Committee Member

Prof.B.P. Deore
Committee Member

MAHATMA PHULE AGRICULTURAL UNIVERSITY,

POST GRADUATE INSTITUTE,

RAHURI, DISTRICT - AHMEDNAGAR (M.S.)

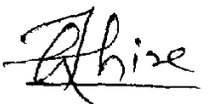
1991

## CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a degree or diploma.

Rahuri

Date: 14-2-1991



(G.Z. Ahire )

Dr. U.T. Desai
M.Sc.(Agri.),Ph.D.
Associate Professor of
Horticulture,
Department of Horticulture,
Mahatma Phule Agricultural
University, Rahuri-413 722,
Dist.Ahmednagar, Maharashtra State,
INDIA.

## CERTIFICATE

This is to certify that the thesis entitled, "Studies to control late season flower production in pomegranate (Punica granatum, L.)" submitted to the Mahatma Phule Agricultural University, Rahuri, District-Ahmednagar, Maharashtra State, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in Horticulture embodies the results of a bona fide research carried out by SHRI.GOKUL ZIPRU AHIRE under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication.

The assistance and help received during the course of these investigations have been duly acknowledged.

Rahuri,
Dated : 14-2-1991

(U.T. Desai)
Research Guide

Dr.N.K. Umrani,
Associate Dean,
Post Graduate Institute,
Mahatma Phule Agricultural University,
Rahuri, 413 722, Maharashtra State,
INDIA.

## CERTIFICATE

This is certified that the thesis entitled, "Studies to control late season flower production in pomegranate (*Punica granatum*, L.)", submitted to the Mahatma Phule Agricultural University, Rahuri, District-Ahmednagar, Maharashtra State, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) embodies the results of a *bona fide* research carried out by Shri.G.Z. Ahire, under the guidance of Dr.U.T. Desai, Associate Professor of Horticulture, Mahatma Phule Agricultural University, Rahuri, District- Ahmednagar, Maharashtra and that no part of the thesis has been submitted for any other degree or diploma.

Rahuri,
Dated : 16/2/91

(N.K. Umrani)

G.Z. Ahire

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Rahuri,

Dated : 14-2-1991

(G.Z. Ahire)

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## ABSTRACT

### STUDIES TO CONTROL LATE SEASON FLOWER PRODUCTION IN POMEGRANATE (Punica granatum, L.)

by

G.Z. Ahire

Mahatma Phule Agricultural University,
Rahuri-413 722, Maharashtra, India.

| | | |
|---|---|---|
| Chairman and Research Guide | : | Dr.U.T. Desai |
| Department | : | Horticulture |

The present investigation was carried out on 7 year old plants of pomegranate cv. Ganesh, spaced at 5 x 5 m at the Instructional-cum-Research Orchard, Department of Horticulture, Mahatma Phule Agricultural University, Rahuri during ambia bahar of 1989. It involved 15 treatments having 5 chemicals viz. GA (20 ppm), Ethrel (250 and 500 ppm), NAA (100, 250 and 500 ppm), MH (1000 ppm) and Carbaryl (0.7%) at different concentrations, in combinations or alone, making in all 13 treatments, and control treatment and hand removal of flowers at regular interval of 14 days as the two additional treatments which were replicated thrice in randomised block design. The treatment application commenced on 75th day after the first irrigation of bahar treatment. Observations on growth, flowering aspects, yield, grade of fruit and fruit quality were recorded and economics was worked out.

Highest number of shoots were produced in 500 ppm Ethrel + 20 ppm GA after 14 days, followed by hand removal of flowers once + 20 ppm GA. While, the lowest shoot number was in 500 ppm NAA. GA treatments increased shoot length while Ethrel, MH, NAA and Carbaryl reduced it. GA and NAA treatments increased leaf area per shoot, while Ethrel, MH and Carbaryl reduced it. The chlorophyll content was less


Contd...

in 500 ppm Ethrel, followed by 1000 ppm MH, 250 ppm Ethrel and 0.7% Carbaryl, while 500 ppm NAA increased it. Carbaryl when used alone produced the phytotoxic effects but Carbaryl preceded by NAA (250 ppm) on the same day (6 hours) did not show any phytotoxic effect. NAA and Ethrel at 500 ppm revealed phytotoxic effects.

Hand removal of flowers at 14 days interval enhanced flower production. Carbaryl, MH and GA inhibited flower production. While Ethrel induced more flowers than the above chemicals.

GA induced more percentage of Male flowers and reduced that of hermaphrodite flowers. While, MH, Ethrel and Carbaryl induced more percentage of hermaphrodite flowers.

Hand removal of flowers at 14 days interval was most effective to remove flower load. Hand removal of flowers + 20 ppm GA, as also 500 ppm Ethrel used as basal spray chemical induced more flower drop.

Treatments revealed significant differences on crop harvest both in terms of fruit number and yield (weight). The number and yield of fruits of different grades was also significantly influenced. The fruit size and quality were also influenced to a greater extent.

The eight treatments (T 5, T 3, T 8, T 10, T 15, T 14, T 2 and T 13) gave increase in net returns over control while six treatments (T 4, T 6, T 7, T 9, T 11 and T 12) gave decrease in net returns over control. The highest increase in net returns was from 250 ppm NAA + 0.7% Carbaryl (Rs.8834.14/ha) followed by hand removal of flowers + 20 ppm GA (Rs.8674.70/ha). While,the highest decrease in net returns was in 500 ppm NAA + 0.7% Carbaryl (Rs.7983.60/ha) and 500 ppm NAA (Rs.3497.48/ha). Hence, 250 ppm NAA + 0.7% Carbaryl on 75th day after first irrigation may be recommended for commercial practice. Further experimentation with 250 ppm NAA and varying concentrations of Carbaryl is suggested.

T.2330

# Introduction

# 1. INTRODUCTION

Pomegranate (Punica granatum, L.) is one of the most favourite fruits of the tropical and sub-tropical regions of the world. It contains proteins (1.6%), fats (0.1%), carbohydrates (14.5%), fibre (5.1%), calcium (10 mg/100 g), magnesium (12 mg/100 g), phosphorus (70 mg/100 g), iron (0.3 mg/100 g), thiamine (0.06 mg/100 g), nicotinic acid (0.3 mg/100 g) and vitamin C (14 mg/100 g), having 68% edible portion. It can be processed into drinks, nectare and jelly. The rind of the fruit and the flower yield a dye used for dying cloths, wool and silk. The rind is also used in indigenous systems of medicine for prevention of intestinal disorders (Patil and Karale, 1989).

Pomegranate is thought to be native of Iran and is being cultivated from time immemorial in the mediterranean countries like Spain, Morocco, Egypt, Afganistan and Baluchistan. It is also cultivated in the tropical parts of United States, Burma, China, Japan and India. In India, it is grown in the states of Maharashtra, Andhra Pradesh, Rajasthan, Gujarath and Karnataka.

The estimated area under pomegranate in Maharashtra has increased beyond 25,000 hectare (Choudhari and Wavhal, 1986) and the state has became major producer of pomegranate in the country. The cultivation is mainly concentrated in Ahmednagar, Poona, Satara and Solapur districts and also coming up in a big way in Sangli, Nasik and Solapur districts. The rapid spread appears to be mainly due to its wide adaptability to

drier tracts with low maintenance cost, steady and high yields, early bearing and better keeping quality of fruits.

Pomegranate bears flowers mainly on current season's shoot either terminally or in the axil of leaf and mostly solitary and rarely in clusters. The commercial practice of pomegranate cultivation in Maharashtra is to stop irrigating the orchard and give stress for two to two and half months before commencement of a particular cropping. After this stress, the crop is irrigated and manured which results in production of new shoots along with flowers. It is then regularly irrigated till the harvest. With this practice, the plant continues to produce the flowers for quite a long time. On ad-hoc basis, harvesting of the fruits which are set during first 2½ months is advocated. The flowers which appear after two and half months are to be removed, otherwise the fruits that set late in the season do not mature properly and also affect quality of the fruits already set. Therefore, farmers remove such late flowers, manually. However, with expansion in cultivation, increase in human labour charges and also due to unavailability of labours some times it has become difficult to carry out this practice.

Research work in other fruit crops has shown that certain chemicals like NAA, GA, Ethrel, CCC, Carbaryl (Sevin) and MH can be used to drop the flowers or to stop the production of flowers. However, no such studies have been carried out in pomegranate. To begin with and to have guide lines for future

work on this aspect, the present studies were planned which will enable either to reduce flower production after two and half months or to drop the flowers that would set fruits after this time. This is anticipated to economise on human labour, help in crop regulation and ultimately improve fruit quality. Thus the objectives of the present investigation were :

1. To see the effects of different chemicals on inhibition of flower induction.
2. To see the effects of different chemicals on production of various types of flowers.
3. To see the effects of different chemicals on flower drop.
4. To compare hand removal of flowers with chemical treatments.
5. To see the effects of different chemicals on total yield and fruit grade.

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# Review of Literature

# 2. REVIEW OF LITERATURE

Pomegranate is gaining commercial importance in fruit industry of Maharashtra in recent years. However, no adequate systematic studies, especially on crop regulation or control of late season flower production have been reported. In the following paragraphs, the work on crop regulation, flower thinning, fruit thinning and related aspects of pomegranate and other fruit crops has been reviewed.

## 2.1 Flowering habit

Pomegranate, being orginally a sub-tropical fruit crop, exhibits different flowering patterns under temperate, tropical and sub-tropical conditions. Lawrence (1951) reported that the inflorescence of pomegranate was terminal and solitary and flowers were borne, one to few, on tips of axillary shoots. While, Nath and Randhawa (1959) observed under Delhi conditions that, in evergreen cultivars of pomegranate, the flower buds of spring flush were borne on matured wood of previous season's growth, and in deciduous cultivars the flowers were borne on current season's growth in cluster either terminally or in axil of leaf.

Nalwadi et al. (1973) who worked under Karnataka conditions reported that the flowers in pomegranate were borne on past season's growth in axil of leaf, mostly solitary. But, Bawale (1978) who worked under Maharashtra conditions, reported that the pomegranate flowers were borne mostly on current season's shoot either terminally or in axil of leaf.

Similarly, Game (1987) from Maharashtra reported that the pomegranate flowers were generally borne on current season's shoot and rarely on past season's growth, either terminally or in the axil of leaf.

2.2 Flower sex and sex ratio

Evreinoff (1957) described the pomegranate flowers having long style as hermaphrodite flowers. He observed these flowers to bear perfect pistil and set fruits. The flowers, with style length upto staminal column, which fall rapidly and rarely set the fruits were designated as intermediate flowers. The third type with the style length shorter than staminal column length were described as sterile or male flowers. Sterile flowers were observed to be very small with small ovaries which did not develop normally and set any fruit, although the stamens were with fertile pollens. This description of the flower types has been endorsed by subsequent workers and adopted in their studies.

Nath and Randhawa (1959) reported that the Japanese Dwarf cultivar of pomegranate had the highest percentage (58.35%) of hermaphrodite flowers and they were more during the early part of the flowering season. With the advance of the flowering season, the percentage of hermaphrodite flowers was decreased.

Bawale (1978) observed 68:16:16 ratio of male, intermediate and hermaphrodite flowers in Ganesh (G.B.G.-1) and 66:10:24 in Mascat cultivars of pomegranate. Fruit set

among the hermaphrodite flowers was observed to be the highest in Ganesh (74.66%) and the lowest in Mascat (36.36%). Fruit set, over the total flowers produced, was 19.26 per cent in Ganesh and 13.97 per cent in Mascat. While, Game (1987) observed 64:10:26 ratio of male, intermediate and hermaphrodite flowers in Ganesh and 66:16:18 in Ganesh-137.

## 2.3 Time and duration of flowering

Hayes (1953) stated that, pomegranate flowers through out the year but intensity is more during the rainy season on the plains of India. Nath and Randhawa (1959) reported that the flowering in pomegranate cultivars, under Delhi conditions, generally started after the breaking of dormancy and appearance of spring growth flush. In evergreen cultivars like Muscat White, Dholka and Ganesh, where there was only cessation of growth during winter and no leaf fall, the vegetative growth began in first week of March and flower buds appeared simultaneously. In deciduous cultivars like Kandhari and Patiala, the new growth started by the middle of March and flower buds appeared as late as the end of May. According to Ranjit Singh (1969), pomegranate flowers in spring in North India and almost through out the year in Central and South India, the flowering being profuse in the early monsoon. According to Phadnis (1974), pomegranate flowering is alround the year with two main seasons of flowering, namely the January-February and June-July with a smaller crop from the flowering during the closing period of the rainy season.

Patil and Sanghavi (1977), Anonymous (1978) and Patil and Karale (1989) characterized three flowering seasons in pomegranate under Maharashtra conditions, though flowering alround the year could be observed under irrigated condition. They are : June-July (Mrig bahar) coinciding with the break of monsson, February-March (ambia bahar) and September-October (hasta bahar). While, Bawale (1978) reported that, in ambia bahar, the flower buds appeared during third week of January in all local cultivars and in cv. Kabul. Whereas, in all the exotic temperate cultivars, the new growth started in the last week of February and flower bud initiation was completed by the second week of March.

As regards the duration of flowering, Singh (1977) observed that the flowering period of pomegranate lasted for about two and half months under Punjab condition. While Game (1987) reported that the flowering duration of ambia bahar cropping lasts for four months.

## 2.4 Crop regulation

In any crop, understanding of the factors governing flowering is important for determing optimum production practices. In fruit crops such as pomegranate, which produce more than one crop in a year, the occurrence of flowering in different seasons is governed by many factors. If may be profuse or scarce as per the season. The interaction of specific physiological and environmental factors causes vegetative and/or reproductive flush in a fruit tree. The growth flushes occur in rhythmic cycles and vary according to

the fruit species and cultivar within a crop. In various fruit crops, for commercial cultivation, the flowering in a particular season and to the desired extent can be regulated by practices such as imposed water stress, prunning, thinning, deblossoming (mechanical and chemical) and by use of plant growth regulators (Teaotia and Pandey, 1970; Singh and Singh, 1975; Rathore, 1975; Westwood, 1978; Ramkumar and Hoda, 1978; Gupta and Nijjar, 1982; Dhaliwal and Sandhu, 1982; Desai et al., 1982; Zora Singh and Sandhu, 1984 and Koen and Jones, 1985).

As stated earlier, three distinct flowering seasons viz., February-March (ambia bahar), June-July (Mrig bahar) and September-October (hasta bahar) in pomegranate have been reported (Cheema et al.,1954; Ranjit Singh, 1969; Phadnis, 1974; Patil and Sanghavi, 1977 and Patil and Karale, 1989). Only one of these is advocated for commercial cultivation. Bahar treatment is a old practice in Central and Southern India to regulate flowering of pomegranate to one of these flowering seasons. It is achieved by with holding irrigation for two to two and half month, prior to the season of flowering. The practice is reported to be helpful for easy management, higher marketable yields and better quality fruits (Phadnis, 1974; Patil and Sanghavi, 1977 and Patil and Karale, 1989).

However, besides the problem of restricting the flowering to one of the seasons, pomegranate cultivation in Maharashtra faces another problem of late season flower production. This means, once the cropping of a particular bahar (either ambia, mrig or hast) has been commenced, pomegranate plant continues

to produce flowers for quite a long time, consequent on each irrigation, even upto end of harvest though the intensity is reduced at the end of the cropping. This is quite peculiar to this crop. The problem needs to be tackled, though not exactly but more over on similar lines as has been done for crop regulation in other crops. Therefore, work done on crop regulation in different crops is reviewed here below in brief.

2.4.1 Mechanical

Hand thinning of either flowers or fruits has been practiced since early times and has been found beneficial in different crops. Hamlton (1953) reported that, hand thinning of bloom improved fruit quality of grape. Winkler (1962) reported that the hand thinning of grape bloom increased the berry size. Sanghavi (1966) also observed hand thinning of grape berries very useful as it produced large berries of uniform size with brilliant colour and improved quality.

Bajwa (1969) stated that, hand thinning of plum fruits (at pea stage) resulted in increase in fruit size, improved fruit quality and production of superior grade fruits, but it reduced total yield.

Teaotia and Pandey (1970) observed in guava that, hand thinning of rainy season blossom reduced 81 per cent fruit crop.

Bajwa et al. (1974) reported that the hand thinning of Jonathan apple at pea stage resulted in increased fruit weight, diameter, volume, quality and production of A-grade fruits.

But it reduced B and C grade fruits and the total yield over the control.

Rane et al.(1983) obtained quality fruits with economics returns by retaining 50 fruits per plant in Muscat cultivar of pomegranate. They practised hand thinning of fruits. They also reported that, the size of fruits decreased as the number of fruits per plant progressively increased, but the total yield by weight was more.

### 2.4.2 Chemical

Since the mechanical methods of crop regulation are quite laborious and time consuming, workers resorted to see the effects of chemicals in this regard. As a result, several chemicals were identified which would either enhance or reduce flowering, induce or stop flowering, reduce the flower and fruit drop or increase the same. The chemicals, especially used for thinning, have been found benificial to increase individual fruit weight, the percentage of high grade fruits and chemical composition. A few works on this aspects are reviewed here under in respect of the chemicals used in present investigation.

#### 2.4.2.1 Naphthalene acetic acid (NAA)

Involvement of auxin in abscission is studied in quite detail. As early as 1933, Laibach reported involvement of auxin in the abscission of leaves, flowers and fruits. However, he noted that the deficiencies as well as very high concentration of auxin may lead to abscission. The low content of auxin

in flowers and fruits leads to their drop. Later in 1943, the effects of high concentration of exogenously applied NAA in flower abscission were attributed to alteration or inhibition of germination and growth of pollen tube (Addicott, 1943). Addicott and Lynch (1955) also found correlation between abscission and auxin content of the organ. The workson records have been summarized by Leopold and Kriedemann (1982) and it appears that the auxin gradient across the abscission zone plays an important role in abscission of flowers and fruits.

Attention on the competition between the setting flowers and fruit-lets was drawn by Struckmeyer and Roberts (1950). They found a temporary delay in abscission of apple flowers and developing fruits following the application of NAA. They proposed that the natural thinning action was the result of temporary competition for nutrients among the developing fruits, whose normal abscission was delayed by the auxin at lower concentration and accelerated at higher concentration. However, during the same time, involvement of ethylene in this phenomenon was indicated by Gawadi and Avery (1950). They showed that the plants treated with auxin had accelerated ethylene production. These workers concluded that the NAA application stimulated ethylene production and caused many of the fruitlets to abscise.

Van Overbeek (1952) suggested that, NAA causes break down of pectic substances in the middle lamella of cells at the

base of pedicel, with concomitant enlargement and elongation of cells in this region. This weakening results in a mechanical fracture of the conductive tissue. Luckwill (1953) found that, increased drop of young fruitlets in apple following the application of NAA was associated with seed abortion presumably induced by the applied NAA. He reported that the exogenous application of NAA affects the flow of endogenous auxin which controls continued nurishment of developing fruits and the fruit embryo abortion occurs due to restriction in mobilizing ability of the treated fruits. His data further indicated that, after cell wall formation had occurred in the endosperm, NAA sprays were no longer effective in fruit thinning. This work supported his earlier observations that the effectiveness of NAA was limited to a period of two to four weeks after full bloom. Similar type of flower thinning action of auxin is reported by Murneek and Teaubner (1953).

Besides the role of auxin in abscission, it was also reported to induce qualitative changes such as the change in flower types. Maiti and Maiti (1969) reported that the spraying of 50 and 100 ppm NAA at prebloom stage resulted in increased hermaphrodite flowers. NAA exhibited promotive effect on hermaphrodite flower bud formation upto 100 ppm beyond which the effect was declined in Bombai mango.

The above narrated basic effects of auxins on abscission and sex of flowers have been utilized for practical purposes by different workers. Leopold (1958) reported successful

thinning of fruits by NAA and its derivatives in peach, olives, grape and pears.

Teaotia and Pandey (1970) observed in guava that, spraying of NAA at full bloom reduced rainy season crop. Chundawat et al.(1975) reported from Hissar that, spraying of 100, 200 and 400 ppm NAA at full bloom stage for flower thinning in guava cv. Banarasi Surkha resulted in 24 to 82 per cent deblossoming and 53.9 to 12.8 per cent fruit set respectively. Similar observations were also recorded by Rathore (1975). Agnihotri and Bhullar (1979) reported from Himachal Pradesh that the spray of 100 and 150 ppm NAA on cv. Allahabad Safeda, when 10-20 per cent flowers had opened, resulted in 74 and 79.50 per cent fruit set reduction over control. While Gupta and Nijjar (1982) reported that the application of 200, 400 and 600 ppm NAA during May, at the time of full bloom, resulted in 37.7, 41.5 and 78.3 per cent blossom thinning in this crop.

Bana et al. (1976) observed that, spraying of NAA (10, 30 and 50 ppm) on apple cultivar Red Delicious resulted in flower and fruit thinning, improved fruit quality. Unrath (1978) reported that the combined spray of Ethrel and NAA resulted in maximum fruit thinning in apple than Ethrel alone. Similar results were obtained by Veinbrants (1980). Similarly, Edgerton (1973) reported that,mixture of NAA and Carbaryl resulted in maximum flower and fruit thinning in apple.

Daulta et al. (1983) reported that the spraying of 100 to 300 ppm Planofix after fruit set (when berries were of pea size) on Beauty Seedless grape caused thinning of berries. Singh and Sandhu (1987) also found that spraying of 50 to 200 ppm Planofix at 2 days before anthesis in Perlette grapes resulted in thinning of berries. It also increased shot berries, berry drop and T.S.S. and decreased bunch weight and acidity.

As regards citrus, Iwahori (1980) reported that, spraying of 200 to 300 ppm NAA at 20 to 30 days after full bloom successfully thins the fruits of Satsuma mandarins. He reported that the ethylene mediated increased in cellulase activity may be considered as mechanism of thinning action of NAA. Josan and Sharma (1987) applied 300 and 600 ppm NAA to Wilking Mandarin (when the fruits attained marble size) during third week of May. They found that the thinning effect of NAA (600 ppm) was significantly prominent with a minimum fruit retention of 5.31 per cent over control (16.23 per cent) as observed one month after the spray treatment. NAA at 600 ppm was recommended to reduce crop load and obtain big sized fruits without much alterning the fruit quality.

2.4.2.2 Gibberellic acid (GA)

Gibberellic acid as a hormone is involved in the regulation of growth and form of plant and the entire range of developmental stages from dormancy to reproduction and

senescence. It is also widely used for crop regulation. Hurd and Purvis (1964) reported that, GA stimulated vegetative growth and exerted indirect effect on inhibition of flowering usually by inducing elongation of stem. Similar results have been obtained in apple (Dennis and Edgerton, 1966, and Buban and Faust, 1983). In some fruit crops, it is postulated to acts as antiflowering agent. Luckwill (1970) suggested that, in apple long shoot produces gibberellins at the growing point which suppress flower bud initiation as long as the growing point continues to produce the anti-flowering gibberellins and the bud remains vegetative. He further opined that, when the extension growth stops, the supply of gibberellins also ceases and the bud, aided by the cytokinin moving up from the root system, become capable of flower initiation. He emphasized the role of growth retardants to promote flower bud initiation by bringing about critical gibberellin and cytokinin balance with a two fold effect : firstly by causing an early cessation of extension of growth and secondly by increasing the concentrations of cytokinin in the xylem sap comming from roots. However, Hoda (1984) opined that the flower bud initiation in tree species is inhibited by high level of endogenous gibberellins originated in fruit or by exogenous application of GA. Nevertheless, the effectiveness of applied GA depends on the stage of crop growth and season of the year. In this respect, Painter and Stembridge (1972) observed in peach that the applications of $GA_3$ in summer resulted in reduction of flowering. The degree of reduction of flowering depended

upon the time and stage of application. $GA_3$ applied at early summer, at the time of flower initiation, and secondly at late summer resulted in mortality of developing buds. Thus, gibberellins show promise in their exploitation for controlling the induction of flowering. The research works regarding the commercial utility of GA in fruit industry are given in the following pages.

In grapes, it was observed by Stewart et al. (1957) that the application of $GA_3$ at 10 to 100 ppm caused increase in T.S.S. and berry size and decrease in acidity in Thompson Seedless grape. But at 100 ppm, it resulted in flower drop. While, Weaver and McCune (1959) reported that the application of 50 ppm GA at pre-bloom and full bloom stage loosened compact clusters and formed shot berries. When sprayed at bloom stage, it resulted in berry drop. Maxwell (1959) observed that the spraying of 15, 20 and 50 ppm GA on grape cv. Thompson Seedless when berry was of pea size resulted in increased berry size. Almost similar finding in this crop have also been reported by Lavee (1960), Weaver and Pool (1971), Mahmood and El-Wakeel(1971), Myrianthousis and Hadjigiorgis (1973) and Bhujabal and and Choudhari (1973). However in respect of flower induction, Abdul Khader and Rao (1984) reported that the application of $GA_3$ at 25, 50 and 100 ppm in grape on 40, 55 and 70th day of prunning (coinciding with the pre-initiation and post-initiation period of flower primordia and bud differentiation)

resulted in significant reduction in number of fruitful shoots and production of maximum vegetative shoots. They inferred that, GA at higher concentration acted as anti-flowering agent and controlled the flowering.

In citrus, gibberellins appears to be strong inhibitors of flowering. Monselise and Halevy (1964) reported that the spraying of 500 ppm GA on Shamouti orange, at 15 days interval from the first November to end of January, resulted in inhibition of flowering and enhanced growth activity. Goldschimidt and Monselise (1970) also reported that the application of $GA_3$ at 0.03 µg per bud, prior to flower bud differentiation, resulted in 75 per cent reduction in number of flowers and, at higher concentration, it completely arrested the flowering without causing any effect on vegetative growth. Application of $GA_3$ to bud after the flower bud differentiation had occurred resulted in reduction of number of flowers per shoot and caused promotion of stem elongation. Nir et al. (1972) reported that, 25 mg $GA_3$ per bud applied to Eureka lemon under normal irrigation conditions, inhibited summer flower formation even when supplied after first stage of flower bud differentiation. But it stimulated vegetative growth of axillary meristem. Similar results were obtained by Iwahori (1980) in this crop. Iwahori and Oohata (1981) also reported that the spraying of 20 ppm GA on Satsuma orange at 2 dates (6 and 20, February) resulted in increased vegetative growth and decreased number of inflorescences in the year of application. Wang (1981) found that the spraying of 50 and 100 ppm

$GA_3$ to whole tree during anthesis resulted in flower thinning and premature fruit drop in orange and lime. Muller and Young (1982) reported that, spraying of GA on sour orange seedlings stimulated plant height and length of internodes.

In mango, Kachru et al. (1971) reported that the spraying of $10^{-1}$ and $10^{-2}$ molar $GA_3$ just before flower bud differentiation in on-year inhibited 95 and 75 per cent flowering, respectively. While Singh and Singh (1974) observed an increase in the length of shoot, number of shoots and number of internodes with GA spray in Dasheri cv. of mango at 20 ppm concentration. Effect of gibberellins on flower sex in mango is elucidated by Maiti (1973) who reported that the spraying of 50 and 100 ppm GA on mango cv. Baramasi at 15 days interval from March to April (till flower bud differentiation) resulted in increase in male flowers and decrease in the hermaphrodite flowers. Supression of hermaphrodite flowers and increase in male flowers was considered to be due to regulation of gibberellin and auxin balance. Higher GA concentration tended to promote maleness. He also inferred that the anti-auxins, retardants or inhibitors increase female flowers. $GA_3$ sprayed before flower bud differentiation reduced hermaphrodite flowers and fruit set over the control. Inhibition of flowering in mango was also found by Rawash et al. (1983) who reported that 500 to 3000 ppm GA spray in November and December inhibited flowering in following spring.

As regards cucurbits, Rodriquez and Lumbeth (1972) studied the synergism and antagonism of GA and growth inhibitor on growth and sex expression in the cucumber and reported that application of $GA_3$ stimulated growth and increased maleness. Sidhu et al. (1981) showed that GA induced male flowers in squash melon. Similar results have been reported by Sutulova (1981) in cucumber. Jamadagni and Patil (1982) reported that gibberellic acid suppressed the formation of female flowers and induced formation of male flowers. Patil et al. (1983) reported that cucumber plants treated with GA at 5 to 25 ppm produced lowest percentage of female flowers at 25 ppm. While Singh et al. (1984) reported that high accumulation of $GA_3$ in the floral parts after treatment induced male flowers in cucumber and reported GA as inducer of maleness.

In peach, Konarli (1974) from Turkey reported that the application of 150 ppm $GA_3$ on peach in first week of flowering resulted in delaying and thinning of flowers.

Clanet and Salles (1976) from France, applied 25, 50 and 300 ppm $GA_3$ to apple tree in May and June. All the June treatments delayed flower initiation and caused thinning of functional flower buds. Flower thinning was 26.8, 31.8 and 48.6 per cent at 25, 50 and 300 ppm $GA_3$, respectively, over the control. Buban and Faust (1983) found that the application of GA, notably of $GA_3$ and $GA_4$, inhibited or suppressed the flowering in apple.

In case of ber, Rajput and Singh (1982) observed increase in fruit weight, shoot length, number of leaves and yield in cv. Banarasi Karaka due to 20 ppm GA. Singh et al. (1982) noticed increase in fruit length, fruit diameter and weight of ber when sprayed with 10 to 50 ppm GA. Similarly, T.S.S., sugar and vitamin C were also increased.

Edgerton (1980) reported that addition of $GA_3$ at 100 ppm to Ethephon reduced the side effects of Ethephon and the variabilities in peach thinning trials over a two year period.

In addition to the above effects, GA also plays an important role in production of number of leaves, leaf area and chlorophyll content. Shibutan and Kinoshita (1966) observed in celery that, application of GA decreased chlorophyll, carotene and vitamin C content of leaves. Similar type of results were obtained by Torri and Nakagawa (1960) in Tea. Krishnamoorthy (1981) stated that the application of $GA_3$ reduces chlorophyll, protein and RNA content. The reduction in chlorophyll is due to dilution of chlorophyll pigment as the chlorophyll synthesis fails to keep pace with rapid increase in leaf cell expansion and increased leaf area.

2.4.2.3 2-chloroethyl phosphonic acid (Ethrel)

Ethylene, a gas, initially got recognition as a ripening hormone. But afterwards, it was revealed that, it has varied actions. Its most dramatic effects are noticed on abscission and on various aspects of flowering. Being a gas, it can not

be used in field in its natural form. Therefore, its commercial formulations Ethrel or Ethephon are used. Its effects, related to present investigations are briefly reviewed here below.

As far as vegetative growth is concerned, Ethrel is reported to act as a potent inhibitor. Heck and Pires (1962) reported that the Ethrel destroyed chlorophyll content by accelerating its break down but it did not inhibit chlorophyll synthesis. Similarly, Knypl and Mazurczyk (1972) reported the inhibitory effect of Ethephon on protein and RNA synthesis and observed stimulated protein and chlorophyll break down in cucumber at higher concentration (500 ppm). Shanks (1969) observed reduction in internodal length of zinnia and sweet potato at 100 to 500 ppm Ethrel which resulted into dwarf and more compact growth of these plants. Such a action of Ethrel was ascribed by Weaver (1972) to break down of plant tissues, destruction of terminal bud consequent on inhibited apical meristem activity by the ethylene released by ethrel after spraying. Similar observations were also made by Rudich et al. (1970), however, they further remarked that at lower concentrations Ethrel reduced internodal length and at higher concentrations it reduced number of nodes in cucumber. Pappiah and Muthuswamy (1974) found in dahalia that the spraying of 500 and 1000 ppm Ethrel after 75 days of planting increased approximately double the number of lateral shoots over the control. El-Beheidi et al. (1978) also observed

growth inhibition resulting into bushy cucumber plants, due to 400 and 600 ppm Ethrel spray. In muskmelon also, Sidhu et al. (1982) noted almost similar observations. Manna and Mukherjee (1983) reported that two sprays of 250 or 500 ppm Ethrel on chrysanthemum resulted in reduced plant height and increased flowering.

Besides the effect of Ethrel on growth reduction as referred above it also resulted in yellowing of leaves (Edgerton and Greenhalgh, 1969), naturally consequent on the reduction in chlorophyll content (Heck and Pires, 1962 and Knypl and Mazurezyk, 1972). Similarly, it inhibits leaf expansion by inhibiting cell division and cell expansion (Krishnamoorthy, 1981).

In addition to its effects on growth inhibition, Ethrel has also been reported to influence reproductive processes affecting the crop yield directly or indirectly. Ethrel has been reported as most effective abscission causing chemical due to release of ethylene, at the base of abscission zone in fruits, flower and leaves (Edgerton and Hatch, 1972).

The above reports indicate that ethylene releasing compounds have varied effects which would be exploited for practical purposes. Such attempts on related aspects in different crops are narrated here below.

Cooke and Randall (1968) reported that, application of ethylene releasing compound Ethrel induced flowering in

pine apple. Randhawa et al. (1970) also reported that Ethrel at 125 to 1000 ppm increased flowering (80%) over the control (12%) within 15 days of treatment application. They again explained that unsaturated hydrocarbons like ethylene are capable of forcing pine apple to flower. They further remarked that since ethylene is primary factor for flower induction, higher concentration of NAA (auxin), which also induce ethylene production, would give more flowering.

Edgerton and Greenhalgh (1968) reported in apple that, fall and spring applications of 250 to 2000 ppm Ethrel suppressed vegetative growth and subsequently promoted flowering. It also helped to control biennial bearing. Edgerton and Greenhalgh (1969) observed that the application of 1000 and 2000 ppm Ethrel at prebloom stage eliminated complete crop of apple. Similarly, spray of Ethrel on Democrat apple resulted in 30.7, 11.5 and 4.7 per cent fruit set at 100, 200 and 300 ppm Ethrel, respectively,over the control (62.7%) when sprayed after 10 days of full bloom. They also reported that the Ethrel applied on plant, inhibited cell division and decreased the growth of immature fruit when applied during month of anthesis. Katzfuss et al. (1975) reported that the application of 150 ppm Ethrel one month after full bloom, with or without second application a week later, increased flower bud initiation in Jonathan apple. Wertheim and Joosse (1975) reported that the spraying of 500 to 2500 ppm Ethrel at full bloom stage resulted in blossom

thinning and accelerated fruit ripening (by 7 to 14 days) of Boskoop apple cultivar. Bana et al. (1976) from Ranikhet, sprayed 250, 500 and 1000 ppm Ethrel on Red Delicious apple after 3 weeks of last petal-fall. It resulted in high fruit thinning with 1000 ppm Ethrel. The T.S.S. and fruit weight were at par with control. However, Knight (1978) in cultivar Laxton's Superb observed similar results at lower concentrations. He reported that, 300 and 600 ppm Ethrel at bloom and ballon fruit stage in apple resulted in fruit set reduction and caused over thinning, respectively. But 300 ppm at bloom and 600 ppm at ballon stage increased fruit weight. From China, LI Peihua et al. (1984) also reported that, 300 ppm Ethrel on Ralls and Delicious apple at 10 days after begining of petal fall and during bloom stage resulted in flower and fruit thinning. Further, in this crop, Basak et al. (1988) in Lobo and Spartan cultivars found that the spraying of 200 ppm Ethrel, 2 days after flowering, increased fruit size and flower bud formation. NAA and Ethephon combined was the best fruit thinning agent. Similar results were obtained in Delicious apple by Unrath (1978). Gianfagna (1989) found that the spraying of 200 ppm Ethrel on apple cv. Cresthaven during late September to early November resulted in leaf abscission and delay in flowering.

Ethrel has also been used in grape with almost similar objectives. Weaver and Pool (1971) reported that the spraying of 10 ppm Ethrel at prebloom caused 50 per cent reduction in berry set of Thompson Seedless grape. While at 100 ppm it

caused no fruit set. Similarly, spraying of 100 ppm Ethrel at full bloom resulted in thinning of all flowers. Singh et al. (1977) reported that, 500 ppm Ethrel one month after berry set caused increase in berry colour, weight, T.S.S. and reduced acidity. The berry ripening was advanced by 7 days in Black Corianth grape.

Burg et al.(1971), who worked on pea, reported that Ethrel inhibited or reduced the rate of DNA synthesis and he associated this effect as probable cause of reduced cell division in young growing point of pea. He also opined that the inhibition of cell division would account for the effect of ethylene on the reduced growth rate of small fruitlets. He further stated that the enhanced fruit growth in later phase may be due to the isodiametrically expansion of cells by altering the orientation of newly deposited microfibrils.

In case of guava, Chundawat et al. (1975) from Haryana observed that the spraying of Ethrel at full bloom stage resulted in 12.7, 12.7 and 4.9 per cent deblossoming at 500, 1000 and 2000 ppm Ethrel, respectively over the control. Agnihotri and Bhullar (1979) sprayed Ethrel at 250 and 400 ppm in May, when 20 per cent flowers had opened, and observed 86.60 to 77.90 per cent fruit set reduction over the control in Allahabad Safeda guava. While, Singh et al.(1978) studied the effect on fruit thinning and noticed that 500 ppm Ethephon on guava after one month set improved fruit colour and pulp quality, and fruit ripening by 12 days.

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In peach, when Ethrel was applied one month after full bloom, at 50 and 150 ppm, it reduced fruit set. At 450 ppm it eliminated all fruits, caused leaf yellowing and 20 per cent leaf fall with 45% reduction in shootlength (Edgerton and Greenhalgh, 1969). Further, Stembridge and Gambrell (1971) reported that the application of Ethrel at three different stages (Post bloom, one month after bloom and 50 days before harvest) resulted in Peach fruit thinning, reduction in fruit size and accelerated fruit maturity. While comparing hand thinning of fruits with that of Ethrel sprays, Lekson (1983) observed that 300 and 350 ppm Ethrel on Collins and Redhaven cultivars at 35-45 days after full bloom (when fruit diameter was 10-15 mm) gave similar results to those obtained by hand thinning of fruits. In this crop, blossom thinning to the extent of 73 to 100% by 300 to 450 ppm Ethrel has been reported by Forlani et al.(1981).

Cucurbits are an important group of plant to study the effect of chemical on flower induction and flower sex. Few of such works regarding effect of Ethrel are given below. Bhandary et al. (1974) observed delayed appearance (8 to 22 days) of staminate flowers and earlier and more production of pistillate flowers with 250 to 500 ppm Ethrel in cucumber. Similar findings were also reported by El-Beheidi et al.(1978) and Sutulova (1981). Patil et al. (1983) reported the highest percentage of female flowers in cucumber with 400 ppm Ethrel. While, Sidhu et al. (1982) sprayed 100, 250 and 500 ppm Ethrel on Muskmelon at 2 and 6 true leaf stages. At 500 ppm concentration, it increased female flowers and yield of crop.

While, Arora et al.(1985) observed in Bottle gourd (Lagenaria siceraria) cvs. Pusa Summer and Prolific Long that 250 ppm Ethrel gave higher number of pistillate flowers and fruits that resulted in high yield.

Besides the above crops, a few reports are available on other crops such as mango, pomegranate, fig, orange, plum, date and Eucalyptus. In mango, Chacko et al.(1972) reported induction of flowering in Langra mango in off season by spraying 200 ppm Ethrel. Chadha et al. (1979) reported that that the spraying of 500 and 1000 ppm Ethrel at pre-bloom (October) and bloom period (January) completely killed the mango panicles. Panicles dropped within 7 days of treatment application.

Shaybany and Sharifi (1973) reported from Iran that the application of 1500 and 2000 ppm Ethrel before 18 days of harvest of Rabbab pomegranate resulted in complete defoliation of tree. Increase in concentration of Ethrel from 0 to 2000 ppm caused decreased T.S.S.:acid ratio, vitamin C and T.S.S. It increased leaf abscission, fruit drop and acidity.

Maugleith and EL-Banna (1974) reported that the pre-harvest (18 days) application of 250 to 500 ppm Ethrel accelerated fruit weight and quality of Sultania fig. Muzumdar and Bhatt (1976) noticed increase in fruit size, juice content and T.S.S. and decrease in acidity when 200 to 400 ppm Ethrel was sprayed on sweet orange after fruit set. Dhuria et al.(1976) from Himachal Pradesh observed that the spraying of Ethrel 10 days after full bloom was very effective in chemical thinning

of plum cv. Beauty. They also found that the spraying of 100 and 500 ppm Ethrel after petal fall and when fruits were of wheat grain size resulted in 25.6 to 87.2 per cent crop reduction with better quality fruits. While in date palm El-Hamady et al. (1983) observed in Hayany and Zagloul cultivars that, 100 and 200 ppm Ethrel after 20 days of fruit set caused optimum fruit thinning. At 400 ppm, it caused over thinning. Ripening of date fruits was accelerated by 8 days. Fruit weight and total sugars were increased and tannin content decreased. Killing of Eucalyptus saligen stamens without injuring pistil by 100 ppm Ethrel was observed by Su and Wu (1984). Nagao and Sakai (1987) reported from America that the spraying of 500 ppm Ethrel on macadamia nut cv. Ikaika in late July resulted in 40 to 60 per cent fruit abscission within 12 days of treatment, respectively. Similarly, spraying of 800 ppm Ethrel at 38 weeks after peak flowering resulted in good quality fruit and increased yield over the control.

2.4.2.4 Maleic hydrazide (MH)

MH is a synthetic plant growth inhibitor. It is also reported to act as an anti-auxin and bring about the changes in reverse direction that would have brought about by endogenous auxin, specifically it inhibits auxin transport. (Jauhari and Amarjit, 1960 and Leopold and Kriedemann, 1982). Besides, it is also reported to bring about various physiological changes. Some workers have also reported its effect in reducing

fruit set and increasing fruit drop in some crops. Some of its effects observed by various workers have been narrated here below.

Harris and Smith (1957) found that the spraying of 500 and 1000 ppm MH in late May (3 week after bloom) was effective in thinning of crop of Pecan nuts of Moore and Success cultivars.

In citrus, Gardner et al. (1961) reported that, MH sprayed at 400 ppm on Dancy mandarin during bloom reduced 30% fruit set and total number of big sized fruits. Similarly Josan and Sharma (1987) reported that the spraying of 1000 and 2000 ppm MH on Wilking mandarin at full bloom stage resulted in thinning of fruits.

Hillyer and Wittwer (1959) observed that, application of 250 to 300 ppm MH at young stage in Acorn squash suppressed the vegetative growth of terminal meristem and development of pollen grains in androecia of staminate flowers. At 800 to 1000 ppm, it delayed the appearance of staminate flowers and enhanced appearance of pistillate flowers.

Singh and Singh (1963) reported that the spraying of 2000 ppm MH on mango cv. Langra in November on shoots in on-year resulted in increased number of shoots and balanced crop load distribution in on and off-years. MH generally encouraged early and less vigorous growth in the year of application. Maiti and Maiti (1969) studied the effect of MH on sex expression in mango. They found that the spraying

of 1000 and 2000 ppm MH before flowering increased hermaphrodite flowers. While at 500 ppm, it decreased the hermaphrodite flowers. They stated that, MH acts as growth inhibitor and antiauxin, which at lower concentration (500 ppm) reduced catabolic activities of plant.

Dubey (1969) observed that the spraying of 500, 1000, 1500 and 2000 ppm MH on sweet pea after 52 days of sowing resulted in suppression of the height of main stem, increased number of laterals and delayed flowering.

Chundawat et al. (1975) reported that, spraying of MH at full bloom on guava caused 17.5, 16.5 and 39.2 per cent deblossoming at 1000,2000 and 3000 ppm, respectively. over the control. However, Agnihotri and Bhullar (1979) observed the effect of lower concentration of MH. They found in Allahabad guava that, spraying of 150 and 200 ppm MH, when 15-20 per cent flowers had opened, resulted in 74.80 and 75.25 per cent fruit set reduction, respectively.

Shanmugam and Muthuswamy (1974) observed in chrysanthemum that the spraying of 500, 1000 and 1500 ppm MH on 45, 60 and 75th day of planting suppressed vegetative growth. The growth inhibition was thought to be due to the antiauxin property which caused dwarfing.

Pappiah and Muthuswamy (1974) reported that the spraying of 1000 and 2000 ppm MH after 75th day of planting resulted in increase in number of laterals and reduced plant height in dahalia.

Krishnamoorthy (1981) stated that, MH applied to Pinus and other plants inhibits meristematic activity in shoot tip and prevents formation of leaves, buds and flowers. But laterals buds, those are dormant, are not affected. These emerge out into branches and plant becomes bushy.

In case of cucurbits, Choudhary and Phatak (1959) reported that, foliar application of 100 and 200 ppm MH at early stages of plant, increased number of female flowers significantly over control. While 800 and 1000 ppm MH suppressed the number of male flowers in cucumbers. Sidhu et al. (1981) also reported that, MH induced the formation of female flowers at lower nodes and increased number of female flowers. Jamadagni and Patil (1982) observed that the foliar applicatin of MH at higher concentration induced female flowers in cucumber. While, Arora et al. (1985) observed in bottle gourd (Lagenaria siceraria) that, 150 ppm MH induced early flowering and more number of flowers and fruits that resulted in high yield.

2.4.2.5 Carbaryl (Sevin)

Carbaryl was originally developed as an insecticide. Later on, its flower and fruit thinning action was also observed in some fruit crops, at higher concentration. Its mode of action is thought to be the reduction in IAA transport in plant tissue which results in abscission (Ebert and Bangerth, 1982).

Batjer and Westwood (1960) could observe thinning effect of Carbaryl in apple during the extended period of 3 weeks after blooming. Further, Batjer and Thompson (1961) reported that, Carbaryl applied on Red Delicious apple usually resulted in reduced seed content of persisting fruits and had no effect on seed number in other cultivars. Horsfall and Moore (1963) tried a combination of carbaryl and NAA on Delicious apple and found that, it was more effective for thinning when applied 19 days after full bloom than two application of carbaryl alone. Williams and Batjer (1964) reported that the application of carbaryl on apple leaves at flowering resulted in thinning of flowers and leaves. When it was applied after fruit set, it interfered with movement of growth factors from spur to fruit or seed to abscission zone, which prevented growth of fruit. It resulted in abscission of fruits which turned red in colour with or without seed abortion. While, Wang et al.(1984) observed that the spraying of 2000 ppm Carbaryl at peak flowering period on Ralls apple, when temperature was low and humidity was high, resulted in 62% flower thinning. LI-Peihua et al. (1984) reported from China that the spraying of 750 ppm Carbaryl and 10 ppm NAA at 10 days after beginning of petal fall in Ralls and Delicious apple resulted in flower and fruit thinning. Similarly, Basak et al.(1988) found in Lobo and Spartan cultivars of apple that the spraying of Carbaryl 2 days after flowering resulted in fruit thinning. They also reported that the combined spray of NAA and Carbaryl resulted in fruit thinning with increased fruit size. Windle and Dam (1989) found in Golden Delicious apple that the combined

spray of 1200 ppm Carbaryl and 100 ppm NAA resulted in fruit thinning and increased fruit size by 36 per cent.

In guava, Gupta and Nijjar (1982) observed that Carbaryl at 2000, 4000 and 6000 ppm at full bloom stage in May resulted in 48.9 to 71.7 per cent blossom and fruit thinning. While in mandarins, Josan and Sharma (1987) reported that, spraying of 5000 to 10,000 ppm Carbaryl at full bloom stage in April, resulted in thinning of fruit and flowers. But this chemical had no significant effect on fruit quality.

The review of literature given in the preceding pages reveal that, in general, crop regulation in various fruit crops can be done both by mechanical and chemical means. As far as the plant growth regulators are concerned, they are reported to act in various ways and, hence, their judicious use is necessary. Many a times, their indirect effects are exploited by the workers for commercial application. Their effects can be, sometimes, influenced by the type of crop, cultivar within a crop, stage of application and concentration used.

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# Material and Methods

# 3. MATERIAL AND METHODS

The present investigation was carried out at the Instructional-cum-Research Orchard of Department of Horticulture, Central Campus, Mahatma Phule Agricultural University, Rahuri during 1989. Geographically, the Central Campus of Mahatma Phule Agricultural University is situated in between 19°47' to 19°57' North latitude and between 74°19' and 74°32' East longitude. It is situated at about 525 metres above the mean sea level. Climatically, this area falls in semi-arid zone with the annual rainfall varying from 360 to 619 mm, the average annual rainfall being 520 mm. However, the precipitation is erratically distributed and most of the rainfall is received through South-West monsoon. The annual mean maximum temperature is 40.7°C and mean minimum temperature is 8.7°C. The relative humidity at 8.00 and 17.00 hours is about 59 and 35 per cent, respectively. The relative humidity, temperature and rainfall distribution during the year 1989-90 is given in Appendix-I.

The investigation was conducted on 7 year old plants of pomegranate cultivar Ganesh spaced at 5 x 5 m. The soil of experimental plot was light to medium, 0.5 m deep, underlaid with murum. The pH was 8.1. The details of material used and the techniques adopted during the course of investigation are described below.

## 3.1 Experimental details

The investigation was conducted during ambia bahar of 1989. For this cropping, the experimental plants were given water stress of about 2 month during November-December, 1988. Then the ambia bahar (January-February flowering) cropping was commenced by irrigating and manuring the plants. This irrigation is called as the first irrigation of the cropping. Thereafter, regular irrigations were given. The treatments were started on 75th day after the first irrigation as described under respective treatments in following paragraph. The other details of the experiment are also given below.

A) Treatments : 15

1. Control
2. Hand removal of flowers at 14 days interval starting from 75th day after first irrigation.
3. Hand removal of flowers only on 75th day after first irrigation and a spray of 20 ppm GA on the same day.
4. Spray of 500 ppm NAA on 75th day after first irrigation.
5. Spray of 250 ppm NAA followed by a spray of 0.7% Carbaryl, both on 75th day after first irrigation.
6. Spray of 500 ppm NAA followed by a spray of 0.7% Carbaryl, both on 75th day after first irrigation.
7. Spray of 500 ppm NAA on 75th day after first irrigation, followed by a spray of 1000 ppm MH (Maleic hydrazide) 14 days later.

8. Spray of 250 ppm Ethrel on 75th day after first irrigation, followed by a spray of 100 ppm NAA 14 days later.
9. Spray of 500 ppm Ethrel on 75th day after first irrigation, followed by a spray of 100 ppm NAA 14 days later.
10. Spray of 250 ppm Ethrel on 75th day after first irrigation, followed by a spray of 20 ppm GA 14 days later.
11. Spray of 500 ppm Ethrel on 75th day after first irrigation, followed by a spray of 20 ppm GA 14 days later.
12. Spray of 0.7% (7000 ppm) Carbaryl on 75th day after first irrigation.
13. Spray of 1000 ppm Maleic Hydrazide (MH) on 75th day after first irrigation.
14. Spray of 250 ppm Ethrel on 75th day after first irrigation.
15. Spray of 500 ppm Ethrel on 75th day after first irrigation.

B) Replications : 3

C) Plant unit per treatment : 5

D) Design : Randomized Block Design

3.1.1 Treatment application

In case of control (Treatment 1), neither the spray of chemical was given nor the flowers were removed. The plants were kept as such. In case of Treatment 2, all the flowers present on the tree on 75th day after first irrigation were removed. Thereafter, in this treatment, the flowers were removed manually at 14 days interval till harvest. In case of Treatment 3, all the flowers were hand removed only once i.e. on the 75th day and on the same day a spray of 20 ppm GA was given. In this treatment (T 3), no flowers were hand removed afterwards.

As regards growth regulator sprays, firstly the stock solution of each chemical was prepared in appropriate solvent. For preparing the the stock solutions, ethyle alcohol for Gibberellic acid and hot water for Maleic hydrazide were used. For Ethrel, Carbaryl and NAA (Planofix) distilled water was used. The required quantity of the plant growth regulator was dissolved in the solvent and the volume of stock solution was made by distilled water. From prepared stock solution, the spray solutions of desired concentrations and quantity were prepared by diluting it with water.

All the above plant growth regulator spray solutions were prepared in separate plastic containers. The plants were sprayed to the point of drenching which required 3 litres of solution per plant. When two sprays were on a plant on the

same day, as in treatment 5 and 6, the second spray was given after 6 hours to ensure that the spray solution of first spray was completely dried.

For spraying NAA solution, the commercial formulation "Planofix" was used since it is popular among the growers.

The details of the chemicals used, regarding active ingradient content and source, are given in the following table.

Details of the chemicals used.

| Plant growth regulator | Chemical name | Actual ingra-dient | Company |
|---|---|---|---|
| Planofix | $\alpha$-naphthalene acetic acid | 4.5% | May and Baker Limited, Bombay |
| Ethrel | 2-chloroethyl-phosphonic acid | 40% | Baker and Baker Chemical Company, Bombay. |
| $GA_3$ | Gibberellic acid | 100% | Polfa-Kunta, Poland |
| MH | Maleic hydrazide | 100% | Sisco Chemical Laboratories, Bombay |
| Carbaryl | 1-naphthyl N-methyl carbamate | 80% | Paushak Limited, Panelar (Gujarath) |

3.2 After care

At the time of first irrigation, each plant was supplied with 25 kg F.Y.M., 325 g N (in form of Urea), 300 g P (Super phosphate) and 300 g K (Murate of Potash). The second dose of nitrogen at a rate of 300 g per plant was given after 45

days of first dose. A light irrigation was given on the 4th day of bahar treatment. Thereafter, normal irrigations were given to the orchards, usually at 8 days interval. Standard schedule of spraying of insecticides and fungicides was fallowed. Weeding was done as and when needed.

### 3.3 Observations

The observations in respect of vegetative growth, flowering aspects, fruit characters and yield were recorded as described below.

#### 3.3.1 Growth

To have indications about the effect of the chemicals used on vegetative growth, the following observations were recorded.

##### 3.3.1.1 No. of new shoots produced

A day before treatment application, four branches on four sides of each experimental tree were tagged. All the new shoots produced on these tagged branches were counted and average number of new shoots produced per branch was worked out.

##### 3.3.1.2 Length of new shoot

After 45 days of treatments (120 days after first irrigation), 4 newly produced shoots, on each of the four tagged branches were randomly selected. Their length was measured with a scale and average length of a shoot is reported.

3.3.1.3 Diameter of shoot

The shoots marked for measuring shoot length were used for this observation. The diameter was measured, one centimetre above the base of the shoot, with the help of vernier callipers. The average shoot diameter is reported.

3.3.1.4 Leaf area

The shoots used for recording shoot length were also used for this observation. All the leaves from these shoots were removed and counted. Their area was measured with the help of leaf-area-meter. The total leaf area per shoot is presented.

3.3.1.5 Chlorophyll content of leaves

For estimating chlorophyll content of leaves, the leaves used for estimating leaf area were used. Four leaves were randomly selected and sample was collected early in the morning. Punches of leaves, avoiding veins, were taken with cork borer and mixed. A sample of 0.2 g was taken and ground in morter and pestle by using 80% acetone. The extract was filtered through Whatman No.41 filter paper in 50 ml volumetric flask and final volume was made by 80% acetone. Absorbance value at 645 and 663 mμ was recorded by using Bausch & Lamb spectronic-20 colorimeter. The chlorophyll content was expressed in mg/g by using following formula given by Arnon (1949).

$$\text{Chlorophyll A} = (12.7 \times A \text{ at } 663 - 2.69 \times A \text{ at } 645) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll B} = (22.9 \times A \text{ at } 645 - 4.68 \times A \text{ at } 663) \times \frac{V}{1000 \times W}$$

$$\text{Total Chlorophyll} = (20.2 \times A \text{ at } 645 + 8.02 \times A \text{ at } 663) \times \frac{V}{1000 \times W}$$

Where, V = Volume of extract

W = Weight of sample

A = Absorbance

### 3.3.2 Flowering characters

#### 3.3.2.1 Number of flowers

##### 3.3.2.1.1 Flowers produced before treatment application

To take the initial count of flowers produced by the tree from first irrigation till the date of treatment application, all the fruits and flowers present on the tree were counted and summation of these was considered as the flowers produced by the tree before treatment application.

##### 3.3.2.1.2 Total flowers produced

Starting from the date of treatment application (75th day of first irrigation), the flowers (also fruits) dropped under each experimental plant were regularly collected and counted and totalled at the end. Similarly, the fruits at all picking were counted and totalled. After complete harvest of the fruits, the flowers that were present on the tree were hand removed and counted. At the end of experiment, the fruits harvested and flowers counted (the dropped and hand removed at end) were summed to get the total flowers produced by the tree.

In case of treatments T 2 and T 3, where the flowers were hand removed as a treatment operation, such flowers were considered as dropped flowers for this purpose.

3.3.2.1.3 Flowers produced after treatment application

From the count of total flowers as calculated in above observation, the count of flowers produced before treatment application was substracted to work out the new flowers produced after treatment application.

3.3.2.1.4 Count of flowers produced periodically

The flowers and fruits dropped under each tree were collected at regular interval and counted. The fruits and flowers present on the tree on that date were also counted. All the flowers and fruits dropped till a particular observation and the flowers and fruits present on the tree on that particular date were totalled to get total flowers produced by the tree till that date. From this total, the similar total of the earlier observation was substracted to work out the new flowers produced during the particular period.

3.3.2.2 Number and kinds of flowers dropped

The number of flowers dropped under each experimental tree were collected at alternate day for two weeks from the day of treatment application. Thereafter, the count of the flowers dropped was taken at 14 days interval. The observation was continued till the end of harvest. The flowers dropped

were also classified into male, hermaphrodite (female) and intermediate flowers (Sonawane, 1986). The data in respect of total flowers and type of flowers dropped periodically is reported.

3.3.2.3 Types of flowers produced

To know the effect of treatments on kind of flowers induced, the count of type of flowers produced was also taken. To record this observation, the flowers that were lying under each tree on the date of treatment application were collected and removed before application of a treatment. Initial flowers present on experimental tree on the date of start of treatment (75th day) were counted and classified into male, hermaphrodite and intermediate flowers. Then, the flowers dropped under each tree from date of treatment application (75th day of first irrigation) till the end of harvest were collected at regular interval as described above (3.3.2.2) and classified into male, hermaphrodite and intermediate. Similarly, the flowers present on the tree at the end of harvest were plucked, classified and the count was added to the count of the dropped male, hermaphrodite and intermediate flowers, respectively to get the total of each type. From this total of each type of flowers, the flowers initially present on tree at the time of treatment application were substracted to work out the number of male, hermaphrodite and intermediate types of flowers produced after treatment application.

3.3.2.4 Number of fruits set

The number of fruits present on the tree on the day of start of treatment (on 75th day after first irrigation) were

counted. The fruits that were lying on the ground on this date were collected and removed, and were not considered. Thereafter, at regular interval, the fruits present on the tree and those dropped were counted. All the fruits dropped till a particular observation and the fruits present on the tree on that particular date were totalled to get the total fruits set by the tree till that date. To work out the number of the fruits set during a particular period, the count of the fruits set till earlier observation was substracted from the latter. The fruits set before treatment application, total fruits set up to the last harvest and those set during a particular period are reported. At latter observations, the harvested fruits were taken into account.

3.3.2.5 Number of fruits dropped

The number of fruits dropped under each experimental tree were collected at regular interval from the date of treatment application till the end of harvest. At each observation, the fruits dropped were collected, counted and removed. The data in respect of periodical fruit drop per tree are reported at 28 days interval from the date of treatment application till the end of harvesting.

3.3.3 Yield

3.3.3.1 Number of fruits

As and when the fruits were matured, they were plucked and counted. At the end of cropping, fruits of all pickings were summed to get the total. At the end of cropping, the immature fruits that were present on the tree were also

removed and counted, and added to the harvested fruits to get the total number of fruits per tree. The immature fruits were considered as unmarketable, and the count of matured and immature fruits is given along with the total number of fruits.

3.3.3.2 Total weight of harvested fruits

As and when the fruits were matured, they were plucked. The individual fruit was weighed on a physical balance. At the end of harvest, the weights of all the fruits harvested from a tree were totalled. The weight of matured, immature and total fruits were taken. The data on yield of marketable and unmarketable fruits is reported in similar manner as in 3.3.3.1.

3.3.3.3 Number of harvested fruits : gradewise

The individual matured fruit, harvested and weighed as in the observation 3.3.3.2 was graded either as A, B, C, or D as below, as described by Sonawane (1986).

1. 300 g and above - 'A' grade
2. 200 to 299 g - 'B' grade
3. 150 to 199 g - 'C' grade
4. 149 g and below - 'D' grade

The count of number of A, B, C and D grade fruits was worked out separately for each tree at each picking. At the end of cropping, the respective counts were totalled to get

the number of fruits of the respective grade per tree. The immature fruits were not considered for A, B, C and D grades.

3.3.3.4 Weight of harvested fruits : gradewise

The total weights of A, B, C or D grade fruits were worked out separately for each grade and for each tree at each picking. At the end of the cropping, the respective weights were totalled to get the total weight of fruits of respective grade per tree.

3.3.4 Fruit character

3.3.4.1 Average weight of fruit: general and gradewise

To calculate the average weight of fruit in each grade viz., A, B, C and D, the total weight of fruits under each grade was divided by the number of fruits of respective grade. Similarly, the total weight of all the fruits, irrespective of the grades, was divided by the total number of all the fruits to work out the general average weight of the fruit in that treatment.

3.3.4.2 Total soluble solids (TSS)

The total soluble solids (TSS) percentage was recorded by Zeist pocket hand refractometer calibrated from 0 to 45°brix scale. For calculating total soluble solids, three fully ripen fruits per treatment were collected at the time of peak harvesting period (two and half month after treatment application). The juice was extracted from the arils and a few drops were

mounted on the clean prism of the refractometer. The scale was read against the light. The average of three reading was taken.

3.3.4.3 Acidity

The juice remained after calculating Total Soluble Solid , was used for estimating the acidity. The acidity of the juice was determined by A.O.A.C. Method (1980). Ten millilitre juice was taken in a conical falsk. To it, about 20 ml of distilled water was added and titrated with 0.1 N NaOH, using 2 to 3 drops of phenolphthalein as an indicator, till pink colour was obtained. The acidity is expressed in terms of per cent citric acid.

3.3.4.4 Visual observations

Besides the data recorded in respect of the above parameters, the visual observations regarding the effect of spray chemicals on foliage, flowers and fruits were also noted from time to time.

3.3.5 Economics

Economics of the different treatments was worked out to compare their efficacy for final utility to the growers. While working out total expenditure for a treatment, the direct cost incurred on treatment application i.e. labour required for spraying/flower removal, cost of chemical and the expenditure that was indirectly influenced by the treatment such as harvesting and marketing charges resulting from decrease or increase

in crop load were taken into consideration. The cost which was identical in all the treatments because of common production practices such as irrigation, manuring, land preparation, watching, intercultural operations and plant protection were not considered. To work out the receipt of produce, in terms of money, the rates/prices prevailing in Bombay market and that would be realized by farmer as per the grades of fruits from time to time, as and when they are harvested,were taken into consideration and the total returns were calculated. The differences between gross receipt of total produce and the expenditure incurred was worked out as net income and estimated net income per hectare is reported. The increase or decrease in net returns over the control was worked out.

3.3.6 Statistical analysis of data

The data obtained in respect of various observations except economics and visual observations were subjected to the statistical analysis as per Panse and Sukhatme (1967).

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# Experimental Results

# 4. EXPERIMENTAL RESULTS

The results of the present investigation obtained in respect of vegetative growth, flowering aspects, fruits set, fruit drop, yield and fruit quality are presented in this chapter under appropriate headings.

## 4.1 Vegetative growth

The data in respect of number of shoots produced, shoot length, shoot diameter and leaf area per shoot are presented in Table 1. While, that in respect of chlorophyll content of leaf are presented in Table 2.

### 4.1.1 Number of new shoots

The data presented in Table 1, in respect of number of new shoots produced per tagged branch, reveal that the number of new shoots varied from 15.15 to 20.70 in different treatments and the differences were significant.

Significantly the highest number of new shoots (20.70) were produced in T 11 (500 ppm Ethrel + 20 ppm GA after 14 days). It was at par with T 3 (Hand removal of flowers + 20 ppm GA) which gave 20.63 number of shoots per branch followed by T 15 (500 ppm Ethrel) with 19.96, T 13 (1000 ppm MH) with 19.72 and T 7 (500 ppm NAA + 1000 ppm MH after 14 days) with 19.40 number of shoots per branch. Significantly the lowest number of shoots were observed in T 4 (500 ppm NAA) which gave 15.15 shoots and it was at par with T 8 (250 ppm Ethrel + 100 ppm NAA after 14 days) and T 14 (250 ppm Ethrel)

Table 1. Effect of different treatments on number of shoots, shoot length, shoot diameter and leaf area per shoot.

| Treatments | | Number of shoots per branch | Shoot length (cm) | Shoot diameter (mm) | Total leaf per shoot (sq.cm) |
|---|---|---|---|---|---|
| T 1 | Control | 18.43 | 12.33 | 1.60 | 51.48 |
| T 2 | Hand removal of flowers | 18.53 | 13.13 | 1.63 | 53.03 |
| T 3 | Hand removal of flowers + 20 ppm GA | 20.63 | 17.77 | 1.61 | 88.35 |
| T 4 | 500 ppm NAA | 15.15 | 9.39 | 1.78 | 62.46 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 18.01 | 11.43 | 1.61 | 66.54 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 18.86 | 10.30 | 1.60 | 54.74 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 19.40 | 9.25 | 1.69 | 59.69 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 16.13 | 10.55 | 1.59 | 44.72 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 18.50 | 9.34 | 1.63 | 42.18 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 18.48 | 11.22 | 1.62 | 49.80 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 20.70 | 10.14 | 1.65 | 45.93 |
| T 12 | 0.7% Carbaryl | 18.11 | 10.61 | 1.54 | 39.52 |
| T 13 | 1000 ppm MH | 19.72 | 9.52 | 1.66 | 40.34 |
| T 14 | 250 ppm Ethrel | 16.60 | 10.42 | 1.59 | 45.12 |
| T 15 | 500 ppm Ethrel | 19.96 | 9.62 | 1.62 | 40.10 |
| S.E. ± | | 0.53 | 0.36 | 0.011 | 1.61 |
| C.D. at 5% | | 1.51 | 1.02 | 0.054 | 4.58 |

which were having 16.13 and 16.60 shoots per branch, respectively.

4.1.2 Shoot length

The data in respect of shoot length, presented in Table 1, reveal that the average shoot length in different treatments varied from 9.25 cm in T 7 (500 ppm NAA + 1000 ppm MH after 14 days) to 17.77 cm in T 3 (Hand removal of flowers + 20 ppm GA) and the differences were significant.

T 3 produced larger shoots than all other treatments. It was followed by T 2 (Hand removal of flowers). The treatment T 7, which produced the shortest shoots, was at par with T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days), T 4 (500 ppm NAA), T 13 (1000 ppm MH) and T 15 (500 ppm Ethrel).

Over all observations indicate that the growth inhibitors namely, Ethrel and MH pronouncely reduced the shoot length while GA increased it.

4.1.3 Shoot diameter

The data regarding shoot diameter, presented in Table 1, indicate that there were significant differences in shoot diameter due to various treatments and it varied from 1.54 to 1.78 mm. Significantly, the highest shoot diameter was observed in T 4 (500 ppm NAA) and T 7 (500 ppm NAA + 1000 ppm MH after 14 days), and the values were 1.78 and 1.69 mm, respectively. The lowest shoot diameter was observed in

T 12 (0.7% Carbaryl) which was at par with T 8 (250 ppm Ethrel + 100 ppm NAA after 14 days) and T 14 (250 ppm Ethrel).

4.1.4 Leaf area per shoot

It is observed from Table 1 that the total leaf area per shoot, due to various treatments, ranged from 39.52 to 88.35 sq.cm. and the differences were statistically significant. The highest total leaf area per shoot was revealed in T 3 (88.35 sq.cm), followed by T 5 (66.54 sq.cm), T 4 (62.46 sq.cm) and T 6 (54.74 sq.cm). The lowest total leaf area per shoot was 39.52 sq.cm which was in T 12. The next treatment to record the lowest total leaf area (40.10 sq.cm) was T 15 (500 ppm Ethrel) followed by T 13 (40.34 sq.cm), which were at par.

In general, it was observed that when there was growth inhibitor (MH or Ethrel) as a basic spray chemical, the total leaf area per shoot was less.

4.1.5 Chlorophyll content

The data in respect of chlorophyll-a, chlorophyll-b and total chlorophyll contents of leaves are presented in Table 2. It is seen from the data that the different treatments had significant differences in these parameters.

The total chlorophyll content due to various treatments varied from 1.36 to 1.91 mg/g. The lowest and the highest values being recorded by T 15 (500 ppm Ethrel) and T 4 (500 ppm NAA), respectively. The treatment T 15 (500 ppm Ethrel) which

Table 2. Effect of different treatments on chlorophyll content of leaves.

| Treatments | Chlorophyll-a (mg/g) | Chlorophyll-b (mg/g) | Total Chlorophyll (mg/g) |
|---|---|---|---|
| T 1 Control | 1.02 | 0.73 | 1.75 |
| T 2 Hand removal of flowers | 1.03 | 0.75 | 1.78 |
| T 3 Hand removal of flowers + 20 ppm GA | 0.98 | 0.76 | 1.70 |
| T 4 500 ppm NAA | 1.04 | 0.87 | 1.91 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 0.96 | 0.73 | 1.69 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 0.99 | 0.88 | 1.87 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 1.01 | 0.82 | 1.83 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 0.79 | 0.70 | 1.49 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 0.70 | 0.69 | 1.39 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 0.78 | 0.70 | 1.48 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 0.71 | 0.67 | 1.37 |
| T 12 0.7% Carbaryl | 0.84 | 0.68 | 1.52 |
| T 13 1000 ppm MH | 0.65 | 0.74 | 1.39 |
| T 14 250 ppm Ethrel | 0.79 | 0.61 | 1.40 |
| T 15 500 ppm Ethrel | 0.72 | 0.64 | 1.36 |
| S.E. $\pm$ | 0.015 | 0.028 | 0.082 |
| C.D. at 5% | 0.043 | 0.080 | 0.23 |

registered the lowest total chlorophyll content was also at par with T 11 (500 ppm Ethrel + 20 ppm GA after 14 days) followed by T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days) and T 13 (1000 ppm MH) which registered 1.36, 1.37, 1.39 and 1.39 mg/g total chlorophyll, respectively. Significant increase in total chlorophyll content, over the control, was observed in T 4, T 6 and T 7 which had 500 ppm NAA as basal spray.

Thus, in general, it was observed that the total chlorophyll content was reduced by all chemicals, except 500 ppm NAA. It was more reduced by Ethrel sprays as compared to other chemicals.

## 4.2 Flowering aspects

### 4.2.1 Number of flowers

#### 4.2.1.1 Flowers produced before treatment application

The data in respect of number of flowers and fruits present on tree before start of treatment application i.e. the flowers and fruits present on tree on the date of treatment application are presented in Table 3, which together were considered as the flowers produced before treatment application.

The statistical analysis of data (Table 3) reveals that there were no significant differences regarding the number of flowers and fruits present on the tree at the time of treatment application.

Table 3. Number of flowers and fruits on trees before treatment application.

| Treatments | Number of flowers per tree | Number of fruits per tree | Total (flowers + fruits) |
|---|---|---|---|
| T 1 Control | 37.27 | 84.12 | 121.39 |
| T 2 Hand removal of flowers | 36.13 | 77.67 | 113.80 |
| T 3 Hand removal of flowers + 20 ppm GA | 37.31 | 71.83 | 109.14 |
| T 4 500 ppm NAA | 40.15 | 67.00 | 107.15 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 39.39 | 76.80 | 116.19 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 42.39 | 64.77 | 107.16 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 36.90 | 77.60 | 114.50 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 38.52 | 73.13 | 111.65 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 39.46 | 73.04 | 112.50 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 38.52 | 80.20 | 118.72 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 40.53 | 77.20 | 117.73 |
| T 12 0.7% Carbaryl | 34.25 | 75.53 | 109.78 |
| T 13 1000 ppm MH | 38.63 | 79.13 | 117.76 |
| T 14 250 ppm Ethrel | 40.66 | 67.93 | 108.59 |
| T 15 500 ppm Ethrel | 40.19 | 70.87 | 111.06 |
| S.E. $\pm$ | 3.70 | 4.01 | 6.96 |
| C.D. at 5% | N.S. | N.S. | N.S. |

4.2.1.2 Number of flowers produced after treatment application

The data in respect of total number of new flowers produced by the respective trees, after application of treatments, are presented in Table 4. It is revealed from the data that the highest number of flowers (148.76) were produced in T 2 (Hand removal of flowers). It was followed by T 1 (Control) with 134.55, T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days) with 125.43 and T 15 (500 ppm Ethrel) with 120.41 number of flowers per tree. Significantly, the lowest number of new flowers produced after treatment application was observed in T 12 (0.7% Carbaryl) which had 71.51 flowers. It was followed by T 13 (1000 ppm MH), T 3 (Hand removal of flowers + 20 ppm GA), T 6 (500 ppm NAA + 0.7% Carbaryl) and T 10 (250 ppm Ethrel + 20 ppm GA after 14 days) with 79.89, 82.21, 92.09 and 92.27 number fof flowers, respectively.

Thus, the data in Table 4 reveal that, 0.7% Carbaryl as also 1000 ppm MH, reduced new flower production most effectively. Hand removal of flowers, at regular interval of 14 days through out the cropping season, induced more flower production. However, hand removal of flowers only once i.e. on 75th day along with application of GA reduced the flower production.

It is further revealed from Table 4 that flower production continued through out the cropping season though the intensity was reduced as season advanced.

| Treatments | | Flowers produced during the period (days) (Number/tree) | | | Total flowers produced (No./tree) |
|---|---|---|---|---|---|
| | | 1 to 28 | 29 to 56 | 57 to 90 | |
| T 1 | Control | 63.04 | 50.82 | 20.69 | 134.55 |
| T 2 | Hand removal of flowers | 66.31 | 54.91 | 27.54 | 148.76 |
| T 3 | Hand removal of flowers + 20 ppm GA | 44.10 | 28.31 | 9.80 | 82.21 |
| T 4 | 500 ppm NAA | 54.02 | 23.82 | 15.42 | 93.26 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 40.63 | 30.67 | 14.00 | 85.30 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 48.76 | 30.72 | 12.61 | 92.09 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 56.61 | 31.56 | 12.77 | 100.94 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 41.59 | 38.81 | 14.43 | 94.83 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 60.03 | 48.41 | 16.99 | 125.43 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 39.87 | 34.41 | 17.99 | 92.27 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 55.31 | 49.00 | 15.02 | 119.23 |
| T 12 | 0.7% Carbaryl | 30.77 | 25.38 | 15.36 | 71.51 |
| T 13 | 1000 ppm MH | 38.81 | 28.28 | 12.80 | 79.89 |
| T 14 | 250 ppm Ethrel | 41.87 | 36.85 | 15.88 | 94.60 |
| T 15 | 500 ppm Ethrel | 57.12 | 47.06 | 16.23 | 120.41 |
| | S.E. ± | 2.90 | 2.32 | 3.16 | 8.30 |
| | C.D. at 5% | 8.24 | 6.60 | 8.98 | 23.59 |

4.2.2 Types of flowers

The data in respect of number of male, hermaphrodite and intermediate flowers produced per tree after treatment application are presented in Table 5 and that in respect of percentage of type of flowers are presented in Table 6.

It is observed that, more number of male flowers were produced by the treatments T 2 (104.92), T 1 (81.64), T 3 (65.75), T 11 (65.37), T 9 (62.53) and T 7 (61.42). While, less number of male flowers were produced in T 13 (44.17), followed by T 12 (44.92), T 14 (48.81) and T 5 (51.85) treatments.

As regards the number of hermaphrodite flowers, the treatment T 3 (7.92) produced significantly the lowest number than all other treatments. While T 15 (32.37), T 9 (31.80), T 11 (27.46) and T 1 (25.47) produced significantly more number of hermaphrodite flowers than rest of the treatments.

In respect of intermediate flower number, T 3 (8.54) produced significantly the lowest number, while T 9 (31.10), T 15 (29.97), T 1 (27.44) and T 11 (26.40) produced more number of this type of flowers than rest of the treatments.

The data in respect of percentage of different types of flowers produced after treatment application, presented in Table 6, reveal that, T 3 (Hand removal of flowers + 20 ppm GA) induced the highest (79.99%) percentage of male flowers as compared to control (60.67%). Next in order were the treatments T 2 (70.53%) and T 4 (62.42%). Lower percentage of male flowers, as compared to control was observed in T 15

Table 5. Number of types of flowers produced after treatment application.

| Treatments | Male flowers (No./tree) | Hermaphrodite flowers (No./tree) | Intermediate flowers (No./tree) |
|---|---|---|---|
| T 1 Control | 81.64 | 25.47 | 27.44 |
| T 2 Hand removal of flowers | 104.92 | 21.09 | 22.75 |
| T 3 Hand removal of flowers + 20 ppm GA | 65.75 | 7.92 | 8.64 |
| T 4 500 ppm NAA | 58.22 | 18.28 | 16.76 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 51.85 | 19.54 | 13.91 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 56.13 | 18.71 | 17.25 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 61.42 | 23.24 | 16.28 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 53.29 | 21.68 | 19.86 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 62.53 | 31.80 | 31.10 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 56.17 | 17.67 | 18.43 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 65.37 | 27.46 | 26.40 |
| T 12 0.7% Carbaryl | 44.92 | 15.02 | 11.57 |
| T 13 1000 ppm MH | 44.17 | 20.44 | 15.28 |
| T 14 250 ppm Ethrel | 48.81 | 23.89 | 21.90 |
| T 15 500 ppm Ethrel | 58.07 | 32.37 | 29.97 |
| S.E. ± | 8.75 | 3.07 | 2.91 |
| C.D. at 5% | 24.87 | 8.73 | 8.27 |

Table 6. Percentage of types of flowers produced per tree after treatment application.

| Treatments | Male flowers (%) | Hermaphrodite flowers (%) | Intermediate flowers (%) |
|---|---|---|---|
| T 1 Control | 60.67 | 18.93 | 20.40 |
| T 2 Hand removal of flowers | 70.53 | 14.18 | 15.29 |
| T 3 Hand removal of flowers + 20 ppm GA | 79.99 | 9.63 | 10.38 |
| T 4 500 ppm NAA | 62.42 | 19.60 | 17.98 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 60.78 | 22.91 | 16.31 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 60.95 | 20.32 | 18.73 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 60.85 | 23.02 | 16.13 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 56.19 | 22.86 | 20.95 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 49.85 | 25.35 | 24.80 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 60.88 | 19.15 | 19.97 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 54.83 | 23.03 | 22.14 |
| T 12 0.7% Carbaryl | 62.82 | 21.00 | 16.18 |
| T 13 1000 ppm MH | 55.29 | 25.58 | 19.13 |
| T 14 250 ppm Ethrel | 51.60 | 25.25 | 23.15 |
| T 15 500 ppm Ethrel | 48.23 | 26.88 | 24.89 |
| S.E. ± | 6.67 | 1.33 | 1.81 |
| C.D. at 5% | 18.96 | 3.78 | 5.15 |

(500 ppm Ethrel), T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days), T 14 (250 ppm Ethrel), T 11 (500 ppm Ethrel + 20 ppm GA after 14 days) and T 13 (1000 ppm MH) and the values were 48.23, 49.85, 51.60, 54.83 and 55.29 per cent, respectively.

As regards percentage of hermaphrodite flowers T 3 (9.63%) inhibited their induction as compared to control (18.93%). While, T 15 (26.88%), T 13 (25.58%) and T 9 (25.35%) induced significantly more hermaphrodite flowers.

The percentage of intermediate flowers (Table 6) was the lowest in T 3 (10.38%) and high in T 15 (24.89%), T 9 (24.80%), T 14 (23.15%) and T 11 (22.14%) as compared to control (20.40%).

Thus, it could be summed up that, GA induced more percentage of male flowers, and low percentage of hermaphrodite and intermediate flowers. While, MH and Ethrel distinctly induced more percentage of hermaphrodite and intermediate flowers.

### 4.2.3 Flower drop

#### 4.2.3.1 Number of flowers dropped : periodical and total

The data in respect of periodical and total flowers drop, depicted in Table 7, reveal that the flower drop continued almost through out the cropping period though, by and large, intensity of flower drop was gradually reduced as the period advanced.

Table 7. Number of flowers dropped after treatment application.

| Treatments | Number of flowers dropped during the period (days) | | | Total flowers dropped (No./tree) |
|---|---|---|---|---|
| | 1 to 28 | 29 to 56 | 57 to 70 | |
| T 1 Control | 49.22 | 54.27 | 37.78 | 141.27 |
| T 2 Hand removal of flowers | 102.44 | 54.91 | 27.54 | 184.89 |
| T 3 Hand removal of flowers + 20 ppm GA | 71.30 | 19.43 | 17.50 | 108.23 |
| T 4 500 ppm NAA | 55.61 | 36.30 | 18.50 | 110.41 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 42.43 | 40.90 | 16.00 | 99.33 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 62.02 | 37.92 | 13.37 | 113.31 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 60.30 | 35.86 | 16.95 | 113.11 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 52.77 | 39.67 | 19.88 | 112.32 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 79.40 | 52.19 | 15.81 | 147.40 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 58.12 | 35.60 | 18.21 | 111.93 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 80.12 | 49.12 | 15.45 | 144.69 |
| T 12 0.7% Carbaryl | 35.13 | 27.21 | 19.95 | 82.29 |
| T 13 1000 ppm MH | 34.96 | 32.29 | 26.90 | 94.15 |
| T 14 250 ppm Ethrel | 55.64 | 36.06 | 21.64 | 113.34 |
| T 15 500 ppm Ethrel | 78.02 | 45.92 | 18.52 | 142.46 |
| S.E. $\pm$ | 9.11 | 3.34 | 4.02 | 15.06 |
| C.D. at 5% | 25.90 | 9.09 | 11.43 | 42.81 |

It could be inferred from the data in Table 7 that the treatment 'T 2', in which the flowers were hand removed at regular interval of 14 days was effective in removing the flower load from the tree. Amongst chemical treatments, the treatment T 11 (500 ppm Ethrel + 20 ppm GA after 14 days), T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days), T 15 (500 ppm Ethrel) and T 3 (Hand removal of flowers + 20 ppm GA) were significantly effective in inducing heavy flower drop/removal during first 28 days. These treatments had 80.12, 79.40, 78.02 and 71.30 number of flowers dropped during first 28 days as compared to 49.22 in control. These treatments continued to show more or less similar effects in subsequent interval, especially T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days), T 11 (500 ppm Ethrel + 20 ppm GA after 14 days) and T 15 (500 ppm Ethrel).

When viewed in light of total flower drop (Table 7), T 2 (Hand removal of flowers) was the most effective to remove the flower load from trees. It was followed by T 9 (147.40), T 11 (144.69), T 15 (142.46), T 14 (113.34), T 6 (113.31) and T 7 (113.11) which were also quite effective to induce flower drop. However, in 0.7% Carbaryl, the number of flowers dropped was the lowest.

4.2.3.2 Percentage of flower drop : periodical and total

The data in respect of percentage of flowers dropped are presented in Table 8. It could be seen from these data that the highest percentage of flower drop was during first

Table 5. Percentage of flowers dropped after treatment application.

| Treatments | Percentage of flowers dropped during the period (days) | | | Total flowers dropped (%) |
|---|---|---|---|---|
| | 1 to 28 | 29 to 56 | 57 to 70 | |
| T 1 Control | 28.64 | 31.59 | 21.99 | 82.22 |
| T 2 Hand removal of flowers | 55.41 | 29.69 | 14.90 | 100.00 |
| T 3 Hand removal of flowers + 20 ppm GA | 59.65 | 16.26 | 14.64 | 90.55 |
| T 4 500 ppm NAA | 41.68 | 27.21 | 13.87 | 82.76 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 34.03 | 32.80 | 12.83 | 79.66 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 46.12 | 28.20 | 9.94 | 84.26 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 43.74 | 26.02 | 12.30 | 82.06 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 39.57 | 29.75 | 14.91 | 84.23 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 48.15 | 31.65 | 9.59 | 89.39 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 44.44 | 27.22 | 13.92 | 85.58 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 50.15 | 30.75 | 9.67 | 90.57 |
| T 12 0.7% Carbaryl | 33.22 | 25.73 | 18.86 | 77.81 |
| T 13 1000 ppm MH | 29.50 | 27.24 | 22.70 | 79.44 |
| T 14 250 ppm Ethrel | 41.13 | 26.66 | 16.00 | 83.79 |
| T 15 500 ppm Ethrel | 48.58 | 28.59 | 11.53 | 88.70 |
| S.E. $\pm$ | 2.65 | 1.61 | 1.47 | 2.41 |
| C.D. at 5% | 7.53 | 4.58 | 4.18 | 6.85 |

28 days in all treatments, except control. T 3 (Hand removal of flowers + 20 ppm GA) with 59.65% followed by T 2 (Hand removal of flowers), T 11 (500 ppm Ethrel + 20 ppm GA after 14 days), T 15 (500 ppm Ethrel), T 9 (500 ppm Ethrel + 100 ppm NAA after 14 days) and T 6 (500 ppm NAA + 0.7% Carbaryl) with 55.41, 50.15, 48.58, 48.15 and 46.12 per cent total flower drop, respectively, were effective as compared to control (28.64%).

As regards the percentage of total flower dropped, treatment T 2 (Hand removal of flowers) was the most effective and removed 100% flowers. While, amongst the chemicals, T 11 (90.57%), T 3 (90.55%), T 9 (89.39%) and T 15 (88.70%) dropped more percentage of flowers over the control (82.22%).

From the above observations, it could be concluded that, when there was Ethrel in a chemical spray treatment, it caused highest percentage of flowers drop than other chemicals. Similarly, the hand removal of flowers at 14 days interval also was the most effective of all. Hand removal of flowers, only once on 75th day and GA spray on same day also removed the flowers quite effectively.

4.2.3.3 Types of flowers dropped

The data in respect of number of various types of flowers (male, hermaphrodite and intermediate) dropped are presented in Table 9, while that in respect of percentage of various types of flowers dropped, based on total flowers produced are presented in Table 10.

Table 9. Number of types of flowers dropped per tree after treatment application.

| Treatments | Number of male flowers | Number of Hermaphrodite flowers | Number of Intermediate flowers |
|---|---|---|---|
| T 1 Control | 104.24 | 16.27 | 20.76 |
| T 2 Hand removal of flowers | 130.40 | 26.22 | 28.27 |
| T 3 Hand removal of flowers + 20 ppm GA | 95.61 | 6.57 | 6.05 |
| T 4 500 ppm NAA | 83.27 | 15.04 | 12.10 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 75.79 | 12.57 | 10.97 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 81.96 | 16.35 | 15.00 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 83.88 | 14.17 | 15,06 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 74.93 | 19.70 | 17.69 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 82.20 | 33.72 | 31.48 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 79.63 | 15.26 | 17.04 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 87.60 | 28.85 | 28.24 |
| T 12 0.7% Carbaryl | 66.44 | 9.01 | 6.84 |
| T 13 1000 ppm MH | 65.53 | 14.78 | 13.84 |
| T 14 250 ppm Ethrel | 69.80 | 22.07 | 21.47 |
| T 15 500 ppm Ethrel | 77.46 | 35.56 | 29.44 |
| S.E. $\pm$ | 11.53 | 3.80 | 2.67 |
| C.D. at 5% | 32.78 | 10.80 | 7.59 |

Table 10. Percentage of types of flowers dropped per tree after treatment application.

| Treatments | Male flowers (%) | Hermaphrodite flowers (%) | Intermediate flowers (%) | Total flowers dropped (%) |
|---|---|---|---|---|
| T 1 Control | 60.67 | 9.47 | 12.08 | 82.22 |
| T 2 Hand removal of flowers | 70.53 | 14.18 | 15.29 | 100.00 |
| T 3 Hand removal of flowers + 20 ppm GA | 79.99 | 5.50 | 5.06 | 90.55 |
| T 4 500 ppm NAA | 62.42 | 11.27 | 9.07 | 82.76 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 60.78 | 10.08 | 8.80 | 79.66 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 60.95 | 12.16 | 11.15 | 84.26 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 60.85 | 10.28 | 10.93 | 82.06 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 56.19 | 14.77 | 13.27 | 84.23 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 49.85 | 20.45 | 19.09 | 89.39 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 60.88 | 11.60 | 13.10 | 85.58 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 54.83 | 18.06 | 17.68 | 90.57 |
| T 12 0.7% Carbaryl | 62.82 | 8.52 | 6.47 | 77.81 |
| T 13 1000 ppm MH | 55.29 | 12.47 | 11.68 | 79.44 |
| T 14 250 ppm Ethrel | 51.60 | 16.32 | 15.87 | 83.79 |
| T 15 500 ppm Ethrel | 48.23 | 22.14 | 18.33 | 88.70 |
| S.E. ± | 6.67 | 2.64 | 1.56 | 2.41 |
| C.D. at 5% | 18.96 | 7.50 | 4.43 | 6.85 |

It will be seen from the data (Table 9) that the flower drop was mostly contributed by male flowers. The removal/drop of number of male flowers was high in T 2, T 1, T 3, T 11 and T 7 (Table 9). While on percentage basis (Table 10) it was high in T 3 (79.99%) followed by T 2 (70.53%), T 12 (62.82%) and T 4 (62.42%).

As regards the drop of number of hermaphrodite flowers, T 15, T 9, T 11, T 2 and T 14 induced more drop (Table 9). On percentage basis (Table 10) higher drop of hermaphrodite flowers was observed in T 15 (22.14%), T 9 (20.45%), T 11 (18.06%), T 14 (16.32%) and T 8 (14.77%) as compared to control (9.47%).

In respect of intermediate flowers, T 9 (31.48) followed by T 15 (29.44) and T 11 (28.24) induced more number of these flowers to drop (Table 9). As regards the percentage of intermediate flowers dropped to the total flower produced (Table 10), it was the highest in T 9 (19.09%), T 15 (18.33%) and T 11 (17.68%), and the lowest in T 3 (5.06%), T 12 (6.47%), T 5 (8.80%) and T 4 (9.07%).

### 4.2.4 Number of fruits set

The data in respect of number of fruits set after treatment application are presented in Table 11. It is revealed from these data that the number of fruits set at different times, in different treatments, varied significantly. The highest number of the total fruits set was in T 1 (30.55)

Table 11. Number of fruits set per tree after treatment application.

| Treatments | Fruits set during the days after treatment ( Numbers/tree ) | | | Total fruits set (No./tree) |
|---|---|---|---|---|
| | 1 to 28 | 29 to 56 | 57 to 70 | |
| T 1 Control | 12.24 | 11.20 | 7.11 | 30.55 |
| T 2 Hand removal of flowers | - | - | - | - |
| T 3 Hand removal of flowers + 20 ppm GA | 6.30 | 3.72 | 1.27 | 11.29 |
| T 4 500 ppm NAA | 8.80 | 8.20 | 6.00 | 23.00 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 10.53 | 9.33 | 5.50 | 25.36 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 11.61 | 5.60 | 3.95 | 21.16 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 8.89 | 8.17 | 7.67 | 24.73 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 8.03 | 7.13 | 5.87 | 21.03 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 6.17 | 5.63 | 5.69 | 17.49 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 8.17 | 5.73 | 4.96 | 18.86 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 6.67 | 4.40 | 4.00 | 15.07 |
| T 12 0.7% Carbaryl | 10.07 | 8.56 | 4.84 | 23.47 |
| T 13 1000 ppm MH | 10.00 | 8.33 | 6.04 | 24.37 |
| T 14 250 ppm Ethrel | 9.37 | 8.53 | 4.02 | 21.92 |
| T 15 500 ppm Ethrel | 7.83 | 6.01 | 4.30 | 18.14 |
| S.E. $\pm$ | 0.84 | 0.42 | 0.75 | 2.51 |
| C.D. at 5% | 2.39 | 1.19 | 2.13 | 7.14 |

followed by T 5 (25.36), T 7 (24.73), T 13 (24.37), T 12 (23.47) and T 4 (23.00). The lowest number was seen in T 3 (11.29) followed by T 11 (15.07), T 9 (17.49) and T 15 (18.14). Hand removal of flowers at 14 days interval did not set any fruit. Thus, hand removal of flowers at 14 days interval, as also the hand removal of flowers only once on 75th day along with 20 ppm GA effectively reduced the number of fruits set after 75th day of cropping. The other better treatment in this regard was 500 ppm Ethrel with (T 11) or without GA (T 15) following it.

### 4.2.5 Number of fruits dropped

The data in respect of number of fruits dropped after treatment application, presented in Table 12, reveal significant effects of different treatments. The total fruit drop was the highest in T 6 (19.65) followed by T 11 (16.97), T 9 (15.84), T 7 (15.66) and T 4 (15.50). The lowest fruit drop was in T 2 (4.77) followed by T 14 (9.33) and T 5 (11.50). Thus, it can be concluded from the data that 500 ppm NAA, 500 ppm NAA + 0.7% Carbaryl spray and 500 ppm Ethrel as basal spray material induced higher fruit drop as compared to control.

## 4.3 Yield

### 4.3.1 Number of fruits harvested.

The data in Table 13, regarding the total number of fruits harvested in different treatments, indicate that the

Table 12. Number of fruits dropped per tree in different treatments after treatment application.

| Treatments | Number of fruits dropped during the days after treatment application | | | Total fruits dropped (No./tree) |
|---|---|---|---|---|
| | 1 to 28 | 29 to 56 | 57 to 70 | |
| T 1 Control | 4.62 | 7.29 | 2.75 | 14.66 |
| T 2 Hand removal of flowers | 1.60 | 0.82 | 2.35 | 4.77 |
| T 3 Hand removal of flowers + 20 ppm GA | 4.00 | 5.40 | 2.34 | 11.74 |
| T 4 500 ppm NAA | 7.50 | 4.50 | 3.50 | 15.50 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 5.40 | 3.10 | 3.00 | 11.50 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 10.30 | 5.85 | 3.50 | 19.65 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 6.66 | 4.92 | 4.08 | 15.66 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 4.70 | 3.00 | 2.90 | 10.60 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 6.20 | 4.90 | 4.74 | 15.84 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 5.79 | 4.99 | 4.11 | 14.89 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 6.09 | 5.90 | 4.98 | 16.97 |
| T 12 0.7% Carbaryl | 5.00 | 4.50 | 2.50 | 12.00 |
| T 13 1000 ppm MH | 6.80 | 4.00 | 4.36 | 15.16 |
| T 14 250 ppm Ethrel | 4.13 | 3.70 | 1.50 | 9.33 |
| T 15 500 ppm Ethrel | 5.86 | 4.82 | 4.13 | 14.81 |
| S.E. $\pm$ | 1.26 | 0.37 | 0.45 | 1.48 |
| C.D. at 5% | 3.58 | 1.05 | 1.28 | 4.21 |

Table 13. Total number of fruits harvested per tree in different treatments.

| Treatments | Marketable | Unmarketable | Total |
|---|---|---|---|
| T 1 Control | 87.25 | 12.76 | 100.01 |
| T 2 Hand removal of flowers | 66.34 | 6.56 | 72.90 |
| T 3 Hand removal of flowers + 20 ppm GA | 67.21 | 4.17 | 71.38 |
| T 4 500 ppm NAA | 70.00 | 4.50 | 74.50 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 81.53 | 9.13 | 90.66 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 62.13 | 4.15 | 66.28 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 77.52 | 9.15 | 86.67 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 77.80 | 5.76 | 83.56 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 69.53 | 5.16 | 74.69 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 78.80 | 5.37 | 84.17 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 70.50 | 4.80 | 75.30 |
| T 12 0.7% Carbaryl | 80.20 | 6.80 | 87.00 |
| T 13 1000 ppm MH | 76.64 | 11.70 | 88.34 |
| T 14 250 ppm Ethrel | 75.12 | 5.40 | 80.52 |
| T 15 500 ppm Ethrel | 68.89 | 5.31 | 74.20 |
| S.E. $\pm$ | 3.13 | 1.31 | 4.60 |
| C.D. at 5% | 8.90 | 3.72 | 13.08 |

number of fruits harvested varied from 66.28 in T 6 to 100.01 in T 1. The highest number of fruits harvested was in control (100.01) followed by T 5 (90.66), T 13 (88.34), T 12 (87.00) and T 7 (86.67). The lowest number was in T 6 (66.28) followed by T 3 (71.38), T 15 (74.20) T 4 (74.50), T 9 (74.69) and T 11 (75.30).

### 4.3.2 Total weight (yield) of harvested fruits

The yield by weight, both of marketable and unmarketable as also the total fruits, is given in Table 14. It is seen from these data that the treatments had significant difference. The highest total yield per tree was seen in treatment T 5 (19.50 kg) followed by T 1 (18.12 kg), T 3 (17.43 kg), T 8 (16.98 kg) and T 10 (16.71 kg). As regards the marketable yield, T 5 was the best followed by T 3, T 1, T 8 and T 10. The lowest total marketable yield was seen in T 6 followed by T 13, T 7 and T 12.

### 4.3.3 Number of fruits harvested as per grade

The data in respect of total number of fruits harvested as per the grades viz., A, B, C, D and also the immature are presented in Table 15.

It is seen from these data that the treatments differed significantly regarding the production of number of fruits of different grades. The highest number of A-grade fruits was harvested from T 3 (16.46) followed by T 5 (12.40), T 11 (12.10), T 15 (11.91) and T 9 (11.90), and the lowest number was from T 12 (9.60) and T 6 (9.95). As regards the number of 'B-grade'

Table 14. Total weight (yield) of harvested fruits per tree in different treatments.

| Treatments | | Weight of harvested fruits (kg/tree) | | |
|---|---|---|---|---|
| | | Marketable | Unmarketable | Total |
| T 1 | Control | 16.87 | 1.25 | 18.12 |
| T 2 | Hand removal of flowers | 15.23 | 0.45 | 15.68 |
| T 3 | Hand removal of flowers + 20 ppm GA | 17.13 | 0.30 | 17.43 |
| T 4 | 500 ppm NAA | 14.87 | 0.44 | 15.31 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 18.72 | 0.78 | 19.50 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 13.53 | 0.40 | 13.93 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 14.84 | 0.89 | 15.73 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 16.46 | 0.52 | 16.98 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 15.43 | 0.38 | 15.81 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 16.32 | 0.39 | 16.71 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 15.49 | 0.36 | 15.85 |
| T 12 | 0.7% Carbaryl | 14.88 | 0.42 | 15.30 |
| T 13 | 1000 ppm MH | 14.24 | 0.76 | 15.00 |
| T 14 | 250 ppm Ethrel | 15.23 | 0.41 | 15.64 |
| T 15 | 500 ppm Ethrel | 15.02 | 0.36 | 15.38 |
| | S.E. $\pm$ | 0.97 | 0.19 | 1.02 |
| | C.D. at 5% | 2.76 | 0.54 | 2.90 |

Table 15. Total number of fruits as per grade in different treatments.

| Treatments | Fruits harvested as per grade (Number/tree) | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | Immature |
| T 1 Control | 10.09 | 20.10 | 25.90 | 31.16 | 12.76 |
| T 2 Hand removal of flowers | 10.95 | 25.30 | 18.10 | 11.99 | 6.56 |
| T 3 Hand removal of flowers + 20 ppm GA | 16.46 | 29.43 | 11.32 | 10.00 | 4.17 |
| T 4 500 ppm NAA | 10.33 | 20.90 | 20.33 | 18.44 | 4.50 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 12.40 | 30.81 | 25.90 | 12.42 | 9.13 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 9.95 | 20.60 | 17.86 | 13.72 | 4.15 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 11.00 | 21.45 | 20.79 | 24.28 | 9.15 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 10.35 | 27.00 | 25.74 | 14.71 | 5.76 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 11.90 | 22.00 | 19.89 | 15.74 | 5.16 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 10.66 | 27.33 | 24.13 | 16.68 | 5.37 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 12.10 | 24.00 | 20.03 | 14.37 | 4.80 |
| T 12 0.7% Carbaryl | 9.60 | 24.30 | 25.90 | 20.40 | 6.80 |
| T 13 1000 ppm MH | 10.00 | 26.30 | 20.90 | 19.44 | 11.70 |
| T 14 250 ppm Ethrel | 10.10 | 26.30 | 23.21 | 15.51 | 5.40 |
| T 15 500 ppm Ethrel | 11.91 | 23.67 | 19.67 | 13.64 | 5.31 |
| S.E. $\pm$ | 1.61 | 1.96 | 1.42 | 2.50 | 1.31 |
| C.D. at 5% | 4.58 | 5.57 | 4.04 | 7.11 | 3.72 |

fruits, T 5 (30.81) was top ranking followed by T 3 (29.43), T 10 (27.33) and T 8 (27.00). In case of 'C + D-grade' fruits, the highest number was produced in T 1 (57.06) followed by T 12 (46.30) and T 7 (45.07). While the lowest number of 'C + D-grade' fruits was found in T 3 (21.32) followed by T 2 (30.09), T 6 (31.58), T 15 (33.31) and T 11 (34.40).

The number of immature fruits were the highest in control (12.76) followed by T 13 (11.70), T 7 (9.15) and T 5 (9.13).

4.3.4 Gradewise total weight (yield) of fruit

The data regarding the total weight of harvested fruits in each grade viz. A, B, C, D as also immature are given in Table 16.

It is seen from the data that the highest weight (yield) of A-grade fruits was observed in T 3 (5.45 kg) followed by T 5 (4.23 kg) and T 11 (4.06 kg), and the lowest in T 12 (3.04 kg), followed by T 13 (3.07 kg), T 1 (3.09 kg) and T 8 (3.29 kg). While, for B-grade fruits, T 3 (8.04 kg) was top ranking followed by T 5, T 8, T 2, T 14 and T 10. As regards C+D grade fruits, the highest weight was in T 1 (8.8 kg) followed by T 7 (6.76 kg), T 12 (6.73 kg), T 5 (6.64 kg) and T 10 (6.54 kg), while the lowest weight was in T 3 (3.64 kg) followed by T 2 (4.95 kg), T 6 (5.00 kg), T 15 (5.26 kg) and T 11 (5.48 kg).

As regards the immature fruits total weight (yield), it was the highest in T 1 (1.25 kg) followed by T 5 (0.78 kg)

Table 16. Total weight (yield) of the harvested fruits as per grade.

| Treatments | Weight of fruits harvested as per grade (kg/plant) | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | Immature |
| T 1 Control | 3.09 | 4.98 | 4.38 | 4.42 | 1.25 |
| T 2 Hand removal of flowers | 3.60 | 6.68 | 3.26 | 1.69 | 0.45 |
| T 3 Hand removal of flowers + 20 ppm GA | 5.45 | 8.04 | 2.19 | 1.45 | 0.30 |
| T 4 500 ppm NAA | 3.33 | 5.27 | 3.67 | 2.60 | 0.44 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 4.23 | 7.85 | 4.80 | 1.84 | 0.78 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 3.35 | 5.18 | 3.05 | 1.95 | 0.40 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 3.49 | 4.59 | 3.46 | 3.30 | 0.89 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 3.29 | 6.75 | 4.43 | 1.99 | 0.52 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 3.97 | 5.63 | 3.58 | 2.25 | 0.38 |
| T 10 250 ppm Ethrel + 20 ppm GA afger 14 days | 3.47 | 6.31 | 4.24 | 2.30 | 0.39 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 4.06 | 5.95 | 3.57 | 1.91 | 0.36 |
| T 12 0.7% Carbaryl | 3.04 | 5.11 | 4.16 | 2.57 | 0.42 |
| T 13 1000 ppm MH | 3.07 | 5.68 | 3.35 | 2.14 | 0.76 |
| T 14 250 ppm Ethrel | 3.31 | 6.34 | 3.65 | 1.93 | 0.41 |
| T 15 500 ppm Ethrel | 3.95 | 5.81 | 3.36 | 1.90 | 0.36 |
| S.E. ± | 0.54 | 0.56 | 0.25 | 0.28 | 0.19 |
| C.D. at 5% | 1.54 | 1.59 | 0.71 | 0.80 | 0.54 |

and T 13 (0.76 kg), and the lowest in T 3 (0.30 kg) followed by T 15 (0.36 kg), T 11 (0.36 kg), T 9 (0.38 kg) and T 10 (0.39 kg).

## 4.4 Fruit Character

### 4.4.1 Average weight of fruit : general and gradewise

The data in respect of average weight of fruit, general as well as grade-wise are given in Table 17. It is seen from the data that the highest average weight of A-grade fruit was observed in T 5 (341.12 g) followed by T 6 (336.68 g), T 11 (335.54 g), T 15 (331.65 g) and T 3 (331.11 g). While the lowest was in T 1 (306.24 g) followed by T 13 (307.00 g), T 12 (316.67 g), T 7 (317.27 g) and T 8 (317.87 g).

In case of B-grade fruits, the highest average fruit was observed in T 3 (273.19 g) followed by T 2 (264.03 g), T 9 (255.91 g) and T 5 (254.79 g), and the lowest was in T 12 (210.29 g) followed by T 7 (213.99 g) and T 13 (215.97 g).

As regards to C-grade fruit, the highest average weight was observed in T 3 (193.46 g) followed by T 5 (185.33 g), T 4 (180.52 g) and T 2 (180.11 g), while the lowest average weight was in T 14 (157.26 g) followed by T 13 (160.29 g), T 12 (160.62 g) and T 7 (166.43 g).

In case of D-grade fruit, the highest average weight was observed in T 5 (148.15 g) followed by T 3 (145.00 g), T 9 (142.95 g) and T 6 (142.12 g), while the lowest was in T 13 (110.08 g) followed by T 14 (124.44 g) and T 12 (125.98 g).

Table 17. The general as well as gradewise average weight of the fruit in different treatments.

| Treatments | Average fruit weight in different grades (g) | | | | Overall average weight of fruit (g) |
|---|---|---|---|---|---|
| | A | B | C | D | |
| T 1 Control | 306.24 | 247.76 | 169.11 | 141.85 | 181.18 |
| T 2 Hand removal of flowers | 328.77 | 264.03 | 180.11 | 140.95 | 215.09 |
| T 3 Hand removal of flowers + 20 ppm GA | 331.11 | 273.19 | 193.46 | 145.00 | 244.19 |
| T 4 500 ppm NAA | 322.36 | 252.15 | 180.52 | 140.99 | 205.50 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 341.12 | 254.79 | 185.33 | 148.15 | 215.09 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 336.68 | 251.46 | 170.77 | 142.12 | 210.17 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 317.27 | 213.99 | 166.43 | 135.91 | 181.49 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 317.87 | 250.00 | 172.11 | 135.28 | 203.21 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 333.61 | 255.91 | 179.99 | 142.95 | 211.68 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 325.52 | 230.88 | 175.72 | 137.89 | 198.53 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 335.54 | 247.91 | 178.23 | 132.92 | 210.49 |
| T 12 0.7% Carbaryl | 316.67 | 210.29 | 160.62 | 125.98 | 175.86 |
| T 13 1000 ppm MH | 307.00 | 215.97 | 160.29 | 110.08 | 169.80 |
| T 14 250 ppm Ethrel | 327.72 | 241.07 | 157.26 | 124.44 | 194.24 |
| T 15 500 ppm Ethrel | 331.65 | 245.46 | 170.82 | 139.30 | 207.28 |
| S.E. ± | 3.61 | 3.23 | 2.95 | 2.38 | 11.95 |
| C.D. at 5% | 10.26 | 9.18 | 8.39 | 6.76 | 33.97 |

As regards the over all general average fruit weight, T 3 (244.19 g) stood first followed by T 2 (215.09 g), T 5 (215.09 g) and T 9 (211.68 g), while the lowest was in T 13 (169.80 g) followed by T 12 (175.86 g), T 1 (181.18 g) and T 7 (181.49 g).

### 4.4.2 Total soluble solids (T.S.S.)

The data in respect of T.S.S. of fruit juice are presented in Table 18. It is revealed from the data that there were significant effects of different treatments on T.S.S. content. The highest T.S.S. was observed in T 9 (16.13%) followed by T 7 (16.10%), T 6 (16.00%) and T 11 (16.00%), while the lowest T.S.S. content was observed in T 14 (13.93%) followed by T 2 (14.16%) and T 13 (14.20%).

### 4.4.3 Acidity

The data regarding the acidity percentage are presented in Table 18 which reveal that the acidity of fruit juice was significantly influenced by different treatments. Highest acidity (0.443%) was observed in T 1 followed by T 14 (0.439%), T 12 (0.434%), T 7 (0.426%) and T 4 (0.425%). While the lowest acidity was in T 5 (0.381%), T 12 (0.410%) and T 11 (0.412%).

### 4.4.4 Visual and other observations

Besides the data reported in preceding paragraphs, the visual observations regarding the effect of spray chemicals on foliage, flowers and fruits were noticed from time to time. They are narrated below in brief.

Table 18. Effect of treatments on T.S.S. and acidity of fruit juice.

| Treatments | T.S.S. (%) | Acidity (%) |
|---|---|---|
| T 1 Control | 14.50 | 0.443 |
| T 2 Hand removal of flowers | 14.16 | 0.410 |
| T 3 Hand removal of flowers + 20 ppm GA | 14.86 | 0.423 |
| T 4 500 ppm NAA | 15.93 | 0.425 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 15.96 | 0.381 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 16.00 | 0.414 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 16.10 | 0.426 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 15.03 | 0.394 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 16.13 | 0.413 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 14.93 | 0.404 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 16.00 | 0.412 |
| T 12 0.7% Carbaryl | 14.86 | 0.434 |
| T 13 1000 ppm MH | 14.20 | 0.417 |
| T 14 250 ppm Ethrel | 13.93 | 0.439 |
| T 15 500 ppm Ethrel | 15.93 | 0.413 |
| S.E. $\pm$ | 0.17 | 0.009 |
| C.D. at 5% | 0.48 | 0.026 |

It was seen by visual observations that in case of 500 ppm NAA, there was upward cupping of leaves. Leaf margin turned coppery red on 3rd day of NAA application and there was no further increase in the intensity. Such leaves persisted on plant till the end. A few young succulent shoots were burned. It also caused drop of fruits immediately after spray. Externally there were some blackish spots on newly set fruits just after NAA application having little reduction in market value. Seed aril colour was more pinkish.

The lower concentaation of NAA (250 ppm) with Carbaryl resulted in orange red fruits which were attractive and more sweet in taste. But higher concentration of NAA + Carbaryl resulted in scorching effect on fruit-lets and dropped the small fruit-lets on 3rd day of chemical treatment application. Newly set fruits present on the tree at the time of treatment application developed blackish spots, externally. Fruits had some what sour taste.

In case of 500 ppm NAA + 1000 ppm MH (after 14 days), the newly set fruits that were on the tree at the time of spray, developed a few blakish spots on rind.

Ethrel showed pale yellow colour of leaves. Leaf abscission occurred to the extent of 15 to 32 per cent. Colour of newly set fruits, that were present on the tree at the time of treatment remained slightly greenish at maturity at lower concentration. At higher concentration, most of the fruits on tree developed yellow colour. Harvesting was 8 to 10 days earlier than control. However, Ethrel at high concentration had rough

leaf surface which was not observed in Ethrel + NAA (T 9). Ethrel followed by GA increased sweetness of juice.

Carbaryl (T 12) caused phytotoxic effect on leaf, inducing downward curling of leaves, flower production was not seen initially for 10 days after treatment application. Afterwards flower production was resumed. Fruits had more reddish colour with slightly more sour taste. Arils were light pink to whitish pink.

## 4.5 Economics

The data in respect of total expenditure, the gross returns at the rate of prices prevailing in the Bombay market and that would have realized as per the grade of the fruit from time to time whenever the crop was harvested, the net returns and increase or decrease in net returns over the control are presented in Table 19 on hactare basis.

It will be seen from the data in Table 19 that the total expenditure incurred due to treatment effect was highest in T 5 (Rs.15873.61/ha) followed by T 10 (Rs.15173.19/ha), T 7 (Rs.15055.54/ha), T 11 (Rs.14597.35/ha) and T 12 (Rs.14415.95/ha) and the lowest was in T 2 (Rs11636.47/ha) followed by T 4 (Rs.12852.54/ha), T 15 (Rs12953.51/ha) and T 6 (Rs.13036.42/ha).

The gross returns (Table 19) were the highest from T 5 (Rs.72969.62/ha) followed by T 3 (Rs.70413.62/ha), T 8 (Rs.66510.75/ha) and T 10 (Rs.66227.45/ha). The lowest

Table 19. Economics of different treatments.

| Treatment | Total expenditure (Rs./ha) | Gross returns (Rs./ha) | Net returns (Rs./ha) | Increase (+) or decrease (-) over control |
|---|---|---|---|---|
| T 1 Control | 13886.39 | 62149.18 | 48262.79 | - |
| T 2 Hand removal of flowers | 11636.47 | 60202.15 | 48565.68 | + 302.89 |
| T 3 Hand removal of flowers + 20 ppm GA | 13476.13 | 70413.62 | 56937.49 | + 8674.70 |
| T 4 500 ppm NAA | 12852.54 | 57617.85 | 44765.31 | - 3497.48 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 15873.61 | 72969.54 | 57095.93 | + 8834.14 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 13036.42 | 53315.61 | 40279.19 | - 7983.60 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 15055.54 | 62596.47 | 47540.93 | - 721.86 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 13995.36 | 66510.75 | 52515.39 | + 4252.60 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 13248.63 | 60087.20 | 46838.57 | - 1424.22 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 15173.19 | 66227.45 | 51054.26 | + 2791.47 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 14597.35 | 62708.85 | 48111.50 | - 151.29 |
| T 12 0.7% Carbaryl | 14415.95 | 62246.88 | 47830.43 | - 432.36 |
| T 13 1000 ppm MH | 13662.90 | 61986.10 | 48323.20 | + 60.41 |
| T 14 250 ppm Ethrel | 13174.80 | 63043.54 | 49868.74 | + 1605.95 |
| T 15 500 ppm Ethrel | 12953.51 | 61410.54 | 48457.03 | + 194.24 |

net returns per hactare were obtained in T 6 (Rs.40279.19/ha) followed by T 9 (Rs.46838.57/ha).

The increase or decrease in net returns over the control presented in Table 19 reveal that the highest increase in net returns (Rs.8834.14/ha) was obtained in T 5 followed by T 3 (Rs.8674.20/ha). The decrease in net returns over the control was observed in T 6 (Rs.7983.60/ha) followed by T 4 (Rs.3497.48/ha), T 9 (Rs.1424.22/ha) and T 7 (Rs.721.86/ha).

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# Discussion

# 5. DISCUSSION

In recent years, pomegranate (Punica granatum, L.) has became one of the major fruit crops of Maharashtra owing to its adaptability to drier tract, precosity in bearing and low maintainance cost. It is originally a sub-tropical fruit crop, and hence exhibits different growth and flowering patterns in tropics and sub-tropics. Under Maharashtra conditions, it flowers throughout the year. However, three main flowering seasons are ambia bahar (January-February flowering), mrig bahar (June-July flowering), and hasta bahar (October-flowering). Commercial cropping is restricted to only one of these seasons. The ambia bahar gives heavy cropping with quality fruits and most of the farmers resort to this bahar (Sonawane, 1986).

It is quite peculiar in pomegranate under Maharashtra conditions that it produces flowers mostly on new shoots and once the flowering of a bahar commences, the plant continues to produce flowers almost through out the cropping season of that bahar. For example, in ambia bahar cropping, it starts producing flowers right from first irrigation in January-February upto the end of harvest in July. The flowers which set fruits during initial period give well matured quality fruits. While, the flowers that are set late in the season produce immature fruits at the time of harvest. These late set fruits also affect the quality of the already set fruits, during earlier part. Therefore, farmers generally adopt a practice of hand removal of flowers that appear after 2½ months of start

of cropping. The practice is laborious, time consuming and in recent years faces the problem of unavailability of labourers, sometimes. However, no studies in this regard are conducted to see the feasibility of chemicals to overcome this problem. The present investigation was therefore undertaken to explore the possibility of using plant growth regulators to tackle this problem and to have guide lines on this aspect for further studies.

In present investigation, using different chemicals like NAA, GA, Ethrel, MH and Carbaryl, based on review of literature, three lines of approaches were envisaged to meet the above objectives of controlling the flowers that are produced after 2½ months after commencement of ambia bahar cropping. These were : 1) to drop the flowers that would set fruits after 2½ month of first irrigation, and for this, Ethrel, NAA and Carbaryl were used; (2) to check the production of new flowers that would appear after 2½ month of commencement of cropping and for this, GA was used; and (3) since pomegranate flowers are borne on current season growth, checking of further growth after 2½ months would automatically control the flower production. For this MH (Maleic hydrazide) was used.

It was further thought that, some of the chemicals used for above respective effects may have deleterious side effects also, particularly Ethrel which may have effect on foliage and modify plant's physiology to a considerable extent.

Therefore, in such treatments subsequent application of growth promoters such as GA and NAA, at lower concentration, were applied for rectification of such anticipated effects, if any. Besides, to have synergestic effects in desired direction some chemicals such as NAA and Carbaryl were combined or NAA was followed by MH. Similarly, it was visualized that higher concentrations of NAA and Ethrel may induce flower drop but also may have bad effects on fruit quality and yield. Further lowering the concentration, would lower down the cost on chemical spraying, and therefore lower concentrations of Ethrel and NAA were used. All these treatments were then compared with control (no removal of flowers) and the commercial practice of hand removal of flowers which is followed by the farmers. The results obtained in this respect have been presented in the preceding chapter. The same are discussed hereunder suitable headings.

## 5.1 Effect on vegetative growth

Plant growth regulators have profound influence on growth and development of a plant. In present experiment, various plant growth regulators used showed their effects on growth and related aspect. The objective of the present investigation was essentially to see the effect on flower and fruit production. However, it was necessary to see if they have marked deleterious effect on vegetative growth. Further, it was visualized to be desirable to have less production of new growth and shoot extension so that the new flowers that appear on new growth would be avoided. It was

observed in present investigation that GA increased the length of shoots, number of shoots, leaf area, and reduced chlorophyll content. NAA reduced shoot length and number of shoots but increased chlorophyll content, shoot diameter and total leaf area. While MH, Ethrel and Carbaryl suppressed the shoot length, total leaf area and chlorophyll content, but showed tendancy to increase number of lateral shoots.

GA is universally known as stimulator of vegetative growth and the results of the present investigation are in agreement with those of Singh and Singh (1974), Mullar and Young (1982), Rajput and Singh (1982), Buban and Faust (1983), and Abdul Khader and Rao (1984). The increase in shoot length with increased leaf area due to GA is attributed to its property of cell elongation in longitudinal direction. It also reduced or suppressed radial growth having reduced shoot diameter. But reduction in chlorophyll content of leaves was evident as also observed by other workers(Wolf and Haber, 1960; Torri and Nakagawa, 1960 and Reddy, 1986) which may be due to the effect of GA on leaf expansion without increase in synthesis of chlorophyll which may dilute chlorophyll pigement in expanding leaves (Krishnamoorthy, 1981).

Ethrel, a source of ethylene, had adverse effect on shoot length, chlorophyll content and total leaf area, while it increased the number of lateral shoots. The finding are in agreement with other worksrs (Shank, 1969; Rudich et al., 1970; Pappaih and Muthuswamy, 1974; El-Beheidi et al.,1978; Sidhu et al.,1982 and Manna and Mukherjee, 1983). It is a

growth inhibitor and such results are anticipated consequent on inhibition of cell division and expansion (Krishnamoorthy, 1981). Besides, it has property to break down apical dominance which might result in increase in number of shoots (Weaver, 1972). Accelerated degradation of chlorophyll due to increase in activity of chlorophyllase enzyme and inhibition of RNA and protein synthesis due to the ethylene which, in turn, may reduce the chlorophyll content has also been reported by other workers (Heck and Pires, 1962; Knypl and Mazurczyk, 1972 and Roberts et al.,1987).

Higher concentration of NAA inhibited both shoot length and shoot number but increased total leaf area and chlorophyll content of leaves. Similar results were also obtained by Singh and Singh (1963) and Tu (1970) who found that higher concentration of NAA resulted in adverse effect on cell division and enlargement of stem tissue. Such results can also be attributed to stimulated ethylene production consequent on higher doses of auxins (Iwahori, 1980; Krishnamoorthy, 1981). The lower concentrations of NAA had milder effects as compared to the higher concentration, which is obvious. It has been reported that lower concentrations of exogenous auxins have favourable action on enzymes. It inhibits AA oxidation and decreases dehydro ascorbic acid level in plant. It leads to increase dehydrogenase enzyme activity and respiration. This is translated into an increase in transpeptidation reactions and protein synthesis leading to enhancement of growth than higher concentration (Marre and Arrigoni, 1957; Singh and Singh, 1974).

A synthetic inhibitor MH, acts as antiauxin which may inhibit naturally occurring processes in plant. In present investigation, it reduced shoot growth, leaf area and chlorophyll content and increased number of lateral shoots. Similar type of results have been observed by Chougule et al. (1955), Hillyer and Wittwer (1959), Singh and Singh (1963), Dubey (1969), Tu (1970), Shanmugam and Muthuswamy (1974), Das and Randhawa (1974), Pappaih and Muthuswamy (1974) and Krishnamoorthy (1981). The reduction in shoot length and leaf area due to MH may be by preventing the cell from entering into mitosis. Maleic hydrazide is also said to reduce the activity of naturally occurring hormones responsible for growth (Chougule et al., 1955). It also retards cell division process in the region of apical meristem. The increase in lateral shoots may be due to break down of apical dominance. Similar line of results has been reported by Nayler and Delvin (1950), Narendra Singh and Jauhari (1965), Sadhu et al. (1973), Shanmugam and Muthuswamy (1974).

As regards the effect of Carbaryl on growth reduction it is worth to see the report of Ebert and Bangerth (1982) who observed reduction in GA content of Carbaryl applied tissue. Further, they opined that Carbaryl interferes with transport of naturally occurring auxin, checking its mobility. Williams and Batjer (1964) also observed interference of Carbaryl on movement of endogenous growth factors. In present study, Carbaryl might have acted in similar manner.

5.2 Effect on flower production

The production of new flowers, late in the cropping season, reduces quality of already set fruits and also the total yield due to utilization of food material for growth of flowers and newly set fruits, that finally remain immature. In present experiment, the maximum production of new flowers occurred in hand removal of flowers, at 14 days interval, which may be due to stimulative effect of the injury to flower pedicel which might have released ethylene and increased flower number (Roberts et al.,1985). Such a hand removal of flowers also remove these sinks at earlier possible time creating little exhaustion of food material before the fruit sets. This would naturally retain the inherent tendancy of the plant to put flowers recurrently.

Amongst the chemical treatments, GA which was preceded by hand removal of flowers that were present on 75th day, inhibited flower production. However, Ethrel increased flowers over the GA and NAA. While, the lowest production of new flowers, even less than GA was observed in Carbaryl and MH. The mechanism of action of plant growth regulators on induction or suppression of flowers is rather obscure.

GA has pronounced effect on inhibition of new flower production especially in tree crops and such finding have been reported by several workers such as Monselise and Halevy (1964), Hurd and Parvis (1964), Dennis and Edgerton (1966), Luckwill (1970), Kachru et al. (1971), Iwahori and Oohata (1981), Buban and Faust (1983), Rawash et al. (1983), Abdul Khader and Rao (1984) and Hoda (1984).

The inhibitary effect of GA on flower production is presumed to be due to changed internal ratio of promoter to inhibitor. It is also reported that exogenous application of GA also effects the level of endogenous auxin leading to changed ratio of auxin to gibberellins. Higher gibberellin level favours the plant to shift a flower bud into a vegetative bud, while high auxin level and low level of gibberellin favours induction of flower buds (Luckwill, 1970; Goldschimidt and Monselise, 1970; Kachru et al.,1971).

On the other hand, Ethrel had flower inducing effect. These type of findings regarding ethrel are reported by many workers (Cooke and Randall, 1968; Edgerton and Greenhalgh, 1968; 1969; Randhawa et al.,1970; Katzufuss et al.,1972 and Manna and Mukherjee, 1983; Rawash et al., 1983). Ethrel is synthetic growth inhibitor. It has been reported to greatly reduce IAA transport in leaf midrib tissue by inhibiting the auxin transport in vascular tissue and causing senescence of leaves which, when upto a certain level, has promotive effect on flower bud initiation (Wood, 1985). It has also been reported that unsaturated hydrocarbons like ethylene are capable of forcing flowering in pine apple. Since it is known that ethrel induces the formation of ethylene in plant, it is suggestive that flower initiation consequent on ethrel application is controlled by ethylene (Randhawa et al.,1970).

NAA in general increased the flowering over GA and the finding are in line with results of Van Overbeek (1946) and

Sen and Maiti (1965). They observed that NAA at 100 ppm showed flower induction while at higher concentration (500 and 1000 ppm) it inhibited or decreased flowering. They opined that change from vegetative to reproductive phase takes place at a time when naturally occurring growth hormones are reduced. Increase in their level by exogenous application might resulted in delay or inhibit flowering. But, in present study the lower concentration of NAA + Carbaryl gave less number of flowers, which may due to inhibitary effect of Carbaryl on flower production. Many workers have reported that higher concentration of exogenous auxins induces ethylene production in plant tissue which is primary factor for flower induction (Gawadi and Avery, 1950; Randhawa et al.,1970). However, along with this property, the phototoxic effects of very high NAA concentration needs to be given attention which may limit this property to a certain level.

MH and Carbaryl act as antiauxin and reduce transport of auxin. In present study, they reduced flower production more than GA. These results of MH are in conformity with Nayler and Dalvin(1950), Jauhari and Amarjit (1960), Dubey (1969), and Krishnamoorthy (1981). The inhibitory effect of MH on growth was evident. This also might have led to less flower production as anticipated. Krishnamoorthy (1981) also stated that MH inhibits meristematic activity in the shoot tip, which prevents the formation of leaves, buds and flowers, but lateral buds which are dormant, are not affected. These come out into branches and the plants become bushy.

Carbaryl, in addition to reduction in growth, might have inhibited flowering due to shift in RNA and protein synthesis and reduction in IAA in plant as envisazed by Ebert and Bangerth (1982).

Thus, hand removal of flowers at 14 days interval induced more flowers than control. GA though had promotive effect on growth, inhibited flower production. NAA and Ethrel revealed flower inducing property over GA, but, their inhibitory effect on the growth at the concentration tried seems to have played significant role in having indirectly total less flower production over control. MH and Carbaryl were found to induce less flower production, even over GA, which appears to be related to less growth, as postulated in present hypothesis for MH, and their possible ability to interfere with transport of endogenous auxins.

5.3 Effect on types of flowers

In present investigation, all the growth regulators (MH, Ethrel, GA and Carbaryl, NAA) were found to alter the sex expression in pomegranate bringing about change in percentage of male, hermaphrodite and intermediate flowers production. GA induced maximum percentage of male flowers. Similar observation have been reported by many workers (Galun, 1959; Peterson and Anhder, 1960; Gopalkrishnan, 1965; Atsman et al., 1968; Rodriquez and Lumbeth, 1972; Maiti, 1973; Sidhu et al., 1981; Patil et al.,1983; and Singh et al.,1984). The involvement of gibberellins as hormones, in expression of male tendancy

is also supported by studies on their endogenous level. GA level in monoecious cucumber plants, which produce male flowers in addition to female once remains more than that in gynoecious plant which produce female flowers (Krishnamoorthy, 1981). Maiti (1973) also considered increased male flower production and suppression of hermaphrodite flower production to be due to the regulation of endogenous auxin balance. He states that, with high GA, there is tendancy to maleness, and the chemicals which inhibit GA synthesis suppress maleness.

Ethrel is a ethylene releasing compound. It induced higher percentage of hermaphrodite and intermediate flowers and reduced the percentage of male flowers. Various workers have observed that Ethrel causes a striking increase in female tendancy of cucumbers (Rudich et al.,1970; Rodriquez and Lumbeth, 1972; Bhandary et al.,1974; El-Beheidi et al., 1978; Sutulova, 1981; Sidhu et al.,1982; Arora et al.,1982; Jamadagni and Patil, 1982; and Patil et al.,1983). Ethylene, the source of biological activity of Ethrel, is known to have many effects opposite to those of gibberellic acid (Scott and Leopold, 1967). On the basis of this anti-gibberellin hypothesis, Robinson et al.(1969) assumed that Ethrel may cause a reduction in the gibberellin level in plant. This may perhaps bring a shift favourable towards femaleness in cucumber plants (Atsman et al.,1968).

As regards NAA, when used alone, it had marginal increase in hermaphrodite as well as male flower percentage

and reduction in intermediate flower percentage. None the less, the influence of auxins on sex change has been suggested by Heslop-Harrison (1957) and supported by Maiti and Maiti (1969) that the sexual differentiation is controlled by the endogenous level of auxin in region neighbouring the flowering primordia. Formation of pistillate organs may be favoured by high auxin level in the vicinity of differentiating primordia and of staminate organs by low auxin level. Yet, it could be said that NAA had little influence in sex expression in pomegranate as revealed in present study. Of course, the concentrations used were higher and at lower concentrations (physiological) it may behave differently.

MH increased the percentage of hermaphrodite flowers and reduced that of male flowers in present investigation. It has been reported by Griesel (1954) and subsequently endorsed by Maiti and Maiti (1969) that increase in hermaphrodite flower formation due to MH is probably because of reduced catabolic activities in treated plant and it acts in same way as that of low temperatures and short days. Similar increase in female flowers due to MH application has been reported by Hillyer and Wittwer (1959), Choudhary and Phatak (1959), Choudhury and Patil (1962), Sidhu et al. (1981) and Jamadagni and Patil (1982).

Thus, in present experiment, it was observed that GA induced less of hermaphrodism and Ethrel and MH decidedly

induced more percentage of hermaphrodite flowers. Effect of Carbaryl was more like Ethrel. Possible conclusive reasons for such behaviour could not be observed from literature. Moreover, plant hormones are now believed to act at gene level and modify the gene expression (Roberts and Hooley, 1988) to effect such changes but the mechanism is not fully understood.

The finding on production of different types of flowers by a chemical in present study revealed that the observations described in earlier pages regarding the production of number of new flowers may not be solely taken as a criterion for fulfilling the objectives of the present investigation. A chemical inducing male flowers, even if produces more flowers, may not deter the objectives since the male flowers will normally drop without increasing crop load. Conversely, a chemical producing less flower with more percentage of hermaphrodite flower may cause failure of crop regulation programme.

## 5.4 Effect on flower drop

The chemicals, besides having influence on flower induction, also have effects on flower and fruit drop which may or may not reduce fruit set or total crop load. In essence, it was one of the objective of the present programme to induce drop of the flowers that would set fruits after 2½ months. In the present investigation, it was observed that the hand removal of flowers at 14 days interval effectively removed all the flowers that appeared after 2½ month.

A perfect flowers takes 19 to 21 days to develop completely before it can set the fruit (Bawale, 1978). The interval of flower removal (14 days) was much less than this and thus removed all the flowers without allowing any one to set the fruit.

As regards the chemical, GA induced more percentage of flower drop as compared to control but it was less than hand removal of flowers. It is obvious since GA induced more male flowers production which automatically drop, after some period.

Ethrel induced the highest flower drop. Ethrel is synthetic growth inhibitor which is stable below pH 4.1 (Morgan, 1986) and releases ethylene gas in plant tissue since plant cell has less acidity than this. The released ethylene acts as abscission agent accelerating formation of abscission zone at the base of flower pedicel or fruit stalk (Ebert and Hatch, 1972 and Morgan, 1986). In the present investigation, ethrel was most effective, at higher concentration of 500 ppm, to drop the flowers. It also acts as antiauxin which prevents IAA transport in plant tissue and causes lossening and dissolution of middle lamella between adjuscent cell wall resulting into drop of leaf, flowers and fruitlets (Webster, 1968 and Wood, 1985). The results of Ethrel as abscission agent as observed in present investigation are in conformity with the results of Edgerton and Greenhalgh (1969), Wertheim and Joosse (1975), Chundawat et al., (1975), Dhuria et al.(1976), and Forlani et al. (1981).

Similarly, Roberts et al.(1987) reported that ethylene gas increases cell wall degrading enzyme, polygalacturonase (PG) which cause abscission of plant parts.

NAA, at higher concentration, also acts in similar manner as that of Ethrel by stimulating production of ethylene gas in plant tissue which causes drop of flowers and fruitlets (Addicott, 1943; Abeles, 1967; Randhawa et al., 1970). Similarly, Murneek and Teaubner (1953) reported the thinning action of applied NAA also by checking the normal pollination, abortion of young embryo and forcing abscission by alteration of the auxin gradient across abscission zone. In present investigation, NAA at higher concentration (500 ppm) was the most effective to drop flowers in following weeks after application. Similar thinning action of NAA on flowers and fruits has also been reported by Gawadi and Avery (1950), Van Overbeck (1952), Luckwill (1953), Chundawat et al.(1975), Rathore (1975), Bana et al.(1976) Unrath (1978), Veinbrants (1980), Iwahori (1980), Gupta and Nijjar (1982), Josan and Sharma (1987), and Singh and Sandhu (1987) in other crops.

As regards the effect of MH and Carbaryl, they could induce some drop initially but it was not as effective as other chemicals. However, over all picture revealed their less effectivity for this action. One of the reasons may be that they induced less flowers production, as the crop load, which can be well nurished by the plant.

Thus, studies on flower drop revealed that hand removal of flowers at 14 days was the most effective to remove the flower load. Next treatment to have more percentage of flower drop was the hand removal of flowers on 75th day followed by GA spray on the same day. The effect of this treatment appears to be combined action of hand removal, and production of male flowers by GA. Ethrel and NAA at higher concentrations effectively dropped the flowers during initial period. MH and Carbaryl appeared to be much less effective.

5.5 Effect on fruits set and yield

Discussion presented in preceding pages regarding the three parameters viz. production of number of flowers, production of types of flowers and drop of flowers indicate that no single parameter of these can be alone useful to evaluate final efficacy of a treatment. Less production of total flower but more production of perfect flowers may give more crop load. The flower drops may be more if male flowers are more, or total drop may be less if less flowers are produced. And therefore, the efficacy of these treatments can be better judged by knowing the level of fruits harvested and quality of the fruits produced. The results obtained in this regard are discussed below.

Plant growth regulators play a role in productivity of plant by influencing flowering intensity, modifying sex ratio, causing early or late flower induction, stimulating pollination and ovary development, and stimulating or

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arresting flower or fruit drop. In the present experiment, control treatment had the highest (100.01) total fruits harvested over the rest of treatments and this may due to more number of flowers produced. Moreover, the other treatments, in present experiment, were designed to control fruit set after 2½ month of first irrigation.

As regards to chemicals, NAA at 250 ppm + 0.7% Carbaryl (90.66), 1000 ppm MH (88.34), 0.7% Carbaryl (87.00) and 500 ppm NAA +1000 ppm MH after 14 days (86.67) gave more number of fruits than other treatments. While, the lowest fruit number was observed in 500 ppm NAA + 0.7% Carbaryl (66.28), hand removal of flowers once + 20 ppm GA (71.38), hand removal of flowers at 14 days interval (72.90), 500 ppm Ethrel (74.20), 500 ppm NAA (74.50), 500 ppm Ethrel + 100 ppm NAA (74.69) and 500 ppm Ethrel + 20 ppm GA (75.30). Thus, it is evident that the treatments were quite effective to reduce the crop load consequent on either less production of total flowers, less production of perfect flowers, more drop or the combined effect of some of these aspects as observed earlier.

Significantly more fruit number over hand removal of flowers + GA was recorded in all plant growth regulator treatments which may be due to more number of hermaphrodite flowers and consequently higher fruits set. The fruits set (11.29) in hand removal of flowers once + 20 ppm GA was significantly lower than any other chemical treatment (Table 11). It is also attributed to induction of more male flowers which drop without any fruit set.

Lower concentration (250 ppm) of auxin (NAA) showed the highest fruits set which may be firstly by inducing less flower drop than other chemicals and also due to stimulative effect for development and enlargement of ovary (Audus, 1959). Similarly, 1000 ppm MH as also 250 ppm Ethrel had good fruits set which may due to higher number of perfect flowers and also less drop in MH. Similar type of findings have been reported by Maiti and Maiti (1969); Arora et al. (1982) and Jamadagni and Patil (1982). While 500 ppm Ethrel had reduced fruits set which may be due to higher drop of newly initiated hermaphrodite flowers.

Besides increase in fruit set, the chemicals also have role in fruit size, and quality of individual fruit which has highly positive significant correlation with total yield by weight and also on the price realized. The fruit size is normally influenced by the crop loads. Besides, plant growth regulators may have profound promotive or inhibitory effect on fruit size. In present investigation, the over all fruit size was found to be significantly reduced by 1000 ppm MH (169.80 g), 0.7% Carbaryl (175.86 g), and 500 ppm NAA + 1000 ppm MH (181.49 g) as compared to control, even though they had less crop load, than control. While hand removal of flowers + 20 ppm GA (244.19 g), 250 ppm NAA + 0.7% Carbaryl (215.09 g), hand removal of flowers at 14 days interval (215.09 g), 500 ppm Ethrel + 100 ppm NAA (211.68 g), 500 ppm Ethrel + 20 ppm GA (210.49 g) and 500 ppm NAA +

0.7% Carbaryl (210.17 g) gave higher total average fruit weight.

As regards the total yield (weight) two treatments viz., 250 ppm NAA + 0.7% Carbaryl, and hand removal of flowers once on 75th day + 20 ppm GA were top working, also having better fruit size. The increase in total yield of fruits by GA treatment can be attributed to better fruit size, better vegetative growth and more leaf area for photosynthetic activity, without phytotoxic effects. While in case of 250 ppm NAA + 0.7% Carbaryl, increased yield may be attributed to more fruit number and good fruit size (Randhawa et al.,1980). Further, NAA at the lower concentration (250 ppm) did not produce any phytotoxic effect, those were observed in higher concentration of NAA. Even the 0.7% Carbaryl sprayed in this treatment did not gave adverse effect that were seen in 0.7% Carbaryl alone.

The price realized by pomegranate fruit is much influenced by the grade of fruit. In the present investigation, the marketable fruits were classified into four grades viz., A, B, C and D, and the economics on the basis of cost involved due to treatment and returns that would be realized as per fruit grade was worked out. It was observed that, since the number of fruits in different fruit grades vary, the net returns over the control, was the final best criterion to evaluate the efficacy of the treatments (Table 19). It was observed that eight treatments (T 2, T 3, T 5, T 8, T 10, T 13,

T 14 and T 15) revealed increased net return over the control. While, six treatments (T 4, T 6, T 7, T 9, T 11 and T 12) reveal decreased net returns over the control.

The treatments (T 5), 250 ppm NAA + 0.7% Carbaryl, and (T 3) hand removal of flowers once on 75th day after irrigation followed by a spray of 20 ppm GA on same day were the best treatments. The positive attributes of treatment T 5 were increased in leaf area, control over total flowers production, less number of unmarketable fruits, increase in marketable fruits and total yield, more number of A and B-grade fruits, higher average weight of A and B-grade fruits and improved fruit quality. Similarly, T 3 also had more leaf area, control over total flowers production, more number of male flowers, increase in marketable fruits with reduction in unmarketable fruits, higher number and weight of A and B-grade fruits, higher average weight of A and B-grade fruits and also improved fruit quality. Similarly, it also increased net returns over the control.

In the preceding paragraph the results obtained in respect of growth, flower production, flower drop, fruit set, number of fruit harvested and fruit size have been discussed. It was observed that no one chemical or treatment could fulfil all the three lines of objectives as described earlier (less flower production, more drop of flowers, and no shoot extension that gives more flowers). The treatment of hand removal of flowers once followed by 20 ppm GA gave good results of reduced fruit set and flower production and increased total

yield with improved fruit size and quality having no phyto-toxic effect on plant. T 5 (250 ppm NAA + 0.7% Carbaryl) was still better and had optimum vegetative growth and new flower production, fruit size was good and yielded more number of A and B-grade fruits. All other treatments were ineffective in respect of these points. These treatments (other than T 3 and T 5) showed good effect for a character but adverse effects for some other characters. Therefore, final crop yield in terms of various grades of fruit and increase or decrease in net returns over the control was the best criterion to evaluate the treatments. Over all, it was observed that spraying of 250 ppm NAA + 0.7% Carbaryl was the best with estimated Rs.8834.14/ha increase in net returns over the control. It was followed by hand removal of flowers once on 75th day followed by 20 ppm GA on same day which gave estimated Rs.8674.70/ha increase in net returns over the control. These treatments can be adopted in their merit of order or as per availability of the chemicals, in commercial cultivation. Further experimentation with 250 ppm NAA and lower concentrations of Carbaryl may be tried.

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# Summary and Conclusion

# 6. SUMMARY AND CONCLUSION

Present investigation was carried out at the Instructional-cum-Research Orchard of the Department of Horticulture, Central Campus, Mahatma Phule Agricultural University, Rahuri during 1989 on seven year old plants of pomegranate cv. Ganesh spaced at 5 x 5 m. Five chemicals viz., GA, Ethrel, NAA, MH and Carbaryl at various concentration and in combination were used, and were compared with control and hand removal of flowers at 14 days interval. The observations in respect of vegetative growth, flower production, flower sex, flower drop, fruit production, fruit size, fruit quality were recorded and economics worked out. The results obtained are summarized here under.

The highest shoot numbers (20.70) was observed in 500 ppm Ethrel + 20 ppm GA after 14 days, followed by hand removal of flowers + 20 ppm GA (20.63). While, the lowest (15.15) was observed in 500 ppm NAA. GA and hand removal of flowers increased the shoot length and number of leaves, while Ethrel, Carbaryl, and MH had opposite effects. But lower concentration of NAA slightly reduced shoot number, length of shoot with increase in leaf area, while higher concentration had opposite effect, except leaf area.

In general, in various treatments, the new flower production showed significant differences but as period advanced, the number of flower production was reduced in all the treatments. Hand removal of flowers at 14 days

interval, Control, and high concentration of Ethrel induced more total flower production. While, Carbaryl, MH, and hand removal of flowers once + 20 ppm GA produced lowest number of flowers.

As regards to sex of flower, GA induced maleness while Ethrel, MH and Carbaryl induced femaleness.

The drop/removal of flowers was the highest in hand removal of flowers at regular interval of 14 days. It was followed by hand removal of flowers once + 20 ppm GA, and 500 ppm Ethrel. While, the lowest flower drop was observed in Carbaryl and MH. The drop of flowers was mainly constituted by the male flowers (over 70%) in hand removal of flowers, and hand removal of flowers + 20 ppm GA. While, the highest percentage of hermaphrodite and intermediate flower drop was observed in 500 ppm Ethrel followed by 500 ppm Ethrel + 100 ppm NAA after 14 days, 500 ppm Ethrel + 20 ppm GA after 14 days. The flower drop was high during first 28 days of treatment application.

As regard to fruitlet drop, 500 ppm NAA + 0.7% Carbaryl induced more fruitlet drop (19.65) followed by 500 ppm NAA + 1000 ppm MH after 14 days (15.66). While, the lowest fruitlet drop was observed in hand removal of flowers at 14 days interval (4.77).

The number of fruits set after treatment application was more in control (30.55) followed by 250 ppm NAA + 0.7% Carbaryl (25.36). While, the lowest was observed in hand removal of flowers + 20 ppm GA (11.29). But no fruit set was observed in hand removal of flowers at regular interval of 14 days.

In respect of yield, the number of fruits harvested in different treatments significantly differred. The highest number of fruits was harvested from control (100.01) followed by 250 ppm NAA + 0.7% Carbaryl (90.66). While the lowest number of fruits was harvested from 500 ppm NAA + 0.7% Carbaryl (66.28). The highest number of marketable fruits was produced from control (87.25) followed by 250 ppm NAA + 0.7% Carbaryl (81.53), while the lowest number of marketable fruits was produced from 500 ppm NAA + 0.7% Carbaryl (62.13). As regards to unmarketable (mostly immature) fruits, the highest number was produced in control (12.76) followed by 1000 ppm MH (11.70), while lowest was in 500 ppm NAA + 0.7% Carbaryl (4.15). The total weight (yield) of harvested fruits also significantly varied in different treatments. Highest total weight (19.50 kg) was observed in 250 ppm NAA + 0.7% Carbaryl followed by Control (18.12 kg), while the lowest weight (yield) was observed in 1000 ppm MH (15 kg). As regards to marketable fruit weight (yield), 250 ppm NAA + 0.7% Carbaryl produced the highest (18.72 kg) followed by hand removal of flowers + 20 ppm GA (17.13 kg), while the lowest was in 1000 ppm MH (14.24 kg).

The highest number of fruits in each treatment were in B-grade, followed by C, A and D-grades.

The highest total weight (yield) of A-grade fruits was obtained in T 3 (hand removal of flowers + 20 ppm GA) followed by 250 ppm NAA + 0.7% Carbaryl (4.23 kg). As regards B-grade, same trend was observed.

The highest general average fruit weight of the treatment as a whole was obtained in hand removal of flowers + 20 ppm GA (244.16 g), followed by 250 ppm NAA + 0.7% Carbaryl (215.09 g), and hand removal of flowers at regular 14 days interval (215.09 g). While the lowest general average fruit weight was in 1000 ppm MH (169.80 g), followed by 0.7% Carbaryl (175.86 g).

The better quality fruits in respect of rind colour, aril colour, T.S.S. and acidity content were observed in 250 ppm NAA + 0.7% Carbaryl, and hand removal of flowers once + 20 ppm GA. While inferior quality fruits were obtained from 250 ppm Ethrel, followed by Control.

The highest net returns per hactare were observed from 250 ppm NAA + 0.7% Carbaryl (Rs.57095.93/ha) followed by hand removal of flowers once + 20 ppm GA (Rs.56937.49/ha) while the lowest net returns per hactare were observed in 500 ppm NAA + 0.7% Carbaryl (Rs.40279.19/ha). The increase in net returns over control was maximum in 250 ppm NAA + 0.7% Carbaryl (Rs.8834.14/ha) followed by hand removal of

flowers once + 20 ppm GA (Rs.8674.70/ha). In all, eight treatments gave increased net returns over the control, and six treatments gave decreased net returns over the control.

In general, it was observed that, 250 ppm NAA + 0.7% Carbaryl gave best results in respect of vegetative growth, optimum flower production and drop, fruit set and fruit weight with more number of A and B-grade fruits and improved fruit quality. It was followed by hand thinning of flowers once + 20 ppm GA. It is concluded that a spray of 250 ppm NAA followed by a spray of 0.7% Carbaryl after 6 hours on 75th days after first irrigation can be adopted for commercial practice.

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# Literature Cited

# 7. LITERATURE CITED


Abdul Khader, JBM. MD. and V.N. Madhava Rao. 1984. Studies on chemical control of flowering in grapevine. II. Effect on flowering and related characters. South Indian Hort. 32(1): 1-15.

Abeles, F.B. 1967. Mechanism of abscission accelerator. Physiol. Pl. 20: 442-54.

Addicott, F.T. 1943. Pollen germination and tube growth as influenced by pure growth substances. Pl. Physiol. 18: 270-279.

Addicott, F.T. and R.S. Lynch. 1951. Acceleration and retardation of abscission by IAA. Sci. 144: 688-89.

Agnihotri, R.P. and J.S. Bhullar. 1979. Chemical deblossoming of Allahabad Safeda guava. Haryana J. Hort. 8(3-4): 203-204.

Anonymous, 1978. 'Dalimbachi Lagawad' (Cultivation of Pomegranate), by Department of Agriculture, Government of Maharashtra.

A.O.A.C. 1980. Official Method of Analysis. (13th Edt.). Association of Official Agriculture Chemists, Washington, D.C. (U.S.A.).

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts-polyphenol oxidase in Beta vulgaris. Pl. Physiol. 24: 1-15.

Arora, S.K., M.L. Pandita and A.S. Sidhu. 1982. Effect of Maleic hydrazide (MH) on vegetative growth, flowering and fruiting of bottle gourd. Scientia Hort. 17(3): 211-215.

Arora, S.K., M.L. Pandita and K.S. Baswana. 1985. Effect of plant growth regulators on flowering and fruiting of bottle gourd (Lagenaria siceraria) cv. Pusa Summer and Prolific Long. Haryana Agric. Univ. J. Res. 15(1): 36-41.

Atsman, D.A., A. Long and E.N. Light. 1968. Content and recovery of gibberellins in the monoecious and gynoecious cucumber plants. Pl. Physiol. 43: 806-10.

Audus, L.J. 1959. Plant growth substances. Leanard Hill (Book) Lt. London, pp.445.

Bajwa, M.S. 1969. Effect of chemical thinning and hand thinning on the fruit size, yield and fruit quality of plum. Punjab Hort. J. 9(3/4): 153-155.

Bajwa, M.S., K.L.Chadha and Kirpal Singh. 1974. Mechanical and chemical thinning of apple. Indian J. Hort. 30(1-4): 529-535.

Bana, D.S., R.D. Srivastava and OM. Hari. 1976. Studies on the thinning of the fruits by hand and with plant growth substances, and their effects on the final retention and quality of apple cv. Red Delicipus. Indian J. Hort. 33(3-4): 227-32.

*Basak, A., Z. Soczek, M. Ceglowski, B. Niezborala, M. Bakun and E. Zandura. 1988. Apple fruit thinning using Ethephon, NAA and Carbaryl applied separately in mixtures and with addition of SADH. Food Sci. Rept. 15(4): 167-175. (Hort. Abst:. 1989.59(6):4573).

Batjer, L.P. and B.J. Thompson. 1961. Effect of 1-naphthyl-N-Methylacarbamate (Sevin) on thinning apples. Proc. Amer. Soc. Hort. Sci. 77: 1-8.

Batjer, L.P. and M.N. Westwood. 1960. 1-naphythyl-N-Methyl carbamate a new chemical for thinning apple. Proc. Amer. Sco. Hort. Sci. 75: 1-4.

Bawale, S.V. 1978. Floral biology of different cultivars of pomegranate (Punica granatum, L.). M.Sc.(Agri.) Thesis, Mahatma Phule Agricultural University, Rahuri Maharashtra, India.

Bhandary, K.R., K.P.V. Shetty and G.S. Sulikeri. 1964. Effect of 2-chloroethyl phosphonic acid (Ethrel) on the sex expression and yield of cucumber (Cucumis sativus, L.). Prog. Hort. 6(2/3): 45-57.

Bhujbal, B.G. and K.G. Choudhari. 1973. Yield and quality of Thompson Seedless grape (Vitis vinifera, L.) as influenced by girdling and gibberellins. Res. J. Mahatma Phule Agril. Univ. 4(2): 108-112.

Buban, T. and M. Faust. 1983. Flower bud initiation in apple tree. Internal control of growth and differentiation. Hort. Rev. 4: 174-203.

Burg, S.P., A. Apelbaum, W. Eisinger and B.G. Kang. 1971. Physiology and mode of action of ethylene. Hort. Sci. 6:359-364.

Chacko, E.K., R.R. Kohli and G.S. Randhawa. 1972. Flower induction in mango (Mangifera indica, L.) by Ethrel and its possible use in control of biennial bearing. Curr. Sci. 41(13): 501.

Chadha, K.L., R.N. Pal and R.K. Sahay. 1979. Effect of abscission promoting chemicals on deblossoming of mango. Indian J. Hort. 36(1-4): 238-243.

Cheema, G.S., S.S. Bhat and K.C. Naik. 1954. Commercial fruits of India with special reference to Western India. McMillan and Company, Calcutta, India. pp. 270-281.

Choudhary, B. and S.C. Phatak. 1959. Sex expression and sex ratio in cucumber (Cucumis sativus, L.) as affected by plant regulator sprays. Indian J. Hort. 16: 161-169.

Choudhary, B. and A.V. Patil. 1962. Effect of plant regulators sprays on sex, fruit set, fruit development in cucumber (Cucumis sativus). Proc. Bihar Acad. Agric. Sci. (10): 28-32.

Choudhari, K.G. and K.N. Wavhal. 1986. Pomegranate : A culture with promise, Paper presented in the symposium on 'Plantation Opportunities in India', held during 31-1-1985 to 2-2-1986 at New Delhi.

Chougule, B.A., B.D. Khot and G.S. Kanekal. 1955. Maleic hydrazide (MH) a promising plant growth inhibition in a crop production. Poona Agric. Colle. Mag. 46: 21-26.

Chundawat, B.S., O.P. Gupta and N.R. Godara. 1975. Crop regulation in Banarasi Surkha: A guava (Psidium guajava, L.) cultivar. Haryana J. Hort. Sci. 4(1/2): 23-25.

*Clanet, H. and J.C. Salles. 1976. Study of the effect of GA on the development of flower primordia in peach. Amelioration des Plantes, France. 26(2): 285-294 (Hort. Abst . 1977. 47(3): 2348).

Clark, H.E. and K.R. Kerns. 1943. Effect of growth regulating substances on parthenocarpic fruit. Bot. Gaz. 104: 639-44.

Cooke, A.R. and D.I. Randall. 1968. 2-chloroethyle phosphonic acid as ethylene releasing agent for induction of flowering in pine apple. Nature. 218: 974-75.

Crane, J.C., C.N. Morei and M.M. Nelson. 1970. Growth and maturation of fruit stimulated by Ethrel (2-chloroethyl phosphonic acid). J. Amer. Soc. Hort. Sci. 95: 367-70.

Dennis, F.G. and L.J. Edgerton. 1966. Effect of gibberellins and ringing upon apple fruit development and flower bud formation. Proc. Amer. Soc. Hort. Sci. 88:14-24.

Daulta, B.S., R.K. Arora and H.K. Singh. 1983. Effect of Ascorbic acid, $GA_3$ and Planofix on the control of berry shattering in Beauty Seedless grape. Prog. Hort. 15(3): 181-82.

Desai, U.T., K.G. Choudhari, S.D. Rane and Y.S. Patil. 1982. Alternation of flowering period in Kaghzi lime with plant growth substances. J. Maharashtra Agril. Univ. 7(2): 161-162.

*Dhaliwal, G.S. and I.P.S. Sandhu. 1982. Effect of pruning on vegetative growth, flowering and fruit set in ber. Haryana J. Hort. Sci. 11(3/4): 208-212. (Hort. Abst. 1985. 55(3): 233).

Dhuria, H.S., V.P. Bhutani and C. Parmar. 1976. Thinning plums with 2-chloroethyl phosphonic acid. Scientia Hort. 4: 279-83.

Dubey, K.L. 1969. Effect of Maleic hydrazide (MH) on the vegetative growth and flower production of sweet pea (Lathyrus odoratus, L.). Pl. Sci. (1-3): 207-209.

Ebert, A. and F. Bangerth. 1982. Possible hormonal mode of action of three apple thinning agents. Scientia Hort. 16: 343-356.

Edgerton, L.J. 1973. Chemical thinning of flowers and fruits. In shedding of plant parts. ed. T.T.Kozlaswki, Academic Press, New Yorks, pp. 435-474.

*Edgerton, L.J. 1980. Thinning peaches with growth regulators (GA + Ethephon). Abstract No.1064, Dept. of Pomology, Cornell, Univ., Ithaca, U.S.A. (Plant Growth Regulator Abst. 6(1): 152).

Edgerton, L.J. and A.H. Hatch. 1972. Absorption and metabolism of 2-chloroethyl phosphonic acid in apples and cherries. J. Amer. Soc. Hort. Sci. 97: 112-114.

Edgerton, L.J. and W.J. Greenhalgh. 1968. Regulation of growth, flowering and fruit abscission of apples and peaches, with Amchem 66-329. J. Amer. Soc. Hort. Sci. 94: 11-13.

Edgerton, L.J. and W.J. Greenhalgh. 1969. Regulation of growth, flowering and fruit abscission with 2-chloroethyl phosphonic acid. J. Amer. Soc. Hort. Sci. 94: 11-13.

*El-Beheidi, M.E., A.A. El-Monsi, I.M. Abo-Alla and A.M. Hewedy. 1978. Effect of nitrogen fertilizer and Ethrel spray on growth, sex expression, seed yield and quality of cucumber. Res. Bull. Faculty of Agril., Ainshams Univ. 19: 908 (Crop Physiol. Abst. 7(1): 263).

*El-Hamady, M.M., A.S. Khadifa, and A.M. El-Hamady. 1983. Fruit thinning in date palm with ethephon. In : Proceedings of the 1st Symposium on date palm in Saudhi-Arabia, Al Hassa, Saudhi Arabia. King Faisal, University. (Plant Growth Regulator Abst . 1985. 11(7): 860).

*Evreinoff, V.A. 1957. Contribution a Letude due grenadier, (Contribution to the study of pomegranate). J. Agric. Trop. Bot. Appl. 4: 124-138. (Hort. Abst . 1957, 28(1): 18).

*Forlani, M., C. Pasquarella and G. Pugliano. 1981. Trial on flower thinning in peach. Prove di diradamento Fiorale net Pesco, Rivista della Ortoflaro. Florofrutti Cultura, Italiana. 65(2): 119-124 (Hort. Abst . 1982. 52(2): 630).

Galun, E. 1959. Effect of GA and NAA on sex expression and some morphological characters in the cucumber. Phyton. 13(1): 1-8.

Game, R.V. 1987. Studies on floral biology of some cultivars of pomegranate. M.Sc.(Agri.) Thesis, Mahatma Phule Agril. Univ. Rahuri, Maharashtra, India.

Gardner, F.E., P.C. Reece and G.E. Horanic. 1961. Thinning of Dancy Mandarin at blossom time with Maleic hydrazide (MH). Proc. Amer. Soc. Hort. Sci. 77: 188-93.

Gawadi, A.G. and G.S. Avery. 1950. Leaf abscission and the so called "abscission layer". Amer. J. Bot. 37: 187-90.

Gianfagma, T.J. 1989. Chemical control with ethephon of bud dormancy, cold hardiness and time of bloom in peach trees. Pl. Growth Regulator Soc. Amer. 17(2): 39-47.

Goldschemidt, E.E. and S.P. Monselise. 1970. Hormonal control of flowering in citrus tree and other woody Perennials. In : Plant Growth Substances. ed. D.J. Carr, Springer Verlg, Berlin. pp. 758-66.

*Gopalakrishnan, P.K. 1965. Effect of plant regulator on certain physiological aspects of sex and flowering behaviour in watermelon (Citrulus vulgaris, Schard) Ph.D. Thesis, IARI, New Delhi. (Plant Growth Regulator, Symposium, ed. K.L. Chadha, 1972. pp. 171-72).

Griesel, W.O. 1954. Retardation of maturation in mangolia flowers by Maleic hydrazide (MH). Sci. 119: 843-50.

Gupta, M.R. and G.S. Nijjar. 1982. Effect of different chemicals in deblossoming of guava. Punjab Agril. J. 22(3/4): 161-163.

Hamlton, J. 1953. Effect of cluster thinning on maturity and yield of grape grown in Yama Mesa. Proc. Amer. Soc. Hort. Sci. 62: 231-34.

Harris, O.W. and C.L. Smith. 1957. Chemical thinning of pecan nut crops. Pro. Amer. Soc. Hort. Sci. 70: 204-208.

Hayes, W.B. 1953. Fruit Growing in India, Kitabistan, Allahabad, pp. 408-411.

*Heck, W. and E. Pires. 1962. Physiology of leaf abscission. Tex. Agril. Exp. Stat. Miss. Publ. MP-613 (In:Ethylene in plant biology, Frederick B. Abeles, 1973, Academic Press, Inc. London, pp.156.

Heslop-Harrison, J. 1957. The experimental modification of sex expression of flowering plants. Biol. Rev. 38-90.

Hillyer, I.G. and S.H. Wittwer. 1959. Chemical and environmental relationship in flowering of acorn squash. Proc. Amer. Soc. Hort. Sci. 74: 558-68.

Hoda, G.V. 1984. Hormonal regulation of fruit bud formation in fruit tree. Acta. Hort. 149: 13-23.

Horsfall, F. and R.C. Moore. 1963. Effect of 1-naphtyl-N-methylcarbamate (Sevin) on thinning of four varieties of apples. Proc. Amer. Soc. Hort. Sci. 82: 1-4.

Hurd, R.G. and O.N. Purvis. 1964. The effect of gibberellic acid on the flowering of spring and winter Rye. Annl. Bot. (London), 28: 137-151.

*Iwahori, S. 1980. Use of growth regulators in the control of cropping of mandarin varieties. Abstract No.1032, Faculty of Agril. Kagoshima Univ. Kogashima, 890, Japan (Plant Growth Regulator Abstr.6 : 66).

*Iwahori, S. and J.T. Oohata. 1981. Control of flowering of satsuma mandarins (Citrus unsitu, Marc.) with gibberellic acid. In : Proceeding of Inst. Soc. Citriculture 1: 242-49 (Plant Growth Regulator Abst. 1983. 9(2): 225).

Jamadagni, B.M. and V.A. Patil. 1982. Effect of growth regulators on sex expression and sex ratio in monoecious cucumber (Cucumis sativus, L.) cv. Khira. Seeds and Farms. VIII 9.

Jauhari, O.S. and R. Amarjit. 1960. A note on effect of Maleic hydrazide (MH) on growth and flowering of aster. Sci. and Cul. 25(1): 697-98.

Josan, J.S. and J.N. Sharma. 1987. Chemical thinning of Wilking mandarin. Indian J. Hort. Sci. 44(3-4): 172-175.

Kachru, R.B.; R.N. Singh and E.K. Chacko. 1971. Inhibition of flowering in mango (Mangifera indica, L.) by gibberellic acid. Hort. Sci. 6(2): 140-141.

*Katzfuss, M., S. Scmidt and T. Buban. 1975. Preliminary trial on the regulation of yield of apple tree with 2-chloro-ethyl phosphonic acid (Ethrel). Archiv. Fur Gartenbau. 23(7): 401-405. (Hort.Abst. 1977. 47(2): 1181).

Leopold, A.C. 1958. Flower bud induction in apple. Ann. Rev. Pl. Physiol. 9: 281.

Leopold, A.C. and P.E. Kriedemann. 1982. Plant Growth and Development. TMH. ed. Tata McGraw-Hill Publ. Co. Ltd., New Delhi, pp. 148.

*Liabach, F. 1933. Wuchssto fee versuche Mit lebenden Orchideen pollinien. Ber detsh. Bot. Gez. 51: 386-392. (In : Aspects of physiology and Biochemistry of Plant hormone. ed. S.S. Purohit, 1984. Kalyani Publisher, New Delhi.)

*LI Peihua, LIV Wanchun, Shiji Wang, Xi Feng Yang, Shuping Zhang and Xiao Shaccheng, 1984. Studies on some chemical substance for thinning flowers and fruits in apple cvs. Ralls and Golden Delicious. Acta Horticulturae Sinica. 11(4): 217-224 (Hort. Abst. 1985. 55(4): 2418).

Luckwill, L.C. 1953. Studies of fruit development in relation to plant hormones.II. Effect of NAA on fruit set and development in apples. J. Hort. Sci. 28: 25-40.

Luckwill, L.C. 1970. The control of growth and fruitfulness of apple trees. The physiology of tree crops. Academic Press, London.

Mahmood, I. and A.T.Y. EL-Wakeel 1971. Relationship between bloom time, GA sprays and thinning of Thompson Seedless table grapes. Agril. Res. Rev. 45(5): 85-89.

Maiti, S.C. 1973. Effect of $GA_3$ sprays on sex expression in mango. Sci. and Cul. 39(3): 150-151.

Maiti, S.C. and S.K. Maiti. 1969. Effect of plant growth regulators on sex expression of mango (Mangifera indica, L.). Third Int. Symposium on Trop. Sub-Trop. Hort. 1972. Vol.2.pp. 148-152.

*Manna, D.C. and D. Mukherjee. 1983. Effect of Ethrel on growth and flowering of chrysanthemum. Indian Agriculturist. 27(3): 241-49. (Plant Growth Regulator Abst. 1985. 11(10): 180).

Marre, E. and O. Arrigoni. 1957. Metabolic reactions of auxin. Pl. Physiol. 10: 289.

Maugleith, M.G. and G.I. El-Banna. 1974. Effect of 2-chloroethyl phosphonic acid sprays on maturation of Sultani Fig fruits. Annl. Agri. Sci. 2: 109-113.

Maxwell, N.P. 1959. Effect of GA on fruit size of Thompson Seedless and Perlette grape. J. Rio. Grande Valley Hort. Sci. 13: 117-118.

Monselise, S.P. and A.H. Halevy. 1964. Chemical inhibition and promotion of citrus flower bud induction. Proc. Amer. Soc. Hort. Sci. 84: 141-146.

*Morgan, P.W. 1986. Ethylene as a indicator and regulator in the development of field crops. In Plant Growth Substances, 1986, ed. M. Bopp. Spinger, Berlin, pp. 375-79.

Muller, I.A. and M.J. Young. 1982. Influence of Gibberellic acid and effectiveness of several carriers on growth of sour orange (Citrus aurantium, L.) seedling. Hort. Sci. 17(4): 673-74.

Murneek, A.E. and F.G. Teubner. 1953. The dual action of naphthalene acetic acid in thinning of apples. Proc. Amer. Soc. Hort. Sci. 61: 149-154.

Muzumdar, B.C. and D.N.V. Bhatt. 1976. Effect of preharvest application of GA and Ethrel on sweet orange (Citrus sinensis) fruits. Prog. Hort. 8(2): 89-91.

*Myrianthous, T.S. and K.P. Hadjigiorgis. 1973. Flower thinning and berry enlargement of Sultania grape by gibberellins sprays. Tech. Bull. Agril. Res. Inst. Cyprus. (Hort. Abst. 1974. 44(8): 5540).

*Nagao, M.A. and W.S. Sakai. 1987. Effect of Ethephon on abscission of macadamia fruits. Proceedings of the Plant Growth Regulator Society America. 70. (Hort. Abst. 1989: 9040).

Nalwadi, U.G., A.A. Farooqui, Dasappa Reddy, M.A.N. Gulabaish, G.S. Suliber and A.S. Nalini. 1973. Studies on the floral biology of pomegranate (Punica granatum, L.) Mysore J. Agri. Sci. 7(2): 213-225.

Narendra Singh and O.S. Jauhari. 1965. Effect of Maleic hydrazide (MH) on growth, development and yield of pea (Pisum sativum, L.). Indian J. Hort. 22: 351-54.

Nath, Nirmalenlu and G.S. Randhawa. 1959. Studies on flower biology in pomegranate. I.Flowering habit, flowering season, bud development and sex ratio in flowers. Indian J. Hort. 16(2): 61-68.

Nayler Aubrey, W.E. and A.Delvin. 1950. MH acts as plant growth inhibitor. Bot. Gaz. 112: 112-116.

*Nir, I., R. Goren and B. Leshem. 1972. Effect of water stress, gibberellic acid and CCC on flower differentiation in 'Eureka' lemon trees. J. Amer. Soc. Hort. Sci. 97(6): 774-78.

Painter, J.W. and G.E. Stembridge. 1972. Peach flowering responses as related to time of gibberellin application. Hort. Sci. 7(4): 389-390.

Panse, V.G. and Sukhatme, P.V. 1967. The statistical methods for Agricultural Workers. 2nd Edition. ICAR, N. Delhi.

Pappiah, C.M. and S. Muthuswamy. 1974. Effect of plant growth regulators on growth and flowering of dahlia (Dahlia varibilis). South Indian Hort. 22-23(1-4): 77-80.

Patil, A.V. and A.R. Karale. 1989. Pomegranate. Fruits of India: Tropical and Sub-Tropical'. Ed. T.K. Bose. Naya Prokash Private Ltd., Calcutta. pp. 538-548.

Patil, A.V. and K.U. Sanghavi. 1977. Pomegranate cultivation in Maharashtra. Punjab Hort. J. 17(7): 127-130.

Patil, V.A., D.B. Bangal, V.R. Kale and B.M. Jamadagni. 1983. Modification of sex expression in cucumber. J. Maharashtra Agri. Univ. 8(3): 283-84.

Peterson, C.E. and L.D. Anhder. 1960. Induction of staminate flowers on gynoecious cucumber with gibberellin ($GA_3$). Sci. 131: 1673-74.

Phadnis, N.A. 1974. Pomegranate for desert and juice. Indian Hort. 19(3): 9-13.

Rajput, C.B.S. and C.N. Singh. 1982. Effect of plant Growth Regulators on vegetative growth and fruiting of ber (Zizyphus mauritiana). Bangladesh Hort. 10(1): 19-22.

Ram Kumar and M.N. Hoda. 1978. Crop regulation studies in Allahabad Safeda guava. Indian J. Hort. 34(1): 13-14.

Randhawa, G.S., H.C. Das and E.K. Chacko. 1970. Effect of Ethrel, NAA and NAD on the induction of flowering in pine apple (Ananus comosus, L.). Curr. Sci. 39: 530-31.

*Randhawa, H.S.; H.C. Dass, H.P. Singh, G.S. Prakash and B.M.C. Reddy. 1980. Effect of NAA on fruit size and maturity of 'Kew' pine apple. Abstract No.1584 IIHR, Bangalore, India. (Plant Growth Regulator Abst. 6(1): 69).

Rane, D.A., A.R. Karale and K.B. Kamble. 1983. Crop regulation effect on yield and quality of pomegranate (Punica granatum, L.) cv. Muscat. Agresco Report, Hort. Dept., MPAU, Rahuri, Maharashtra.

Ranjit Singh. 1969. Fruits. National Book Trust of India. New Delhi. pp. 135-137.

Rathore, D.S. 1975. Deblossoming of rainy season crop of guava by NAA. Prog. Hort. 7(3): 63-65.

*Rawash, M.A., A. EL-Hamady, S. EL-Nabawy, A.S. Khalifa and H. El-Masary. 1983. Regulation of flowering and fruiting in mango by using plant growth regulator. Annl. Agril. Sci. 28(1): (Plant Growth Regulator Abst. 1985. 11(1): 145).

Reddy, K.J. 1986. Effect of plant growth regulators on growth of kagazi lime. M.Sc.(Agri.) Thesis, MPAU, Rahuri, Maharashtra, India.

Roberts, J.A.; D. Grierson and G.A. Tucker. 1987. Genetic variants as aids to examine the significance of ethylene in development. In: Hormone action in Plant Development. ed. G. Hoad, J.R. Lenten, M.B. Jackson and R.K. Atkin, Nutterworth, London, pp. 107-118.

Roberts, J.A., G.A. Tucker and M.J. Mounders. 1985. Ethylene and foliar senescence. In: Ethylene and Plant Development. ed. J.A. Roberts and G.A. Tucker, Nutterworth, London. 267-75.

Roberts, J.A. and R. Hooley. 1988. Mechanism of action (Ethylene)- towards a molecular understanding. In: Plant Growth Regulators. ed. J.A. Roberts and R. Hooley. Blackie, Chapman and Hall, New York. pp. 151-169.

Robinson, R.W., S. Shannon and M.D. Gaurdia, 1989. Regulation of sex expression in the Cucumber. Bio. Sci. 19: 141-142.

Rodriquez, B.P. and V.N. Lumbeth. 1972. Sinergism and antagonism of GA and growth inhibitor on growth and sex expression in Cucumber. J. Amer. Soc. Hort. Sci.97(1): 90-92.

Rudich, J., N. Kedar and A.H. Halvey. 1970. Changed sex expression and possibilities for hybrid seed production in some cucurbits by application of Ethrel and Alar (B-995). Euphytica. 19: 47-53.

Sadhu, M.K., S.K. Sen and P.K. Sen. 1973. Effect of some growth regulating chemicals on growth, flowering and fruit set in guava. Orissa J. Hort. 1(1): 5-12.

Sanghavi, K.U. 1966. Effect of certain mechanical and chemical treatments on the improvement of the quality of Bhokari and Italian Eliquna varieties of grape. M.Sc.(Agri.) Thesis, Poona Univ., Poona, India.

Scott, P.C. and A.C. Leopold. 1967. Opposing effects of gibberellins and ethylene. Pl. Physiol. 42: 1021-22.

Sen, P.K. and S.C. Maiti. 1965. Chemical control of growth and flowering I. Effect of growth regulators on flowering in mang. In: Growth and Development of Plants. ed. R.D. Asana and K.K. Nanda. Today and Tomorrow's Book Agency. New Delhi-5, pp.54-60.

Shanks, J.B. 1969. Some effects and potential use of Ethrel (2-chloroethyl phosphonic acid ) on ornamental crops. Hort. Sci. 4: 56-58.

Shanmugam, A. and S. Muthuswamy. 1974. Effect of MH on growth and flowering of chrysanthemum (Chrysanthemum indicum, L.). Prog. Hort. 6(1/4): 495-500.

Shaybany, B. and H. Sharifi. 1973. Effect of preharvest application of ethephon on leaf abscission, fruit drop and constituent of fruit juice in pomegranate. J. Hort. Sci. 48(3): 293-96.

*Shibutan, S. and K. Kinoshita. 1966. Study on the influence of Gibberellins on celery. The influence of GA on chlorophyll, total carotene and vitamin C. Sci. Rep., Fac. Agric. Okayama. 27: 27-34.

Sidhu, A.S., M.L. Pandita and S.K. Arora. 1981. Effect of growth regulators on growth, sex expression and yield in squash melon (Citrullus valgaris). Var. Fistulosus. Haryana Agril. Univ. J. Res. 11(4): 485-89.

Sidhu, A.S., M.L. Pandita and R.S. Hooda. 1982. Effect of growth regulators on growth, flowering, yield and quality of Muskmelon. Haryana Agril. Univ. J. Res. 12(2): 231-35.

Singh, J. 1977. Studies on the floral biology of pomegranate (Punica granatum, L.). M.Sc.(Agri.) Thesis, PAU, Ludhiana, India.

Singh, A.K., B.P. Singh and R.B. Ram. 1982. Effect of GA on physical and chemical characters of ber (Zizyphus mauritiana). Bangladesh Hort. 10(1): 47-49.

Singh, A.R. and J.R. Singh. 1974. Effect of foliar applications of N and plant growth regulator on growth character in mango. Hort. Adv. 9: 15-20.

Singh, I.S., R.J. Weaver and B.S. Chundawat. 1977. Timing of ethephon application on ripening and quality of raisin grape cv. Black Corianth. Haryana Agril. Univ. Res.J. 7(3): 97-102.

Singh, H.K., I.S. Singh and K.S. Chauhan. 1978. Effect of pre-harvest application of 2-chlorophyll phosphonic acid (Ethrel) on ripening and quality of guava cv. Sardar. Udyanika, 2(1/2): 17-20.

Singh, S.K. and A.S. Sandhu. 1987. Berry thinning in Perlette grape through pre-bloom application of planofix. Punjab Hort. J. 27(1-2): 34-36.

Singh, P. and J. Singh. 1975. Chemical deblossoming in guava. Sci. and Cul. 4(41): 162-163.

*Singh, P.K., C.B. Choudhury, S.L. Mehta and N. Sivakami. 1984. Uptake and translocation of gibberellic acid in cucumber. J. Nuclear Agril. Bio. 13(1): 1-4. (Crop Physiol. Abst. 10(1): 3478).

Singh, S. and B. Singh. 1963. Alternate bearing of mango. II. Regulation of growth and bearing with plant growth regulators. Punjab Hort. J. 3: 137-147.

Sonawane, P.C. 1986. Studies to explore the possibility of regulating the cropping season of pomegranate (Punica granatum, L.) between Hasta and Ambia bahar. M.Sc.(Agri.) Thesis, MPAU, Rahuri, Maharashtra, India.

Stembridge, G.E. and C.E. Gambrell. 1971. Thinning peaches with bloom and post bloom applications of 2-chloroethyl phosphonic acid. J. Amer. Soc. Hort. Sci. 96(1): 7-9.

Stewart, W.S., D.D. Halsey and P.T. Ching. 1957. Effect of gibberellic acid spray on Thompson Seedless grape. Lasca leaves. 7: 80.

Struckmeyer, B.E. and R.H. Roberts. 1950. A possible explaination of how naphthalene acetic acid (NAA) thins apples. Proc. Amer. Soc. Hort. Sci. 96: 7-9.

Sutulova, V.I. 1981. Determining the potential yield of cucumber following treatment with growth regulator. Lenina. 5: 43-44.

*Su, X.R. and S.M. Wu. 1984. A preliminary report of trial on regulating flowering stage by killing stamen with ethephon in Eucalyptus saligria. Forest Sci. Tech. 9: 1-2.(Plant Growth Regulator Abst. 1986. 12(2): 2222).

Teaotia, S.S. and I.C. Pandey. 1970. Crop regulating studies in guava. Prog. Hort. 1(4): 25-28.

Torri, H. and M. Nakagawa. 1960. The growth promoting effect of GA on the tea shoot. Study of Tea. 22: 23-24 (M.Sc.(Agri.) Thesis, MPAU, Rahuri, 1986 by K.J. Reddy).

*Tu, G.S. 1970. Studies on inducing chrysanthemum flowering by the combination of electric lighting and spray of growth substances. J. Agric. Assis. China. 68.

Unrath, C.R. 1978. The development of Ethephon's potential for spur Delicious apples. Acta. Hort. 80: 233-243.

Van Overbeek, J. 1946. Control of flower formation and fruit size in apple. Bot. Gaz. 108: 43-74.

Van Overbeck, J. 1952. Agriculture application of growth regulators and their physiological basis. Annu. Rev. Pl. Physiol. 3: 87-108.

*Veinbrants, N. 1980. Studies on the use of ethephon as a thinning agent in apple. Abstract No. 1467, Dept. of Agril. Fruit Crop Branch, Austrilia. (Plant Growth Regulator Abst. 6(1): 245).

Wang, D. 1981. Effect of BA and GA on fruit drop of citrus. Hort. Sci. 16(5): 657-59.

*Wang, C.Q., S.K. Liu, T.H. Chen, L.H. Shao and F.F. Chang. 1984. The flower thinning effect of lime-sulpher mixture on Ralls' apple trees. Inst. of Pomology. Shanixi Academy of Agril. Sci. Shanixi, China 1: 7-8 (Hort. Abst. 54(12): 8886).

Weaver, R.J. 1972. Plant Growth Substances in Agriculture. H. Freeman and Company, San Franscico, U.S.A. pp.594.

Weaver, R.J. and S.B. Mccune. 1959. Effect of gibberellin on seeded grape (Vitis vinifera) and its translocation within the vine. Hilgardia. 28: 625-45.

Weaver, R.J. and R.H. Pool. 1971. Chemical thinning of grape. cluster. Vitis. 10: 201-209.

Webster, D.B. 1968. Physiology of leaf abscission. Pl. Physiol. 43: 1512.

*Wertheim, S.J. and M.L. Joosse. 1975. Experiences from trials with blossom thinning agent Ethrel in apple. Fruitteelet. 65(17): 464-65 (Hort Abst. 45(12):9190).

Westwood, M.N. 1978. Temperate zone pomology. W.H. Freeman and Company, San Franscisco, U.S.A. pp. 169-185.

Williams, M.W. and L.P. Batjer. 1964. Site and mode of action of 1-naphthyl-N-methyl carbamate (Sevin) in thinning apples. Proc. Amer. Soc. Hort. Sci. 85: 1-10.

Windle, B.E. and H.V. Dam. 1989. Comparison of fruit thinning spray on four apple cultivars. Acta. Hort. 240: 229-32.

Wolf, F.T. and A.H. Haber. 1960. Chlorophyll content of gibberellin treated wheat seedlings. Nature. 186: 217-18.

Wood, B.W. 1985. Effect of Ethephon on IAA transport, IAA conjugation and antidotal action of Ethrel in relation to leaf abscission in pecan. J. Amer. Soc. Hort. Sci. 110(3): 340-343.

Winkler, A.J. 1962. Means of improve grape quality. In : General Viticulture. Univ. of Calif. Press, London. pp. 285-313.

*Zora Singh and A.S. Sandhu. 1984. Effect of time of prunning of growth, flowering, fruit set and maturity of Umran jujube. Indian J. Agril. Sci. 54(8): 685-89. (Hort. Abst. 1985. 55(2): 167).

* Originals not seen

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# Appendix

# APPENDIX I

Meteorological data on temperature, relative humidity and rainfall during 1989-90.

| Month | Meteorological week No. | Temperature C | | Relative Humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Maximum | Minimum | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| January | 1 | 28.6 | 10.3 | 67 | 29 | 0.0 |
| | 2 | 27.9 | 11.0 | 75 | 37 | 0.0 |
| | 3 | 29.6 | 10.8 | 67 | 27 | 0.0 |
| | 4 | 30.4 | 11.9 | 71 | 29 | 0.0 |
| | 5 | 31.2 | 11.8 | 64 | 22 | 0.0 |
| February | 6 | 31.1 | 10.0 | 63 | 23 | 0.0 |
| | 7 | 31.2 | 11.1 | 55 | 22 | 0.0 |
| | 8 | 30.1 | 8.7 | 46 | 13 | 0.0 |
| | 9 | 38.6 | 13.3 | 47 | 15 | 0.0 |
| March | 10 | 34.7 | 16.1 | 58 | 22 | 3.2 |
| | 11 | 33.6 | 15.9 | 59 | 19 | 0.0 |
| | 12 | 35.6 | 19.5 | 55 | 24 | 0.0 |
| | 13 | 31.0 | 16.4 | 73 | 37 | 0.0 |
| April | 14 | 36.2 | 14.6 | 46 | 15 | 0.0 |
| | 15 | 38.1 | 17.0 | 48 | 15 | 0.0 |
| | 16 | 38.7 | 21.5 | 49 | 19 | 0.0 |
| | 17 | 38.4 | 20.5 | 46 | 22 | 0.0 |
| | 18 | 37.3 | 21.2 | 60 | 26 | 9.5 |
| May | 19 | 39.6 | 20.8 | 44 | 15 | 0.0 |
| | 20 | 40.7 | 22.4 | 55 | 21 | 0.0 |
| | 21 | 39.3 | 23.0 | 61 | 22 | 0.0 |
| | 22 | 36.6 | 23.9 | 75 | 39 | 10.5 |
| June | 23 | 33.5 | 23.0 | 84 | 54 | 52.8 |
| | 24 | 31.7 | 28.4 | 78 | 51 | 0.0 |
| | 25 | 32.9 | 22.4 | 80 | 49 | 27.0 |
| | 26 | 31.6 | 22.7 | 81 | 56 | 15.3 |

Contd..

Appendix I.(Contd..)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| July | 27 | 31.3 | 22.1 | 80 | 50 | 5.2 |
| | 28 | 32.0 | 21.8 | 81 | 50 | 4.4 |
| | 29 | 30.6 | 22.5 | 88 | 63 | 68.2 |
| | 30 | 28.1 | 22.0 | 87 | 69 | 125.6 |
| | 31 | 29.4 | 21.8 | 86 | 59 | 0.2 |
| August | 32 | 28.5 | 22.0 | 85 | 64 | 2.7 |
| | 33 | 28.4 | 21.1 | 92 | 71 | 33.8 |
| | 34 | 28.2 | 21.8 | 88 | 68 | 17.5 |
| | 35 | 29.7 | 21.4 | 86 | 58 | 0.8 |
| September | 36 | 31.2 | 20.1 | 86 | 52 | 7.8 |
| | 37 | 29.8 | 21.3 | 90 | 62 | 65.7 |
| | 38 | 31.1 | 21.9 | 93 | 59 | 84.0 |
| | 39 | 30.4 | 21.6 | 94 | 61 | 83.3 |
| October | 40 | 30.6 | 20.2 | 90 | 50 | 1.0 |
| | 41 | 33.3 | 18.3 | 82 | 29 | 0.0 |
| | 42 | 32.9 | 16.4 | 77 | 26 | 0.0 |
| | 43 | 31.6 | 15.2 | 70 | 29 | 0.0 |
| | 44 | 31.6 | 12.9 | 76 | 29 | 0.0 |
| November | 45 | 30.5 | 14.5 | 74 | 33 | 0.0 |
| | 46 | 31.4 | 17.8 | 73 | 35 | 0.0 |
| | 47 | 31.2 | 14.1 | 68 | 25 | 0.0 |
| | 48 | 30.2 | 13.5 | 70 | 28 | 0.0 |
| December | 49 | 27.9 | 9.3 | 77 | 28 | 0.0 |
| | 50 | 27.5 | 9.1 | 70 | 30 | 0.0 |
| | 51 | 27.6 | 13.8 | 82 | 45 | 0.0 |
| | 52 | 27.1 | 13.8 | 82 | 45 | 0.0 |
| January 1991 | 53 | 29.2 | 14.2 | 85 | 40 | 5.5 |
| | 54 | 29.5 | 11.0 | 70 | 24 | 0.0 |
| | 55 | 30.2 | 9.5 | 63 | 21 | 0.0 |

## APPENDIX II

Prices in the Bombay Market for pomegranate fruits as per grade.

| Date | Price in Rupees per dozen of fruits for various grades | | | |
|---|---|---|---|---|
| | A | B | C | D |
| 13-3-89 | 53.00 | 28.00 | 17.00 | 11.00 |
| 20-3-89 | 52.00 | 30.00 | 15.00 | 10.00 |
| 3-4-89 | 55.00 | 30.15 | 13.20 | 8.90 |
| 17-4-89 | 51.00 | 34.00 | 14.90 | 9.00 |
| 24-4-89 | 58.00 | 35.00 | 16.50 | 10.00 |
| 2-5-89 | 62.00 | 39.50 | 18.00 | 11.00 |
| 15-5-89 | 59.00 | 40.00 | 18.00 | 10.80 |
| 30-5-89 | 63.00 | 39.00 | 18.00 | 12.00 |
| 12-6-89 | 53.00 | 34.50 | 15.00 | 9.00 |
| 26-6-89 | 46.00 | 32.00 | 12.00 | 8.00 |
| 10-7-89 | 45.00 | 21.00 | 10.90 | 7.00 |
| 24-7-89 | 41.00 | 22.00 | 12.50 | 6.00 |
| 8-8-89 | 43.00 | 21.00 | 13.50 | 5.90 |
| 21-8-89 | 45.00 | 22.20 | 12.00 | 6.70 |
| 30-8-89 | 36.00 | 24.00 | 10.00 | 8.30 |
| 15-8-89 | 32.00 | 21.00 | 13.00 | 7.20 |

Number of flowers produced per tree after treatment application.

| Treatment | | Flowers produced during days (Number/tree) | | | | | Total (No./tree) |
|---|---|---|---|---|---|---|---|
| | | 1 to 14 | 15 to 28 | 29 to 42 | 43 to 56 | 57 to 70 | |
| T 1 | Control | 38.74 | 24.30 | 28.69 | 22.13 | 20.69 | 134.55 |
| T 2 | Hand removal of flowers | 40.30 | 26.01 | 29.10 | 25.81 | 27.54 | 148.76 |
| T 3 | Hand removal of flowers + 20 ppm GA | 20.10 | 24.00 | 15.00 | 13.31 | 9.80 | 82.21 |
| T 4 | 500 ppm NAA | 24.00 | 30.02 | 13.82 | 10.00 | 15.42 | 93.26 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 20.00 | 20.63 | 16.10 | 14.57 | 14.00 | 85.30 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 24.76 | 24.00 | 15.72 | 15.00 | 12.61 | 92.09 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 26.11 | 30.50 | 18.00 | 13.56 | 12.77 | 100.94 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 20.59 | 21.00 | 20.81 | 18.00 | 14.43 | 94.83 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 29.61 | 30.42 | 22.41 | 26.00 | 16.99 | 125.43 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 19.00 | 20.87 | 18.00 | 16.41 | 17.99 | 92.27 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 28.21 | 27.00 | 25.20 | 23.80 | 15.02 | 119.23 |
| T 12 | 0.7% Carbaryl | 15.65 | 15.12 | 14.11 | 11.27 | 15.36 | 71.51 |
| T 13 | 1000 ppm MH | 20.00 | 18.81 | 15.00 | 13.28 | 12.80 | 79.89 |
| T 14 | 250 ppm Ethrel | 19.90 | 21.97 | 19.80 | 17.05 | 15.88 | 94.60 |
| T 15 | 500 ppm Ethrel | 29.90 | 27.22 | 22.11 | 24.95 | 16.23 | 120.41 |

| Treatment | | Number of flowers dropped during the period (Number/tree) | | | | | | | | | | Total (No./tree) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1-7 | 8-14 | 15-21 | 22-28 | 29-35 | 36-42 | 43-49 | 50-56 | 57-63 | 64-70 | |
| T 1 | Control | 16.50 | 12.35 | 10.85 | 9.52 | 15.20 | 12.54 | 14.68 | 11.85 | 10.50 | 27.28 | 141.27 |
| T 2 | Hand removal of flowers | 56.23 | 20.20 | 15.16 | 10.85 | 15.00 | 14.10 | 12.15 | 13.66 | 10.10 | 17.44 | 184.89 |
| T 3 | Hand removal of flowers + 20 ppm GA | 42.81 | 8.84 | 9.65 | 10.00 | 8.10 | 5.20 | 3.20 | 2.93 | 8.50 | 9.00 | 108.23 |
| T 4 | 500 ppm NAA | 18.50 | 12.30 | 16.20 | 8.61 | 10.00 | 7.80 | 9.00 | 9.50 | 8.10 | 10.40 | 110.41 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 12.90 | 8.94 | 14.59 | 6.00 | 14.00 | 10.11 | 11.21 | 5.58 | 6.10 | 9.90 | 99.33 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 19.50 | 10.50 | 19.20 | 12.82 | 13.20 | 9.21 | 11.11 | 4.40 | 5.12 | 8.25 | 113.31 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 18.50 | 10.40 | 19.40 | 12.00 | 12.11 | 9.11 | 10.90 | 3.74 | 6.11 | 10.84 | 113.11 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 16.10 | 12.67 | 13.00 | 11.00 | 12.10 | 9.90 | 12.00 | 5.67 | 8.11 | 11.77 | 112.32 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 29.02 | 17.54 | 18.11 | 14.73 | 16.12 | 10.11 | 14.12 | 11.84 | 5.81 | 10.00 | 147.40 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 18.12 | 14.00 | 15.11 | 10.89 | 11.10 | 9.10 | 10.00 | 5.40 | 8.90 | 9.31 | 111.93 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 30.11 | 17.51 | 18.50 | 14.00 | 16.42 | 9.19 | 12.11 | 11.40 | 5.50 | 9.95 | 144.69 |
| T 12 | 0.7% Carbaryl | 10.23 | 8.09 | 9.13 | 7.68 | 10.11 | 6.10 | 6.90 | 4.10 | 6.10 | 13.85 | 82.29 |
| T 13 | 1000 ppm MH | 9.42 | 8.00 | 9.50 | 8.04 | 11.20 | 6.10 | 8.30 | 6.69 | 8.90 | 18.00 | 94.15 |
| T 14 | 250 ppm Ethrel | 17.11 | 14.19 | 15.12 | 9.22 | 12.10 | 8.99 | 10.11 | 4.86 | 7.11 | 14.53 | 113.34 |
| T 15 | 500 ppm Ethrel | 28.40 | 18.10 | 19.10 | 12.42 | 15.20 | 10.11 | 13.20 | 7.41 | 8.30 | 10.22 | 142.46 |

APPENDIX V

Number of flowers dropped per tree at alternate day for first 14 days.

| Treatment | 2nd | 4th | 6th | 8th | 10th | 12th | 14th | Total |
|---|---|---|---|---|---|---|---|---|
| T 1 Control | 6.30 | 5.10 | 4.10 | 3.35 | 4.10 | 3.80 | 2.10 | 28.85 |
| T 2 Hand removal of flowers | 36.13 | - | 9.80 | 8.50 | 6.15 | 10.15 | 5.70 | 76.43 |
| T 3 Hand removal of flowers + 20 ppm GA | 37.31 | - | - | 3.10 | 3.44 | 3.50 | 4.30 | 51.65 |
| T 4 500 ppm NAA | 8.10 | 6.00 | 4.11 | 4.01 | 4.20 | 2.00 | 2.38 | 30.80 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 6.00 | 3.95 | 2.60 | 2.41 | 2.90 | 2.10 | 1.88 | 21.84 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 9.12 | 7.90 | 2.10 | 3.11 | 5.00 | 2.00 | 0.77 | 30.00 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 8.11 | 6.30 | 2.30 | 4.90 | 6.00 | - | 1.29 | 28.90 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 6.20 | 5.40 | 5.00 | 3.09 | 4.18 | 3.11 | 1.79 | 28.77 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 11.90 | 8.20 | 8.80 | 4.10 | 7.50 | 3.30 | 2.76 | 46.56 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 6.40 | 6.00 | 5.00 | 3.41 | 4.90 | 3.00 | 3.41 | 32.12 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 12.00 | 9.11 | 8.30 | 4.90 | 6.10 | 4.11 | 3.10 | 47.62 |
| T 12 0.7% Carbaryl | 4.13 | 2.90 | 3.10 | 2.50 | 3.01 | 1.41 | 1.27 | 18.32 |
| T 13 1000 ppm MH | 4.11 | 2.99 | 1.91 | 2.10 | 3.19 | 2.10 | 1.02 | 17.42 |
| T 14 250 ppm Ethrel | 6.31 | 5.10 | 4.21 | 4.00 | 5.00 | 3.80 | 2.88 | 31.30 |
| T 15 500 ppm Ethrel | 11.90 | 9.10 | 8.09 | 5.02 | 7.01 | 3.90 | 1.48 | 46.50 |

APPENDIX VI

Number of fruits set per tree after treatment application.

| Treatments | Fruits set during days (Number/tree) | | | | | Total fruits set per tree |
|---|---|---|---|---|---|---|
| | 1 to 14 | 15 to 28 | 29 to 42 | 43 to 56 | 56 yo 70 | |
| T 1 Control | 6.10 | 6.14 | 5.20 | 6.00 | 7.11 | 30.55 |
| T 2 Hand removal of flawers | - | - | - | - | - | - |
| T 3 Hand removal of flowers + 20 ppm GA | 3.10 | 2.20 | 3.12 | 1.60 | 1.27 | 11.29 |
| T 4 500 ppm NAA | 4.70 | 4.10 | 4.0 | 4.20 | 6.00 | 23.00 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 5.53 | 6.00 | 4.33 | 4.00 | 5.50 | 25.36 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 5.60 | 6.01 | 3.10 | 2.50 | 3.95 | 21.16 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 4.09 | 4.80 | 4.17 | 4.00 | 7.67 | 24.73 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 4.00 | 4.03 | 4.00 | 3.13 | 5.87 | 21.03 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 3.01 | 3.16 | 3.00 | 2.63 | 5.69 | 17.49 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 4.17 | 4.00 | 3.03 | 2.70 | 4.96 | 18.86 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 3.60 | 3.07 | 2.20 | 2.20 | 4.00 | 15.07 |
| T 12 0.7% Carbaryl | 5.07 | 5.00 | 4.56 | 4.00 | 4.84 | 23.47 |
| T 13 1000 ppm MH | 6.01 | 3.99 | 4.33 | 4.00 | 6.04 | 24.37 |
| T 14 250 ppm Ethrel | 5.00 | 4.37 | 4.50 | 4.03 | 4.02 | 21.92 |
| T 15 500 ppm Ethrel | 3.13 | 4.70 | 3.00 | 3.01 | 4.30 | 18.14 |

APPENDIX VII

Number of fruit dropped per tree after treatment application.

| Treatments | Fruits dropped during days (Number/tree) | | | | | Total (No./tree) |
|---|---|---|---|---|---|---|
| | 1 to 14 | 15 to 28 | 29 to 42 | 43 to 56 | 57 to 70 | |
| T 1 Control | 2.37 | 2.29 | 3.50 | 3.75 | 2.75 | 14.66 |
| T 2 Hand removal of flowers | 1.40 | 1.20 | 0.82 | - | 1.35 | 4.77 |
| T 3 Hand removal of flowers + 20 ppm GA | 2.15 | 1.85 | 3.00 | 2.40 | 2.34 | 11.74 |
| T 4 500 ppm NAA | 5.30 | 2.20 | 2.50 | 2.00 | 3.50 | 15.50 |
| T 5 250 ppm NAA + 0.7% Carbaryl | 3.40 | 2.00 | 2.10 | 1.00 | 3.00 | 11.50 |
| T 6 500 ppm NAA + 0.7% Carbaryl | 7.90 | 2.40 | 3.00 | 2.85 | 3.50 | 19.65 |
| T 7 500 ppm NAA + 1000 ppm MH after 14 days | 4.60 | 2.06 | 2.92 | 2.00 | 4.08 | 15.66 |
| T 8 250 ppm Ethrel + 100 ppm NAA after 14 days | 2.50 | 2.20 | 1.95 | 1.05 | 2.90 | 10.60 |
| T 9 500 ppm Ethrel + 100 ppm NAA after 14 days | 4.20 | 2.00 | 2.00 | 2.90 | 4.74 | 15.84 |
| T 10 250 ppm Ethrel + 20 ppm GA after 14 days | 3.00 | 2.79 | 2.69 | 2.30 | 4.11 | 14.89 |
| T 11 500 ppm Ethrel + 20 ppm GA after 14 days | 4.01 | 2.08 | 3.10 | 2.80 | 4.98 | 16.97 |
| T 12 0.7% Carbaryl | 4.00 | 2.00 | 2.44 | 2.06 | 1.50 | 12.00 |
| T 13 1000 ppm MH | 4.20 | 2.60 | 2.00 | 2.00 | 4.36 | 15.16 |
| T 14 250 ppm Ethrel | 2.93 | 1.20 | 1.85 | 1.85 | 1.50 | 9.33 |
| T 15 500 ppm Ethrel | 3.80 | 2.06 | 2.80 | 2.02 | 4.13 | 14.81 |

Details of Expenditure incurred per hactare.

| Treatments | | Harvesting and grading charges (Rs./ha) | Packing and Transport charges (Rs./ha) | Marketing charges (Rs./ha) | Cost of plant growth regulators (Rs./ha) | Spraing charges (Rs./ha) | Total expenditure (Rs/ha) |
|---|---|---|---|---|---|---|---|
| T 1 | Control | 240.02 | 9917.42 | 3728.95 | - | - | 13886.39 |
| T 2 | Hand removal of flowers | 174.96 | 7540.65 | 3612.13 | - | 308.73 | 11636.47 |
| T 3 | Hand removal of flowers + 20 ppm GA | 171.31 | 7639.34 | 4228.82 | 60.30 | 1380.16 | 13476.13 |
| T 4 | 500 ppm NAA | 178.80 | 7956.67 | 3457.07 | 60.30 | 1199.70 | 12852.54 |
| T 5 | 250 ppm NAA + 0.7% Carbaryl | 217.58 | 9267.26 | 4378.17 | 120.60 | 1890.00 | 15873.61 |
| T 6 | 500 ppm NAA + 0.7% Carbaryl | 159.07 | 7062.11 | 3198.94 | 120.60 | 2495.70 | 13036.42 |
| T 7 | 500 ppm NAA + 1000 ppm MH after 14 days | 208.01 | 8811.44 | 3755.79 | 120.60 | 2159.70 | 15055.54 |
| T 8 | 250 ppm Ethrel + 100 ppm NAA after 14 days | 200.54 | 8843.27 | 3990.65 | 120.60 | 840.30 | 13995.36 |
| T 9 | 500 ppm Ethrel + 100 ppm NAA after 14 days | 179.26 | 7903.24 | 3605.23 | 120.60 | 1440.30 | 13248.63 |
| T 10 | 250 ppm Ethrel + 20 ppm GA after 14 days | 202.01 | 8956.93 | 3973.65 | 120.60 | 1920.00 | 15173.19 |
| T 11 | 500 ppm Ethrel + 20 ppm GA after 14 days | 180.72 | 8013.50 | 3762.53 | 120.60 | 2520.00 | 14597.35 |
| T 12 | 0.7% Carbaryl | 208.80 | 9116.07 | 3734.78 | 60.30 | 1296.00 | 14415.95 |
| T 13 | 1000 ppm MH | 212.02 | 8711.41 | 3719.17 | 60.30 | 960.00 | 13662.90 |
| T 14 | 250 ppm Ethrel | 193.25 | 8538.64 | 3782.62 | 60.30 | 600.00 | 13174.80 |
| T 15 | 500 ppm Ethrel | 178.08 | 7830.50 | 3684.63 | 60.30 | 1200.00 | 12953.51 |

# Vita

## 9. VITA

G.Z. Ahire

A Candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

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| | | |
|---|---|---|
| Title of Thesis | : | Studies to control late season flower production in pomegranate (Punica granatum, L.) |
| Major field | : | Horticulture (Pomology) |
| Biographical information | : | |
| Personal data | : | Born at Village Brahmangaon, Taluka- Satana, Dist-Nashik on September 8, 1966. Son of Shri.Zipru Ratan Ahire of Brahmangaon, Tal- Satana Dist- Nashik. Unmarried. |
| Educational | : | Passed S.S.C. in March 1982 in Nutan English School, Brahmangaon, Tal- Satana, Dist- Nashik and H.S.C. in 1984, in College of Science, Satana, Dist- Nashik. Received the Bachelor of Science (Agriculture) degree with first class in Agriculture, 1988 from the College of Agriculture, Dhule, Mahatma Phule Agricultural University, Rahuri. |

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