

**EFFECT OF GROWTH REGULATORS ON
FLOWERING, FRUITSET, YIELD AND QUALITY IN
PHALSA (*Grewia sub-inaequalis* DC)**

By

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B.Sc. Horticulture

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**ANDHRA PRADESH HORTICULTURAL UNIVERSITY
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JULY, 2010

CERTIFICATE

ABHIJIT DEBNATH has satisfactorily prosecuted the course of research and that the thesis entitled “**EFFECT OF GROWTH REGULATORS ON FLOWERING, FRUITSET, YIELD AND QUALITY IN PHALSA (*Grewia sub-inaequalis* DC)**” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled “**EFFECT OF GROWTH REGULATORS ON FLOWERING, FRUITSET, YIELD AND QUALITY IN PHALSA (*Grewia sub-inaequalis* DC)**” submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE**, of the **Andhra Pradesh Horticultural University, Venkataramannagudem**, is a record of the bonafide research work carried out by Mr. **ABHIJIT DEBNATH** under our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

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July, 2010

DECLARATION

I, Mr. ABHIJIT DEBNATH, hereby declare that the thesis entitled “EFFECT OF GROWTH REGULATORS ON FLOWERING, FRUITSET, YIELD AND QUALITY IN PHALSA (*Grewia sub-inaequalis* Dc)” submitted to ANDHRA PRADESH HORTICULTURAL UNIVERSITY for the Degree of MASTER OF SCIENCE IN HORTICULTURE is a result of original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

Place: Rajendranagar

(ABHIJIT DEBNATH)

Date: 09.07.2010

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LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---------------------------|---|-----------------------------------|
| 2, 4-D | : | 2, 4-Dichloro phenoxy acetic acid |
| % | : | per cent |
| @ | : | at the rate of |
| °C | : | Degree centigrade |
| C.D. | : | Critical Difference |
| cm | : | centimeter |
| cv. | : | Cultivar |
| Contd. | : | Continued |
| <i>et al.</i> | : | and others |
| Fig. | : | Figure |
| fruits tree ⁻¹ | : | fruits per tree |
| FYM | : | Farm Yard Manure |
| g | : | gram |
| GA ₃ | : | Gibberellic acid |
| ha | : | hectare |
| ha ⁻¹ | : | per hectare |
| hrs | : | hours |
| <i>i.e.</i> | : | that is |
| K | : | Potassium |
| kg | : | kilogram |
| kg tree ⁻¹ | : | kilogram per tree |
| kg ha ⁻¹ | : | kilogram per hectare |
| Max. | : | maximum |
| m | : | meter |
| mm | : | millimeter |
| mg | : | milligrams |

| | | |
|-----------------------------|---|--|
| Min. | : | minimum |
| ml | : | milliliter |
| N | : | Nitrogen |
| N | : | Normality |
| NAA | : | Naphthalene Acetic Acid |
| NaOH | : | Sodium Hydroxide |
| No. | : | Number |
| P | : | Phosphorus |
| ppm | : | parts per million |
| RBD | : | Randomized Block Design |
| S. Em | : | Standard error difference of two treatment means |
| t | : | tonnes |
| t ha ⁻¹ | : | tonnes per hectare |
| TSS | : | Total Soluble Solids |
| yield tree ⁻¹ | : | yield per tree |
| yield hectare ⁻¹ | : | yield per hectare |
| <i>viz.</i> | : | namely |
| / | : | per |

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ABSTRACT

A field experiment entitled “Effect of growth regulators on flowering, fruitset, yield and quality in Phalsa (*Grewia sub-inaequalis* DC)” carried out during 2009-2010 in Model Orchard at College of Horticulture, Rajendranagar, Hyderabad.

The experiment was laid out in a Randomized Block Design with nine treatments and replicated thrice. The treatments consists of two levels each of Naphthalene acetic acid 25 and 50 ppm, Gibberellic acid 50 and 100 ppm, Kinetin 15 and 50 ppm, Ethrel 250 and 500 ppm and control. The growth regulators were applied twice *i.e.*, first spray at pre bloom and second spray at post bloom stage. Data was recorded on number of flowers per shoot, days to 50 percent flowering, fruit set, number of fruits per bush, days to first picking, fruiting duration, crop duration, fruit weight and yield characters. Chemical analysis was done to determine quality parameters of the fruit.

The results revealed that application of NAA 25 ppm was effective in increasing the number of flowers per shoot (394.26), increasing fruitset 41.22 per cent over control, higher number of fruits per node (25.29), less number of days to 50 per cent flowering (51.17), flowering to fruit set (14.00 days) followed by GA₃ 50 ppm.

Earlier days to first picking (96.00), less fruiting duration (18.17 days) and crop duration (115.17days) was recorded with GA₃ 50 ppm treatment followed by NAA at 25 ppm and GA₃ 100 ppm.

GA₃ 100 ppm was most effective in improving yield per plant (3.05 kg), yield per hectare (7.63 t ha⁻¹) and hundred fruit weight (61.48g) compared to NAA, kinetin, ethrel and control treatments.

All the growth regulators significantly improved fruit quality i.e., TSS, acidity, TSS to acid ratio, reducing sugar, pulp weight, stone weight, pulp to stone ratio and shelf life of the fruit.

Ethrel 500 ppm recorded maximum total soluble solids content (25.72 %) and minimum was recorded in control (19.80%). Maximum reducing sugar (18.91%), TSS to acid ratio (10.98), Pulp weight (51.45g), pulp to stone ratio (5.85g) and minimum titratable acidity (2.26 %) and stone weight (8.83g) was recorded with GA₃ 100 ppm compared to NAA, kinetin, ethrel and control.

Kinetin 30 ppm recorded maximum shelf life (51.46 hrs) and minimum shelf life was recorded in control (36.12 hrs).

Application of GA₃ 100 ppm was found to be good for increasing the yields and improve quality of Phalsa fruits under the agro-climatic conditions of Hyderabad.

The next better treatment was GA₃ 50 ppm followed by NAA 25 ppm to increase yield and improve quality of Phalsa.

Chapter I

Introduction

CHAPTER - I

INTRODUCTION

Phalsa (*Grewia sub-inaequalis* DC) belongs to the family Tiliaceae is one of the hardy tropical and Subtropical fruit plant, withstand drought and grown under adverse climatic conditions. It can be cultivated on neglected and poor soils. It is also grown as an inter-crop in mango, aonla, bael and ber commercial orchards. Phalsa cultivation favoured around big cities where fruits have good demand in market.

The ripe Phalsa fruits are consumed fresh, as desserts or processed into refreshing fruit and soft drinks enjoyed during summer months in India (Salunkhe and Desai, 1984). The fruits are excellent for processing into quality beverages, ready to serve, nectar, syrup and squash.

The medicinal qualities are known since Vedic times. The fruits are somewhat astringent and have cooling effect (Kirtikar and Basu, 1933).

Morton (1987) stated that the unripe Phalsa fruits alleviate inflammation and are also being administered in respiratory, cardiac, and blood disorders.

Ripe fruits are sub acidic in taste and rich source of vitamin A (16.11 μ g/100 g fruit) and vitamin C (22 mg/100 g fruit) and minerals (Sharma *et al.*, 2008). Nutritive value of Phalsa is 725 calories/kg edible fruit; moisture, 81.13%; protein, 1.58%; fat, 1.82%; crude fiber, 1.77%; and sugar, 10.27% (Morton, 1987).

Phalsa is commercially cultivated in the state of Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh, Bihar, West Bengal and Maharashtra.

Phalsa is a bushy plant and grow into a tree if left unpruned. The plant bears many small berry-like fruits of deep reddish brown colour. The Phalsa fruits begin to ripe from March to April. Fruit are small sized and ripen over period about a month. Therefore a number of pickings required at two to three days interval which are very expensive.

The Phalsa bears flowers on the current year's growth in the axils of the leaves. There are 3 to 7 peduncles and each peduncle has 3 to 6 flowers of yellow colour. Generally, the flowers of Phalsa are hermaphrodite having well developed androecium and gynoecium in the same flower and a normal flower has 4-5 sepals, 4-5 petals, 70-80 free stamens with well developed gynoecium. Duration of the receptivity of stigma is very short and maximum receptivity is attained on the day of anthesis, after which the stigmas were non- receptive. Phalsa is self compatible, but pollens are not able to reach the stigma to effect the self pollination due to detraction of stamens away from the stigma causes low fruitset (Randhawa and Dass, 1962).

Low fruitset, poor shelf-life of fruits and prolonged harvesting period involving several pickings are the major problem in production of Phalsa which come in way of its commercial production.

Application of growth substances viz. Auxins and Gibberellins has proved effective in increasing fruitset and yield in several fruit crops including Phalsa

(Randhawa *et al.* 1959b). Application of GA₃ results in increased yield and better grade Phalsa fruits (Randhawa *et al.* 1967).

Exogenously application of these growth regulators provides growth factor for the ovary development, inhibiting the abscission of the developing ovary, improving pollen germination and pollen tube growth causes fruit set (Singh and Randhawa, 1961).

Ethrel sprayed at full bloom stage found to be increasing TSS content of the Phalsa fruits (Rema and Sharma, 1991) and efficacy of kinetin in increasing shelf life by reducing the physiological loss of weight of fruit crops was shown by various workers (Dedolph *et al.*, 1961; Randhawa *et al.*, 1976).

Ripe fruits should be harvested daily and have poor keeping quality. The fruits cannot be stored long, therefore, should be marketed as soon as possible. The short shelf-life of Phalsa fruits are only suitable for local market (Anand, 1960) or need to be processed immediately after harvesting (Salunkhe and Desai, 1984).

Phalsa is the most perishable fruit. At normal field temperatures, physiological activity is so high that fruits begin to destroy itself soon after harvesting.

Systematic work has not been done so far to improve its flowering, fruitset, yield and quality. Therefore the present investigation is carried to find the effect of growth regulators on the flowering, yield, quality and shelf-life of Phalsa, by manipulating these objectives:-

Objectives-

1. To study the effect of growth regulators on flowering, fruitset and yield of Phalsa fruit.
2. To study the effect of growth regulators on quality of Phalsa fruit.
3. To standardize the optimum concentration of growth regulators for increase the quality and yield of Phalsa fruit.

Chapter II

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

The literature pertaining to the effect of plant growth regulators on flowering, yield quality and shelf life of Phalsa is very limited. Hence, the work done was also reviewed to get an insight into the problem in respect of growth regulators effect on Phalsa crop and also other related tropical and subtropical fruit crops.

2.1 Effect of growth regulators on flowering

Rao and Shanmugavelu (1973) reported that pruning combined with foliar spray of ethrel 200 ppm at fortnightly intervals from August to November induced profuse flowering which ultimately produced higher yields over control in cultivars Mulgoa and Baneshan. Sen *et al.*, (1973) reported that when sprayed ethrel at concentrations of 250 and 500 ppm thrice at monthly intervals during August, September and October inhibited shoot growth and enhanced the percentage of shoots flowered over control in Langra and Bombai varieties of mango.

Sanyal *et al.*, (1996) reported that spraying of ethrel four times at monthly interval at 1 ml/l of water showed an increased in flowering during “off” year in both the irregular bearing mango cvs. langra and Himsagar at Kalyani, West Bengal.

Brahmachari *et al.*, (2006a) conducted an experiment at the Ranchi Agricultural College, Kanke, Jharkhand, India with pre flowering spraying of NAA at 10, 20, 30 and 40 ppm; GA₃ at 50, 100, 150 and 200 ppm; and two controls (water spray and unsprayed)

and reported that pre flowering spray of 20 ppm NAA recorded the earliest panicle emergence, date of first flowering and 50% flowering, and the highest percentage of flowering shoots in mango.

Shaban (2009) studied the effect of summer pruning and spraying immediately after pruning with GA₃ at 0, 25, 50 or 100 ppm and reported that severe pruning and application of GA₃ at 50 ppm gave the maximum number of panicles per shoot of Zebda mango trees.

Kadam *et al.*,(2005) conducted experiment at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India with NAA and GA₃ both (50 and 100ppm) and observed that application of GA₃ 50 ppm at flowering stage produced more number of flowers (8.52) and reduced flower development period (46.46days) but flowering duration(58.83 days) was extended in Sapota.

Nambisan *et al.*,(2007) conducted experiment at the instructional-cum-research orchard, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri,Maharashtra,India with NAA and GA₃ both (10,20,30 ppm). NAA (30ppm) sprayed twice at flowering and three month thereafter recorded highest flowers per shoot (13.6) as compared to control (12.0) in Sapota.

Chavan *et al.*, (2009) conducted an experiment at Department of Horticulture, Marathwada Agricultural University, Parbhani with NAA and GA₃ both (50,100,150ppm) and reported that spraying of NAA (150 ppm) one at the time of

flowering and second at the pea stage and third at lag phase of fruit development produced highest number of flowers per shoot (54) while least number of flowers per shoot (42.76) recorded in GA₃ 50 ppm in Sapota. Less duration (56.35 day) of flowering was recorded in NAA 150 ppm, while control recorded more duration of flowering (63.43 days).

Edgerton and Greenhalgh (1969) studied the effect of ethrel on apple and peach branches or young trees at several stages of development from pre-bloom to harvest and ethrel application at 1000 to 2000 ppm during the pre-bloom checked vegetative growth and promoted flower bud formation.

Kender and Ramily (1970) working on grapevine reported that ethrel at 100, 200, 400 ppm applied at bud burst stage promoted femaleness compared to control.

Modlibowska (1973) reported that ethephon or SADH was useful to control plant growth, induce flowering and bring young trees of plum and cherry into bearing. Crisosto *et al.*, (1990) reported that ethephon at 250 and 500 mg/litre applied at 10% leaf-drop stage delayed flowering by 13 and 16 days, respectively but did not reduce yield in Italian Prune.

Cottin (1989) studied the effect of application of 1000, 1250 or 1500 ppm ethrel (ethephon) at pre bloom stage increased the production of flowering shoots (72.24%) but caused defoliation and spraying of 250 ppm ethrel with 2% mineral oil to nonbearing tree resulted in earlier flowering of Tahiti lime (*C. latifolia* Tan.) in the humid tropics.

Borah and Mohan (1993) studied that highest percentage of flowering of 87.50 was recorded in the pineapple plants treated with NAA 10 ppm at 34 functional stages of the plant and the lowest in control which recorded only 50 percent flowering. Maximum flowering was advanced by 91.19 days in the ethrel treated plants over control.

2.2 Effect of growth regulators on fruit set

Growth regulators like GA₃, NAA and Kinetin have been effectively used for improving fruit set in many fruit crops. These growth regulators when applied exogenously were found to have two-fold functions viz., (a) providing of growth factor for the ovary development and (b) inhibiting the abscission of developing ovary.

Prasad and Bajpai (1963) obtained maximum fruit set (69.35%) in Phalsa with 25 ppm NAA. In another study on Phalsa, Randhawa *et al.*, (1959) observed that spraying of 10 and 20 ppm GA₃ at full bloom stage increases fruit set (34.7 %) and (22.1 %) respectively over control in Phalsa. Randhawa and Singh (1962) also obtained markedly increased fruit set in Phalsa over control by 10 ppm GA₃ sprays.

Rao and Rao (1963) applied GA₃ at several concentrations (150-2000 ppm) to flowering shoots of Phalsa as aqueous sprays and found that GA₃ at 300 ppm increased fruit set by 34.00 (sprays at bud stage) and 15.6 (sprays at flowering) percent over control, whereas 500 ppm GA₃ treatment increased fruit set by 23.6 percent sprays at bud stage and 11.7 percent sprays at flowering stage. Reddy (1977) also reported that fruit set

increased with increase in concentration of NAA upto 20 ppm whereas GA₃ was effective at lower concentration (10 ppm) only sprayed during pre bloom stage of Phalsa .

Prasad (1990) observed that fruit set in Phalsa was increased by NAA treatment and GA₃ treatments. The increase in fruitset (72.31%) was highest with pre bloom and full bloom spray of NAA (25 ppm) and higher fruitset (68.34%) was recorded with GA₃ 50 ppm. Lower fruitset (54.36%) was recorded in control.

Kadam *et al.*, (2005) observed that application of NAA 100 at flowering stage increased fruit set (41.66 %) in Sapota.

Nagargoje *et al.*, (2007) conducted an experiment at Department of Horticulture, Marathwada Agricultural University, Parbhani, Maharashtra, India with spraying of NAA of 50 and 100 ppm at 50% flowering and at the pea stage of fruit development on uniformly selected branches and revealed that application of 100 ppm NAA was superior in reducing flower drop as well as in increasing fruit set (47.58%) and fruit retention (26.00%) in Sapota (*Manilkara zapota*) cv. Kalipatti and control recorded 38.72% fruitset and 16.28% fruit retention.

Nambisan *at al.*,(2007) reported that NAA (30ppm) and GA₃ (30ppm)spray twice during flowering and three month there after recorded highest number of fruit set per shoot (1.7) and fruit set percentage (13.9%) was highest with 30 ppm GA₃ over control(1.4) and (11.7%) respectively on Sapota cv. Kalipatti. Chavan *et al.*, (2009)

highest per cent of fruit set (43.13) was recorded with the application of NAA 150 ppm and lowest fruit set was in control (36.00%).

Birendra Prasad *et al.*, (2006) reported fruit set was enhanced by the pre flowering application of GA₃ 100 ppm in mango. Koruna *et al.*, (2007) at Sabour, Bihar, reported that ethrel 200ppm found effective treatment to increase fruit set per panicle of mango cv. Langra.

Thakur *et al.*, (1990) conducted an experiment at Sabour, Bihar to study the effect of growth regulators on fruit-set and retention of litchi with GA₃ (50 and 100 ppm), NAA (25 and 50 ppm) and ethrel (50 and 100 ppm) were applied on cultivars Purbi and Deshi. The highest fruit set (298.9 in Purbi and 314.14 in Deshi) was by spraying of GA₃ 50 ppm whereas lowest (244.10 in Purbi and 273.14 in Deshi) under control.

Brahmachari and Ruby Rani (2001) conducted an experiment at Sabour; Bihar reported that highest percentage of fruit set (41.44%) was observed with GA₃ 100 ppm sprayed at panicle emergence stage and spraying of Kinetin with 20 ppm at panicle stage increased fruit set (32.97%) over control (29.72%) on the litchi trees.

Pandey (1999) reported that GA₃ (15 ppm) showed highest initial number of fruit set (179.00) and final number of fruit retained (18.25) compared to control (170.00) and (8.75) in ber cv. Banarasi Karaka.

Agusti *et al.*, (1990) reported that Kinetin 5 mg/ liter increased fruit set (24.56%) over control in the orange cultivar Navelate (*Citrus sinensis* (L.)).

Kachave and Bhosle (2007) reported that spraying of GA₃ at flower emergence stage during first week of January reduced the days required from flowering to fruit set (25.37) and longest duration recorded in control(35.75days) in Kagzi lime fruits.

2.3 Effect of growth regulators on crop maturity

Several researchers have reported that by the application of plant growth regulators, the number of days required for crop maturity can be reduced. The relationship between maturity and time to ripen and fruit quality is of great importance. Lesser the maturity longer is the time to ripen. Ripe fruits from early harvests have poor quality but with advanced maturity quality is improved.

Prasad (1990) reported that fruits from Phalsa bushes treated pre bloom and full bloom stage with GA₃ 50 ppm and NAA 25 ppm came to harvest (1.51days) and (2.83 days) earlier than control. Fruits from control bushes were available for longer time (53 days) whereas in treated bushes harvesting was over within 48 to 52 days.

Similarly, spraying of NAA (25 ppm) on panicles just before colour break stage advanced maturity 4.67 days over control and days taken to maturity after spray was recorded 11.33 days .Control recorded 16.04 days to maturity of litchi fruits (Sharma *et al.*, 1986). Siddique and chakrawar (1980) reported that maturity advanced 3.16 days over control in grapes.

Application of kinetin 250 ppm at the veraison stage delayed ripening by two days, whereas ethrel 500 ppm enhanced it by four days of Beauty Seedless grapes over

control (Panwar *et al.*, 1994). Brahmachari and Ruby Rani (2001) reported that spraying of Kinetin with 20 ppm and 40ppm at three different stages i.e. at panicle emergence, after completion of fruit set and on immature fruits just before colour break stage delayed ripening 4.83 days and 6.33 days respectively. Spraying of GA₃ 50 ppm and 100 ppm delayed ripening 2.17 days and 3.67 days respectively over control in litchi.

Mahajan and Sharma (1995) studied the effect of pre-harvest application of ethrel 500 ppm and 750 ppm at colour break stage advanced the ripening of fruits by 4 days and shortened the ripening period by 6 days over control of *L. chinensis* cv. Dehradun fruits.

Borah and Mohan (1993) conducted an trail at Assam Agricultural University with NAA (10 ppm, 25 ppm, 50 ppm) and ethrel 25 ppm and concluded that NAA 50 ppm spray at 34 functional leaves stage in pineapple required least number of days from flower emergence to maturity (136.71)and maximum number of days to maturity under control(177.32).

Ethrel plays a vital role in the ripening of fruits after maturity but time and concentration varies with the type and fruits and variety. Sharma *et al.*,(1986) reported that ethrel at 400 ppm sprayed on litchi panicles just before colour break stage advanced maturity 8.00 days over control and 8.00 days taken to maturity after spray and longer days recorded in control (16.00 days)

2. 4 Effect of growth regulators on number of fruits per plant

Thakur *et al.*, (1990) reported that spraying of GA₃ 50 sprayed before flowering and fruit bud development stage recorded maximum number of fruit per panicle (21.10) and (22.33) respectively in Purbi and Deshi cultivars of litchi and minimum number of fruits per panicle (14.57) and (15.58) was recorded in control respectively .

Application of NAA 25 ppm at full bloom stage recorded higher number of berries per bunch (118.1) and control recorded minimum number of berries per bunch (20.8) in grape (Mohammed and Hulmani, 2000).

Shinde *et al.*, (2008) reported that GA₃ 50 ppm sprayed at an interval of one month commencing the first at pea size of fruits on mringa bahar recorded maximum number of fruits per tree (985.40) and control recorded minimum number of fruits per tree (733.35).

Fruit number per tree (580.2) and (532.00) was increased by NAA 100 ppm and GA₃ 50 ppm respectively sprayed at pea stage of Sapota (kadam *et al.*, 2005). Chavan *et al.*, (2009) reported that NAA at 150 ppm sprayed one at the time of flowering and another two at pea stage and lag phase of fruit development recorded maximum number of fruits per shoot (54.00) and minimum (43.5) was recorded in control in Sapota.

Rema and Sharma (1993) reported that full bloom spray of ethrel at 240 ppm and 480 ppm twice at 7 days interval induced abscission but removed only 20.88 g per plant and 5.20 per cent of green fruits per plant by shaking in Phalsa.

Mohammad and Mohammad (1990) also reported that application of 50 or 100 ppm ethrel at full bloom or at the onset of pit hardening resulted in significant increases in fruit thinning of Muntakhab Al-Latifiya plum cultivar (*Prunus salicina* L.).

Hutton (1992) reported that A single, high volume spray of ethephon (as ethrel at 42-60 ml/100 l of water), applied in a heavy-set year at 6-8 weeks post-bloom when fruitlets diameter was 10-15 mm, induced a 15-20% reduction in fruit number in Late Valencia oranges and improved fruit size and marketable outturn with negligible yield penalty and internal fruit quality was unaffected.

Rooijen (1992) reported that Ethrel-A (ethephon) at 25 ml + Amid-thin [2-(1-naphthyl)acetamide] at 75 g/100 liters water applied post-bloom either to the older wood or to the whole tree, followed or not by 2 further sprays of ethrel alone after 10 days reduced fruit numbers/tree and yields/tree of Elstar apple trees.

Abdel-Hamid (1999) observed that ethrel at 100 or 200 ppm applied to Flordaprince peaches at the closed pink bud stage or at full bloom increased fruit abscission percentage and reduced number of fruits.

2. 4 Effect of growth regulators on fruit weight

Sprays of GA₃ (20 ppm) at pre bloom and full bloom stage increased the test weight while the sprays of Celemone (NAA) (0.5 and 2 ml) were ineffective in increasing the test weight of Phalsa (Reddy, 1977).

Rema and Sharma (1991) observed that two spray of Planofix(NAA) 150 ppm at full bloom stage produced higher fruit weight (60.06 g/100 fruit weight) by picking of fruits and control produced lower fruit weight (52.55 g/100) in Phalsa.

Rema and Sharma (1993) reported that spraying of ethrel at 960 and 1920 ppm before harvest reduced the fruit weight to 49.79 g and 46.98 g respectively and spraying of ethrel at 240 ppm and 480 ppm at full bloom stage also reduced the fruit weight 48.48 g and 49.91g respectively as compared to control (52.55g) in Phalsa fruit.

Desai *et al.*, (1993) reported that highest fruit weight (244.2 g) was obtained by hand removal of flowers plus application of 20 ppm GA₃ at the time of flowering and again at 45 and 90 days after fruit set in pomegranate cv. Ganesh. Venkatesan and Mohideen (1994) reported that NAA at lower concentrations (25 and 50 ppm) enhanced the fruit weight. Pawar *et al.*, (2005) observed that GA₃ 75 ppm recorded the maximum fruit weight (215.75 g) in pomegranate cv. Mridula.

The greatest increase in weight fruit (18.76g) was obtained with the application of 40 ppm GA₃ at pre bloom and after fruit set spray of litchi (Suryanarayana and Das, 1974). Spraying of 50 ppm GA₃ and 25 ppm NAA during panicle emergence, fruitset and before harvest increased fruit weight (16.98g and 18.00g) respectively and control recorded lower fruit weight(14.13g) of litchi (Sharma and Dhillon, 1984). In litchi the application of NAA 20 to 50 ppm twice, first at panicle emergence and second at the completion of fruit set enhanced fruit weight (17.39 to 18.78g) over control (Sarkar *et al.*, 1984).

Shafat and Shabana (1980) recorded increased fruit weight (16.3g and 16.9g) with 40 and 60 ppm NAA sprayed twice during khalal stage and 16 weeks after pollination (late chimri stage) in dates. Mohammed *et al.*, (1986) reported that the application of GA₃ 50, 100 and 150 ppm to date palm cultivars 'Zahdi' and 'Sayer' during the slow period of fruit development and 12-14 weeks after full bloom increased fruit weight than control and GA₃ 150 ppm gave the highest fruit weight (13.12g) in 'Zahdi' and (8.47g) in 'Sayer' cultivars.

In aonla, Syamal and Chhonkar (1984) reported increased fruit weight (10 fruit weight) (374.38g) and (379.69g) with GA₃ 50 ppm and Planofix 60 ppm respectively, sprayed at leaf fall, full bloom and fruit set (pea stage) and control recorded lower fruit weight (359.83g).

In ber cv. Banarasi, when NAA was tried at 10, 20 and 30 ppm during post bloom and fruitset stage, all the treatments showed increased fruit weight particularly NAA 10 ppm recorded highest fruit weight (17.35g) (Singh and Singh, 1976). In cultivar Sanaur-2, the average fruit weight (14.72g) was increased with 50 ppm NAA over control (Bal *et al.*, 1982).

Rajput and Singh (1982) conducted a trial by spraying twice 40 ppm Planofix and 20 ppm GA₃ in ber (cv. Banarasi Karaka) during fruitset and again 15 days thereafter recorded highest mean fruit weight (16.35g and 17.80 g) and lowest fruit weight in control (14.24 g). Pandey (1999) conducted experiment at Horticultural Gardens of Chandra Shekhar Azad University of Agriculture and Technology; Kanpur, India and

reported that the fruit weight was increased with the spray of 10 to 20 ppm NAA and 15 ppm GA₃ at pea stage in Ber cv. Banarasi Karaka. Highest fruit weight (15.20 g/fruit) with 10 ppm NAA and lowest was under control (10.10 g/fruit).

Kale *et al.*, (2000) reported that weight of the fruits was increased with different concentrations of GA₃ (10, 20 and 30 ppm) in all the eight ber cultivars and the highest increase in the fruit weight (18.24g/fruit) was recorded in case of 20 ppm GA₃.

Gibberellic acid 45 ppm applied at pin head stage appreciably increased bunch weight (154.4g) and berry weight (8.24g) of Perlette grapes (Patil *et al.*, 1980). (Brar *et al.*, 1980) at Punjab Agricultural University, Ludhiana, India reported that spraying of Kinetin above 100 ppm or in combination with GA₃ (50 and 100 ppm) or both at both the levels at the pre bloom and berry set stages markedly reduced the bunch weight (175.0g and 148.3g) respectively, whereas Kinetin at 50 and 100 ppm increased the bunch weight (276.7g) and (275.0g) over control (146.3g) of grape cv. Perlette.

GA₃ 25 ppm applied at the beginning of flowering and again 15 days later increased berry weight (7.56g) in Gulabi grapes (Thilak, 1983). Spraying of fruit clusters with GA₃ 75 ppm increased the berry weight in Thompson Seedless grapes (Al – Dujaili *et al.*, 1987). Varma (1991) observed that GA₃ applied at pre-bloom plus at bloom stage increased the average weight of bunches (210.34g) and individual berries.

Panwar *et al.*, (1994) trailed an experiment at Hissar and reported that spraying of ethrel 500 ppm and Kinetin 250 ppm at the veraison stage improved average bunch

weight (319.48g) and (319.17g) respectively over control (200.00g) and also improved 25 ripe berries fresh weight (29.97g) and (28.59g) over control (25.05g) in grape also reported that application of GA₃ 250 ppm at veraison stage increased the fresh weight of the berries (45.30g/25 berries) over the control (25.05g/25 berries) in Beauty seedless grapes.

Mohammed and Hulamani (2000) observed that NAA (25ppm) applied at full bloom stage produced highest bunch weight (182.1g) and kinetin (30 ppm) produced higher bunch weight (125.4 g) compared to control (34.6g).

Sarkar and Ghosh (2004) at Horticultural Research Station, Mondouri, Nadia, West Bengal, India spraying twice of GA₃ 30 mg/L during pea stage of fruit growth and marble stage of fruit growth recorded highest fruit weight (235.5g) and lowest fruit weight was recorded in control (191.00g) of mango cv.Amrapali. Koruna *et al*; (2007) reported that ethrel (200ppm) treatment recorded higher fruit weight (260.19g) and control recorded lower control (240.45g) in mango cv. Langra.

Dutta *et al.*,(2008) reported that NAA(20 ppm) and GA₃(20 ppm) sprayed once at pre-flowering and again at 30 days after fruit set increased the fruit weight(70.65g) and (67.45g) respectively over control(57.71g) in Carambola.

Shinde *et al.*, (2008) at Babulgaon, Akola, India recorded maximum weight of fruits per tree(42.72) over control(22.51) with two sprays at an interval one month

commencing the first at pea size of fruits on mringa bahar application of GA₃ 50 ppm of acid Lime.

2.5 Effect of growth regulators on yield

Increased yield (1.99 g and 2.35g) in Phalsa during pre bloom and full bloom spray of Celemone (NAA) (5 ppm) and GA₃ (20 ppm) was observed by Reddy (1977). Randhawa *et al.*, (1959) reported highest yields in Phalsa with full bloom spray of 40 ppm GA₃ treatment and stated that 40 ppm GA₃ sprays increased yield (19.8 %) over control. Though all the concentrations (10, 25 and 50 ppm) of GA₃ increased yield, the 25 and 50 ppm sprays were the most effective in this regard (Singh *et al.*, 1966). The average increase in yield of Phalsa sprayed with 25 ppm GA₃ was 30.33 per cent over control. Fruit yields were best (1.69 kg/bush) with GA₃ (60 ppm) in combination with 1000 ppm ethephon (ethrel) in Phalsa (*Grewia sub-inaequalis*) (Moti Singh *et al.*, 1986). Rema and Sharma (1993) observed that ethrel 240 ppm spray during full bloom stage reduces total yield per plant whereas ethrel 480 ppm and ethrel 480ppm + Planofix 153 ppm spray during full bloom stage increases total yield per plant in Phalsa.

Bhujbal and Chaudhari (1972) noticed that all the GA₃ treatments (60, 80 or 100 ppm) increased the yields in Thompson seedless grapes and reported that the higher concentration (100 pm) gave the maximum yield (47.26 t ha⁻¹) increased when applied at full bloom. GA₃ at 5-25 ppm reduced the number of berries per bunch in case of Italian Eliquine grapes (Sanghani and Phadnis. 1973). GA₃ at 10, 20 or 30 ppm sprayed 10 days

before full bloom or at full bloom reduced the number of berries per bunch in grapes cv. Moscatelon (Franzia and Spinola 1982).

Varma (1991) observed that GA₃ applied at pre-bloom plus at bloom stage increased the yield (49.12 t ha⁻¹) in Thompson seedless grapes. Kashyap *et al.*, (1992) obtained highest berry yield (144.76g/bunch) with application of GA₃ 20 ppm at flowering plus 75 ppm at fruit set in Thompson seedless grapes. Lakshmanana *et al.*, (1992) reported that berry yield was increased in different seedless cultivars of grape with the application of GA₃50 ppm.

Mohammed and Hulamani (2000) observed that NAA (25ppm) applied at full bloom stage was found to be the best which produced highest number of berries per bunch(134.8)and kinetin (30 ppm) produced higher number of berries per bunch (107.1) whereas control produced lowest number of berries (24.0)per bunch.

Venkatesan and Mohideen (1994) conducted an experiment with different growth regulators on pomegranate cv. Ganesh and reported that NAA 25 ppm recorded the highest number of fruits per tree. Pawar *et al.*, (2005) reported higher yield (17.61 kg/tree) with the spraying of GA₃ 75 ppm before fruit set in pomegranate than any other treatments.

Pandey (1999) reported that GA₃ (15 ppm) showed highest fruit yield (44.03 kg/tree) and lowest yield in control (16.38 kg/tree) of ber cv. Banarasi Karaka. Kale *et al.*, (2000) reported that yields of ber cv. Umran were increased by GA₃ 20 ppm over

control. Singh and Randhawa (2001) reported that highest yield (166 kg/tree) was recorded with NAA (60 ppm) of ber cv. Umran.

Rawash *et al.* (1998) observed that spraying of Taimour mango trees with NAA 40 ppm during flower bud differentiation stage increased number of fruits (554) per tree and yield (171.00 kg) per tree.

Spraying twice of GA₃ 30 mg/L during pea stage of fruit growth and marble stage of fruit growth found to increased in number of fruit/plant (169.99), fruit yield/plant (235.5 kg) and yield/ha (15.98 ton) at harvest and lowest number of fruit/plant (130.66), fruit yield/plant (24.95 kg) and yield/ha (9.98ton) in control of mango cv.Amrapali (Sarkar and Ghosh 2004).

Ruby and Brahmachari (2004) reported that GA₃ 100 ppm sprayed twice during first spray just after completion of fruitset and another fortnight before harvesting produced maximum yield (34.24kg/ plant) of mango(cv. Amrapali). Birendra Prasad *et al.*, (2006) studied on the effects of NAA (10, 20, 30, 40 or 50 ppm), GA₃ (50, 100, 150 or 200 ppm) on mango (cv. Amrapali) fruit. The highest fruit yield was obtained with 100 ppm GA₃ (9.5 kg per plant).

Sanyal *et al.*, (1996) reported that ethrel treatment at 1 ml/L recorded highest yield (88.9 kg/plant) in “on” year and in the “off” year, treatment with ethrel 1 ml/L and KNO₃ 10⁴ mg/L increased in yield in both the irregular bearing mango cvs.langra and Himsagar.

Koruna *et al.*; (2007) reported that ethrel (200 ppm) increased yield (190.19 kg) in mango cv. Langra and control recorded (154.91 kg).

Tripathi and Sukhla (2007) reported that aqueous solution of GA₃ at 100 ppm sprayed on strawberry plant before flower bud initiation stage recorded maximum yield per plant (112.95g) and control recorded (51.49 g).

Chavan *et al.*, (2009) reported that highest number of fruit (2633) per tree and yield per tree (215.51kg) was produced by NAA 150 ppm in Sapota.

2. 6 Effect of growth regulators on total soluble solids

Total soluble solids of Phalsa fruits increased (26.50 % and 27.04 %) with pre bloom and full bloom stage spray of Celemone NAA (20 ppm) and GA₃(100 ppm) and control recorded (25.00 %) (Reddy,1977). Moti Singh *et al.* (1986) also reported increased total soluble solids (24.3%) content in Phalsa with full bloom and pre harvest spray of 60 ppm GA₃ + ethephon 1000 ppm. Prasad (1990) reported that highest increase in the content of TSS (24.67%) was obtained in Phalsa, when the bushes were sprayed with GA₃ 100 ppm at pre bloom and full bloom stage. Singh *et al.*, (1986) observed that spraying of ethrel at 1000 ppm during pre harvest stage increased the total soluble solids content (26.54%) of Phalsa fruits. Singh *et al.*, (1996) observed that pre-harvest spraying of ethephon at 500 ppm increased the total soluble solids from 19 to 22 per cent in Phalsa. Rema and Sharma (1993) observed that spraying of ethrel 240 ppm and 500 ppm

during full bloom stage increased the total soluble solids 26.6 percent and 27.7 percent respectively and control recorded lowest TSS 24.2 percent in Phalsa fruit.

Mahajan and Sharma (1995) studied the effect of pre-harvest application of ethrel 500 ppm at colour break stage was the most effective on improving the TSS (19.8%) whereas lowest in control (17.0%) of *L. chinensis* cv. Dehradun.

Brahmachari and Ruby Rani (2001) reported that spraying of GA₃ 50 ppm at panicle emergence stage, after completion of fruitset and on immature fruits just before colour break stage of litchi increased TSS (19.20%) and lowest in control (18.00%). Khan *et al.* (1976) observed increased in total soluble solids content (17.16⁰ Brix) with application by NAA 40 ppm at fruitset and preharvest spray in litchi cv. Rose Scented. Sarkar *et al.*, 1984 reported highest TSS (18.74%) with the spraying of 40 ppm NAA in litchi.

GA₃ 75 ppm sprayed at fruitset recorded maximum TSS (16.50%) and minimum TSS (15.20%) was in control in pomegranate cv. Mridula (Pawar *et al.* 2005)

Singh and Singh (1980) obtained more total soluble solids in juice of delight grapes with 10 ppm GA₃ sprayed at flowering stage. TSS was higher (22.4%) in 60 ppm GA₃ while control fruits had lowest content (19.2%) sprayed after fruitset and maturity stage in citrus (Daulta, 1982). Panwar *et al.*, (1994) reported that spraying of ethrel 500 ppm and GA₃ 250 ppm at the veraison stage recorded higher TSS (16.23 % and 17.45%)

respectively and Kinetin 250 ppm spray recorded lower TSS (15.87%) of ripe berries of Beauty Seedless grapes.

Mohammed and Hulamani (2001) reported that spraying GA₃ at 50 ppm during full development of flower bud, 50 % bloom stage and full bloom stage recorded higher TSS (21.8⁰ Brix) and Kinetin 20 ppm and 30 ppm increased T.S.S (20.6⁰ and 20.9⁰ Brix) and least was in control (19.8⁰ Brix) of Arkavati grapes.

Pre-harvest spray of GA₃ 50 ppm recorded the highest TSS of 19.81°Brix while control fruits recorded 18.0°Brix on mango cv. Amrapali (Singh *et al.*, 1995). Khader (1991) reported lower TSS treated with 200 mg/litre of GA₃ at marble size stage followed by another spray 10 days later in mango cv. Dashehari.

Birendra Prasad *et al.*, (2006) reported that pre flowering spray of NAA at 20 ppm produced highest concentrations of TSS (22.5°Brix) and lowest TSS (16.5°Brix) recorded of mango (cv. Amrapali).

Koruna *et al.*, 2007 reported that ethrel 200 ppm sprayed after fruitset was more effective in increased TSS (21.97%) and least was in control (19.74%) of mango cv. Langra.

Spraying Washington Navel orange trees with 50 or 100 ppm GA₃ at full bloom increased the TSS content (11.42% and 11.77%) respectively (Deidda, 1971). GA₃ (100 or 500 ppm) applied to single branches during flowering had less effect on total soluble solids in Clementine mandarins (Cutuli, 1971).

Total soluble solids contents were affected in date palm cv. Zahdi with NAA 10, 20, 40 or 60 ppm and higher TSS (37.8%) was recorded with NAA 20 ppm (Shafaat and Shabana, 1980). However, TSS content (69.60°Brix and 69.80°Brix) of fruits with GA₃ 50 and 100 ppm sprayed during slow growth of fruit development and 12-14 weeks after full bloom and pollination was higher than the untreated fruits of cultivar 'Zahdi' of date palm (Mohammed *et al.*, 1986).

Higher TSS content (14.04 %) in guava was recorded by Islam and Siddique (1973) with application of 250 ppm GA₃. In Allahabad Safeda and Lucknow-49 TSS contents (12.56 % and 13.23%) were the higher with GA₃ 20 ppm treatment at pre harvest spray (Kumar and Hoda, 1974). GA₃ application to the newly set fruits of Allahabad Safeda at 200 ppm gave the highest total soluble solids (12.45 %) in the fruits at maturity (Ram, 1979). In seedless guava, GA₃ 250, 500 and 1000 ppm sprayed during flower bud stage and 10 days thereafter increased total soluble solids from 8.28 per cent in control to 10.76 per cent, 12.08 per cent and 11.36 per cent respectively (Phani Prasad, 1980).

Pandey (1999) reported that NAA 20 ppm sprayed at pea stage recorded maximum T.S.S (16.95 ° Brix) in fresh fruits of ber cv. Banarasi Karaka whereas; spray of GA₃ caused decrease in TSS content of the fresh fruits. Kale *et al.*, (2000) reported that GA₃ and NAA increased TSS content in Ber; however, the per cent increase was more under 20 ppm GA₃ (17.55%) than 20 ppm NAA (15.24%).

Singh *et al.*, (2002) reported that spraying of ethrel at 300 ppm two weeks before the anticipated harvest date increased fruit TSS (14.03°Brix) of 'Royal Delicious' apple and control recorded lowest TSS (12.80°Brix).

Katiyar *et al.*, (2008) observed the effect of pre-harvest application of 60 ppm NAA recorded the maximum TSS content (11.67 %) of guava cv. Sardar.

2.7 Effect of growth regulators on acidity of fruits

Rema and Sharma (1993) reported that the spraying of ethrel at 960 and 1920 ppm before harvest reduced the acidity to 2.29 (%) and 1.93 (%) respectively and spraying of ethrel 240 ppm and 480 ppm twice at full bloom stage increased the acidity 2.18(%) and 2.32(%) and control recorded higher acidity 2.24 (%) in Phalsa. .

The percentage of titrable acidity in litchi fruit pulp was influenced by 10, 20 and 40 ppm GA₃ treatments, the maximum decreased acidity (0.36%) by 40 ppm (Suryanarayana and Das, 1974). Khan *et al.* (1976) reported that NAA 40 ppm and GA₃ 50 ppm were most effective in reducing the acidity of the fruits in litchi cv. Rose scented.

Sarkar *et al.* (1984) recorded reduction in the acid content of litchi fruits; each increased concentration of NAA significantly reduced the titrable acidity over control. Lower acidity (0.34%) was recorded with NAA 30 ppm sprayed panicle emergence and completion of fruitset and higher acidity was recorded in control (0.49%). Sharma and Dhillon (1984) have reported in case of litchi fruits that titrable acidity was less than that of untreated fruits, in the fruits treated with GA₃.

Mahajan and Sharma (1995) studied the effect of pre-harvest application of ethrel 500 ppm at colour break stage lowered acidity (0.32%) over control (0.38%) of *L. chinensis* cv. Dehradun fruits. Brahmachari and Ruby Rani (2001) reported that GA₃ at 100 ppm spraying thrice during panicle emergence, after completion of fruitset and on colour break stage reduced acidity (0.58%) and spraying of Kinetin 20 ppm and 40 ppm reduced acidity (0.58%) and (0.60%) and control recorded higher acidity (0.61%) of litchi.

Pawar *et al.*, (2005) reported that the lowest acidity (0.35%) was recorded in NAA 30 ppm and highest acidity (0.44%) was recorded in control in pomegranate cv. Mridula.

GA₃ 10, 20 and 40 ppm sprayed during fruitset and pre harvest stage recorded increased in acidity over control (0.25%), the maximum (0.28%) recorded by GA₃ 10 ppm in Banganapalli (Suryanarayana and Das, 1970). Singh *et al.*, (1977) noticed minimum acidity (0.24%) at 200 ppm GA₃, sprayed at frequent intervals of one week on Banarasi Langra from mustard stage onwards. Khader *et al.*, (1988) reported that the maximum titrable acidity of 0.35 per cent was recorded in mango fruits treated with GA₃ 200 ppm while control fruits recorded 0.23 per cent.

Syamal and Chhonkar (1984) observed that, acidity percentage of aonla (cv. Banarasi) decreased over control with Planofix (20, 40 or 60 ppm) and GA₃ (40 or 50 ppm), sprayed at leaf fall, full bloom and fruit set (pea stage).

In seedless cultivar of guava, GA₃ (250-1000 ppm) sprayed during flower bud stage and 10 days thereafter reduced acidity from 0.84 per cent in control to 0.42 per cent (Phani Prasad, 1980).

Katiyar *et al.*, (2008) observed the effect of foliar application of 90 ppm GA₃ recorded lowest (0.45 %) acidity of guava cv. Sardar.

In ber cv. Sanaur-2, acidity decreased under all NAA treatments (10 to 50 ppm) but more decreased in acidity (0.29% and 0.27%) when lower doses of NAA (10 or 25 ppm) were used (Bal *et al.*, 1982). Panday (1999) reported that acid content in fresh ripe ber fruits 'Banarasi Karaka' fruits increased with application of both GA₃ and NAA. Kale *et al.* (2000) reported that minimum acid content (0.26% and 0.27%) was recorded with the higher concentration of GA₃ and NAA at 30 ppm.

Ghosh and Chattopadhyay (1994) reported that GA₃ (25 or 50 ppm) and NAA (15 or 30 ppm) did not affect acidity percentage of Nagpur santra. Saraswathi *et al.*, (2003) reported that spraying of GA₃ at 10, 15 and 20 ppm did not influence the acidity in mandarins. Ansari *et al.*, (2008) reported that GA₃ (10 or 20 ppm) and NAA (10 or 20 ppm) are ineffective in reducing acidity of the fruits in Nagpur mandarins.

The titrable acidity was decreased at all the concentrations of GA₃ (25, 50 and 75 ppm) over control in grapes (Sharma *et al.*, 1971). In the cultivar Gulabi, GA₃ 25 ppm applied at beginning of flowering and again 15 days later reduced berry acidity (0.69%)

(Thilak, 1983). Similarly, Ezzahonani *et al.*, (1985) obtained a decreased in acidity (0.87% and 0.073%) with bloom-sprayed vines at 5 and 20 ppm GA₃ in grape.

Panwar *et al.*, (1994) reported that spraying of ethrel 500 ppm and Kinetin 250 ppm at the veraison stage reduced acidity (0.79%) and (0.90%) and control increased acidity (1.02%) of the ripe berries of Beauty Seedless grapes. Mohammed and Hulamani (2001) reported less effect of NAA (25, 50, 75 ppm), GA₃ (25, 50, 75 ppm) and Kinetin (25, 50, 75 ppm) in decreasing acidity percentage in Arkavati grapes.

Warusavitharana *et al.* (2008) reported that GA₃ 25 ppm in combination with Brassinosteroid and Benzyladenine applied at 7 to 8 mm berry diameter stage was found better for reducing acidity (0.89%) and increasing TSS: acid ratio (10.02) in Thompson seedless grapes.

Baskran and Sathiamurty (2008) reported that spraying of ethrel (350 ppm) twice before flowering increases acidity (0.158%) over control (0.083%) in papaya.

2. 8 Effect of growth regulators on reducing sugar

Prasad *et al.*,(1990) reported that reducing sugars (18.72%) was higher at 50 ppm GA₃ sprayed during pre bloom and full bloom stage and control recorded lowest (18.12%)in Phalsa.

The content of the reducing sugar were higher at 50 and 100 ppm GA₃ treatments sprayed during slow growth of fruit development and 12-14 weeks after full bloom and pollination than in the control in cv. Zahdi of dates (Mohammed *et al.*, 1986)

Mahajan and Sharma (1995) studied the effect of pre-harvest application of ethrel 500 ppm at colour break stage improved the reducing sugar (13.5%). Control recorded least reducing sugar (10.8%) of *L. chinensis* cv. Dehradun fruits.

Mohammed and Hulamani (2001) reported that GA at 50 ppm sprayed during flower bud development, 50% bloom and full bloom stage recorded higher reducing sugars (15.03g %) in Arkavati grapes. Josan *et al.*, (2001) studied that trunk girdling along with brushing of bunches or in combination with GA₃ resulted in improved reducing sugars (17.05%) of grape cv. Perlette.

Birendra Prasad *et al.*, (2006) studied on the effects of NAA at 20 ppm recorded highest amount of reducing sugars of mango (cv. Amrapali) fruit.

2.9 Effect of growth regulators on pulp weight

Spraying of NAA (25 ppm) at full bloom and again 10 days later, give the highest weight of pulp (52.32 g) to fruit in Phalsa (Prasad and Bajpai, 1963).

Fruit pulp weight (76.55g) was highest in mango treated with NAA at 200 ppm applied prior to flower bud differentiation stage (Zora Singh and Dhillon, 1986).

Pulp per cent age of ber fruits was maximum with NAA (25 ppm) sprayed twice, firstly just after fruit set and again one month after first spray (Bal *et al.*, 1980).

The greatest increase in the edible pulp weight of litchi fruit (cv. Dehradun) was obtained with the application of 40 ppm GA₃ (Suryanarayana and Das, 1974, Khan *et al.*, 1976).

Singh and Singh (1981) recorded highest pulp percentage (75.3%) in Kaula mandarins with GA₃ at 15 ppm and lowest pulp percentage (55.45%) recorded in control.

Spraying Planofix (60 ppm) and GA₃ (50 ppm) thrice at leaf fall, full bloom and fruitset increased pulp weight (56.32g and 58.45g) respectively of aonla fruits (Syamal and Chhonkar, 1984).

Mohammed *et al.*, (1986) reported that the application of GA₃ 50, 100 and 150 ppm to date palm cultivars 'Zahdi' and 'Sayer' during the slow period of fruit development and 12-14 weeks after full bloom increased pulp weight than control and GA₃ 150 ppm gave the highest pulp weight(6.89g) in 'Zahdi' and(4.35g) in 'Sayer'cultivars.

Maximum pulp per cent age (79.44%) was recorded with GA₃ 100 ppm sprayed thrice during panicle emergence stage, after completion of fruit set and on immature fruits in litchi and lowest was recorded in control(56.12%)(Brahmachari and Ruby Rani,2001)

Ruby Rani and Brahmachari, 2004 reported that spraying of GA₃ 100 ppm during fruit set and fortnight before harvesting produced maximum pulp weight (178.21 g) and control recorded least fruit weight (126.84g) in Amrapali mango.

2.10 Effect of growth regulators on seed weight

Reddy (1977) observed reducing seed content in Phalsa fruits with concentration reduction (20, 10, and 5 ppm) of Celemone(NAA) and increase in concentration (10, 15 and 20 ppm) of GA₃. Among these pre bloom and full bloom spray of Celemone 5 ppm and GA₃ 20 ppm both recorded least seed content(13.50 %) and control recorded seed content 15.40 %. GA₃ applied at 1000 ppm and 2000 ppm was effective in producing parthenocarpic fruits (45.3 % and 38.6 %) at bud stage and at flowering stage, the production of seedlessness fruits went upto 38.6% and 45.3% respectively in Phalsa (Rao and Rao, 1963).

The percentage of seed low in litchi fruits treated with NAA and GA₃ and it recorded minimum values (11.24 % and 16.43%) respectively with 25 ppm NAA and 50 ppm GA₃(Sharma and Dhillon,1984).

Stone weight of ber decreased in all the NAA treatments (10, 25 and 50 ppm) sprayed twice, firstly just after fruit set and again one month after first spray (Bal *et al.*, 1980).

Gibberellic acid at 10-40 ppm applied thrice at fortnightly intervals starting from 14 days before full bloom reduced the number of seeds in 'pant Lemon-1'. Among these Gibberellic acid 40 ppm recorded 35.16 % reduction in seed number over control (Babu and Lavania, 1985).

Appreciable number of seedless berries was induced in Anab-e- shahi, Bokri, Alamwick and Gross Colman (Pusa) varieties of grape following pre bloom GA₃ application (Dass and Randhawa, 1970).Yadav *et al.*, (1977) reported that a combination of 50 ppm GA₃at full bloom and 25 ppm at fruit set may be applied for producing seedless grapes from cultivar ‘Hur’. Post bloom application of 100 ppm GA₃ resulted in parthenocarpic fruit development in Picolit grapes (Scienza *et al.*, 1979).

Ruby Rani and Brahmachari, 2004 reported that spraying of GA₃ 100 ppm during fruit set and fortnight before harvesting produced minimum stone weight (33.64 g) in Amrapali mango and maximum recorded in control (41.45g).

2.11 Effect of growth regulators on shelf life

Rao *et al.*,(1996) evaluated the effects of pre-harvest applications of kinetin (10 or 15 ppm) on shelf life of sweet orange cv. Sathgudi. Kinetin at 15 ppm application reduces the weight loss and also resulted in the highest percentage of sound fruits even after 18 days of storage and extended the shelf life.

Sudhavani and Ravi Sankar (1998) observed that pre harvest spray of GA₃ (15 ppm) + Carbendazim (0.05%) recorded delayed ripening 22.33 days and longer shelf life (29.67 days) after harvest. Control recorded shorter shelf life (16.00 days) of Baneshan mango fruits.

Mohammed and Hulamani (2001) in Karnataka, India studied the effects of NAA at 25, 50 and 75 ppm; gibberellic acid at 25, 50 and 75 ppm; kinetin at 10, 20 and 30 ppm

sprayed three stage viz., inflorescence axis elongated stage and full development of flower buds, 50 per cent bloom stage and full bloom stage on grapes cv. Arkavati. Lower physiological weight loss (7.1 %) was observed with Kinetin 30 ppm treated bunches and highest shelf life (10.5 days) was observed with Kinetin 30 ppm treated bunches of Arkavati grapes. Higher physiological weight loss (13.5 %) and shelf life (6.3 days) was recorded in control.

Suriender *et al.*, (2004) reported that aqueous solution of kinetin 50 ppm at berry set stage extended the shelf life (2.67 days) of the fruit bunches and reduced the physiological weight loss in the berries of grapes.

Brahmachari and Ruby Rani (2005) studied the effects of pre-harvest sprays of NAA (25 and 50 ppm), GA₃ (50 and 100 ppm), kinetin (20 and 40 ppm) on the storage life of guava cv. Sardar. All the growth substances sprayed significantly prolonged the storage life and improved the quality of fruits.

Katiyar *et al.*, (2008) in Kanpur, Uttar Pradesh, India observed the effect of foliar application of plant growth regulators, GA₃ (30, 60, 90, 120 ppm), and NAA (20, 40, 60, 80 ppm) on the postharvest life of guava fruits. Foliar sprays of 90 ppm GA₃ applied 30 days prior to harvest was recorded higher shelf life (4.56 days) over control..

Chapter III

Materials and Methods

CHAPTER – III

MATERIALS AND METHODS

The materials and methods adopted during the course of the present investigation are briefly described in this chapter. This experiment was carried out during 2009-2010 in the college of Horticulture, Rajendranagar, Hyderabad. The details are presented under the following heads.

3.1 EXPERIMENTAL SITE

The present experiment entitled, **“Effect of growth regulators on flowering, fruitset, yield and quality in Phalsa (*Grewia sub-inaequalis* DC)”** was undertaken from November 2009 to April 2010 at Model Orchard, College of Horticulture, Rajendranagar, Hyderabad. The orchard is situated at an altitude is 534 m above mean sea level. Its geographical location is 77°55' East longitude and 18°59' North latitude.

3.2 CLIMATIC CONDITIONS

Rajendranagar, Hyderabad falls in the belt of semi-arid tropical climate. Meteorological data pertaining to rainfall, average minimum and maximum temperatures, humidity percentage and hours of sunshine recorded during the period of experimentation are presented in Appendix-I. During the period of experimentation the total rainfall received was 20.2 mm. The weekly mean maximum and minimum temperatures ranged from 27.7° to 38.3°C and 11.8° to 22.1°C respectively. The relative humidity at 7.14

hours and 14.14 hours ranged from 65.9 to 88 per cent and 28.6 to 74 per cent respectively. The weekly mean sunshine hours ranged from 4.4 to 9.1 hours.

3.3 SOIL

The soil of the experimental site was subjected to physical and chemical analysis. Soil samples were drawn at different places in the experimental orchard and were pooled and analyzed with the procedure suggested by Piper (1950) and Jackson (1967).

Table 1: Physico-chemical properties of soil

| S.No. | Properties of soil | Percentage/Value |
|-------|---|------------------|
| 1. | Mechanical composition (%) | |
| | a. Course sand | 55.5 |
| | b. Fine sand | 12.8 |
| | c. Silt | 18.2 |
| | d. Clay | 12.3 |
| | Textural class | Sandy loam |
| 2. | Chemical composition | |
| | Chemical analysis | Value |
| | a. Soil pH | 7.2 |
| | b. Electrical conductivity dsm^{-1} | 0.31 |
| | c. Organic Carbon (%) | 0.93 |
| | d. Available nitrogen (kg N ha^{-1}) | 306.2 |
| | e. Available phosphorus ($\text{kg P}_2\text{O}_5 \text{ ha}^{-1}$) | 16.64 |
| | f. Available potassium ($\text{kg K}_2\text{O ha}^{-1}$) | 319.0 |

The analysis of soil sample given in Table 1 indicated that the soil was red sandy loam, medium in available nitrogen, low in phosphorus and high in potassium.

3.4 DETAILS OF THE ORCHARD

The Phalsa (*Grewia sub-inaequalis* DC) bushes were planted in the year 1984 at a spacing of 2x2 m. The bushes were vigorous, healthy and bearing regularly.

3.5 EXPERIMENTAL DETAILS

3.5.1 Details of the treatments

The treatments consisted of spraying of four growth regulators *viz.* NAA, GA₃, Kinetin and Ethrel each at two different concentrations and a control (water spray).

The details of the treatments are given below:

T₁ – Naphthalene Acetic Acid (25 ppm)

T₂ – Naphthalene Acetic Acid (50 ppm)

T₃ – Gibberellic Acid (50 ppm)

T₄ - Gibberellic Acid (100ppm)

T₅ – Kinetin (15 ppm)

T₆ – Kinetin (30 ppm)

T₇ – Ethrel (250 ppm)

T₈ – Ethrel (500 ppm)

T₉- Control (water spray)

3.5.2 Design of the experiment

The experiment was laid out in a Randomized Block Design with different concentrations of growth regulators as 9 treatments replicated thrice. Two plants were sprayed in each treatment. The field plan and layout is given in Fig.1.

3.5.3 Preparation of spray solutions

Stock solution of NAA, Kinetin and GA₃ were prepared by dissolving one gram of these chemicals separately in 95 per cent alcohol and then made up to one liter by adding distilled water. The required concentrations of NAA, Kinetin and GA₃ solutions were obtained by diluting stock solution with water of required quantity. The solutions thus prepared were immediately used for spraying on the trees.

Solution of ethrel 250 ppm and 500 ppm concentration were prepared by dissolving 0.25 ml and 0.5 ml per liter of distilled water respectively. The plants were sprayed with Knapsack sprayer after diluting the solutions with calculated amount of water.

3.5.4 Imposition of treatments

Spraying on both flowers and foliage was done with growth regulators by knapsack sprayer at the time of pre bloom and another post bloom stage. Care was taken to avoid drifting of the spray solutions.

3.6 DETAILS OF FIELD OPERATIONS

3.6.1 Pruning

All the bushes were uniformly pruned to sixty (60 cm) height above the ground level to remove the last season's growth, disease and pest infected branches and dried branches on 26th November 2009 for fruiting purpose.

3.6.2 Manures and fertilizers

Recommended dose of fertilizers were applied per each tree. Fertilizers were applied at the rate of 100 kg N: 40 kg P₂O₅ : 25 kg K₂O per hectare (as per the recommendation of Pandir and Pathak, 1981). The N, P and K were applied in the form of urea, single super phosphate and murate of potash respectively. Nitrogen was applied in two split doses, one at the time of the first irrigation and the second after one month of the first application whereas, full dose of phosphorus and potash were applied once along with the first dose of nitrogen. The fertilizers along with FYM (2 baskets per bush), Groundnut cake (0.5 kg/bush) and Neem cake (0.5 kg/bush) were incorporated into the soil in the basins around the bush immediately after pruning and irrigated.

3.6.3 Irrigation

The first irrigation was given immediately after pruning and fertilizer application; later on the irrigations were given at 7-10 days interval depending on the soil moisture status. The field was maintained weed free throughout the period of experimentation.

3.6.4 Harvesting

The fruits were harvested with the attainment of maturity which was judged by dark purple colour of the fruits. The fruits of each bush were harvested two to three days starting from the commencement of the first picking till the final picking.

3.7 OBSERVATIONS RECORDED

3.7.1 Physical parameters

Five shoots were selected at random in each bush and tagged for recording following parameters

3.7.1.1 Number of flowers per shoot

The total number of flowers was counted after treatment on each shoot. The average was worked out.

3.7.1.2. Days to 50 percent flowering

Days taken from the pruning date to the 50 percent flowering shoots per bush was recorded for each treatment.

3.7.1.3 Fruit set

The total number of flower bud was counted on each shoot. The fruit set was calculated by dividing the total number of fruits by the total number of flowers and expressed as percentage.

3.7.1.4 Flowering to fruitset (days)

Days taken from 50 percent flowering shoots to the 50 percent fruitset shoots per bush was recorded for each treatment.

3.7.1.5 Number of fruits per node

Numbers of fruits per node were counted on five randomly selected shoots of each bush. The average was worked out.

3.7.1.6 Number of fruits per shoot

Numbers of fruits per shoot were counted on five randomly selected shoots of each bush. The average was worked out.

3.7.1.7 Number of fruits per plant

The total number of fruits per plant were recorded in hundreds, after each picking and added up.

3.7.1.8 Days to first picking

Days taken from the date of pruning to the appearance of the first ripe fruit on the bush was recorded as days taken for first picking.

3.7.1.9 Fruiting duration (days)

Days taken from the date of first picking to the final harvesting was recorded for each treatment as fruiting duration.

3.7.1.10 Crop duration (days)

Days taken from the date of pruning to the final harvesting was recorded for each treatment as crop duration

3.7.1.11 Fruit weight (g)

The weight of the fruits was recorded in grams taking a random sample of 100 fruits from the harvest of each treated bush. The data was recorded at the time of picking using a top pan balance and the average was worked out.

3.7.1.12 Yield per plant (kg)

Fresh weight of the total fruits collected after each picking were recorded in grams separately for each bush using a YAMATO balance. The mean plant yield per treatment was calculated in terms of cumulative weight of fruits in kgs from all pickings of the two bushes of that treatment

3.7.1.13 Yield per hectare (t ha⁻¹)

Yield per hectare was estimated by multiplying the yield per tree with the number of trees accommodated in a hectare and was expressed in tonnes per hectare.

3.7.2 Qualitative parameters

3.7.2.1 Total soluble solids (%)

Determined by squeezing the juice on hand refractometer at room temperature and expressed as per cent TSS (Ranganna, 1986). Mean was worked out.

3.7.2.2 Titrable acidity (%)

It was estimated by the method of Ranganna (1986). A known volume of clear filtered fruit juice was taken in a hundred ml beaker and two drops of phenolphthalein indicator was added. It was titrated against 0.1 N NaOH with continuous stirring during titration. The end point was indicated when the colour changed from red to fair pink. The acidity was expressed in percent of citric acid and it was calculated by using the following formula:

$$\text{Titration acidity (TA) (Milli equivalent/100g)} = \frac{\text{Titer value (ml)} \times 0.1 \text{ N NaOH} \times 100}{\text{Sample volume (ml)}}$$

3.7.2.3 Reducing sugars (%)

The reducing sugars were estimated by Fehling's method using methylene blue as indicator and expressed in terms of percentage (A.O.A.C. 1980).

3.7.2.4 TSS: Acid ratio

TSS: Acid ratio was calculated by dividing TSS value with the acid value.

3.7.2.5 Pulp weight

The pulp content of 100 fruits, taken at random from each treatment at harvest is weighted (excluding stone material and fiber) on a top pan balance and the mean weight was worked out for all treatments and recorded in grams.

3.7.2.6 Stone weight

The separated stones, under each treatment, from a harvested random sample of 100 fruits were screened and weighted and recorded in grams after each picking. Average was worked out.

3.7.2.7 Pulp to stone ratio

Pulp to stone ratio was arrived by dividing the pulp weight by stone weight of each treatment respectively.

3.7.2.8 Shelf life

Studies on shelf life was made by taking the freshly harvested fruits in a polyethylene bag to which aeration was provided by making small holes. The spoiled fruits were removed at six hours interval.

The fruits which considered as spoiled are:

1. The fruits which become very soft with some liquid oozing out of stalk end of the fruit.
2. Fungus affected fruits.
3. Over shriveled fruits.

When sixty percent of fruits got spoiled, it was considered as the end of shelf life and the time (hrs) was recorded treatment wise.

3.8 Statistical Analysis

The data were analyzed using a computer software programme by the method of variance outlined by Panse and Sukhatme (1978). Statistical significance was tested by F value at 5% probability. Critical difference at 0.05% level was worked out for the effects which were significant. The results have been depicted graphically where ever necessary.

Chapter IV

Results

CHAPTER - IV

RESULTS

The results of the present investigation entitled, “**Effect of growth regulators on flowering, fruitset, yield and quality in Phalsa (*Grewia sub-inaequalis* DC)**” conducted during November 2009 to March 2010 are presented here under.

4.1 Number of flowers per shoot

The data recorded on the effect of different growth regulators on the number of flowers per shoot are presented in Table 2 and are shown graphically in Fig 2. The mean number of flowers per shoot ranges from 394.26 to 332.34.

NAA 25 ppm recorded significantly higher number of flowers per shoot (394.26) over rest of the treatments. Lowest number of flowers per shoot (332.34) was recorded with control. GA₃ at 50 ppm was next best to record the number of flowers per shoot (382.39).

Number of flowers per shoot also significantly increased with GA₃ 100 ppm (370.73). NAA 50 ppm (362.31) and ethrel 250 ppm (360.53) were on par and significantly superior to ethrel 500 ppm (354.97) which in turn on par with kinetin 30 ppm (353.33). Kinetin 15 ppm (347.15) recorded lowest number of flowers per shoot (347.15) among the treatments but significantly superior than the control.

Naphthalene acetic acid at 25 ppm treatment was significantly superior to NAA at 50 ppm and other treatments. GA₃ at 50 ppm was superior to GA₃ 100 ppm and ethrel at 250 ppm was superior to ethrel 500 ppm but kinetin at 30 ppm was superior to kinetin 15 ppm.

The overall view of entire data indicated that number of flowers per shoot of Phalsa was enhanced by NAA followed by GA₃, ethrel, kinetin over control. Among the treatments 25 ppm NAA proved to be best for increasing number of flowers per shoot of Phalsa.

4.2 Days to 50 per cent flowering

The data on the mean number of days taken to 50 per cent flowering shoots are presented in Table 2 and are shown graphically in Fig 3. The mean number of days taken to 50 per cent flowering shoots ranges from 51.17 to 60.33.

A significant difference in days to 50 per cent flowering shoots was recorded in all the treatments. The lowest number of days to 50 per cent flowering shoots was recorded with NAA 25 ppm (51.17) which were on par with GA₃ at 50 ppm (53.33) and highest of 60.33 days was observed in control. NAA 50 ppm (54.33 days), GA₃ at 100 ppm (55.83 days) and ethrel 500 ppm (56.33 days) were on par with each other. Kinetin 15 ppm, kinetin 30 ppm, ethrel 250 ppm and ethrel 500 ppm were on par with each other but significantly superior than control.

It is evident from the data that the growth regulators exerted significant positive influence on the number of days taken to 50 per cent flowering shoots. NAA and GA₃ at lower concentrations compared to higher concentrations induced early flowering in Phalsa.

4.3 Fruit set (%)

The data recorded on the effect of growth regulators on the percentage of fruit set are presented in Table 3 and are shown graphically in Fig.4. The fruit set ranged from 23.32 per cent to 71.02 per cent.

Highest fruit set (71.02 %) was obtained with NAA at 25 ppm followed by GA₃ at 50 ppm (69.57%) which was on par with each other. GA₃ 100 ppm recorded fruit set (63.17%) which was on par with NAA 50 ppm (62.64%). Kinetin 30 ppm and kinetin 15 ppm produced fruit set (56.50%) and (57.72%) respectively which in term on par with each other. Minimum fruit set 23.32 per cent in ethrel 500 ppm followed by ethrel 250 ppm (27.71 %). Control recorded fruit set was (50.29).

Naphthalene acetic acid at 25 ppm followed by GA₃ 50 ppm treatment was significantly superior to NAA at 50 ppm and GA₃ 100 ppm. Kinetin 15 ppm and 30 ppm which were on par with each other significantly improved fruit set over control. Control was significant than both the ethrel concentrations.

Thus, it was observed that the lower concentrations of the two growth regulators (NAA and GA₃) and kinetin at higher concentration were more effective in improving fruit set.

An overall view of the entire data indicated that fruit set in Phalsa was enhanced by NAA treatments followed by GA₃ followed by kinetin over control. Among the NAA treatments, 25 ppm proved to be the best for improving fruit set.

4.4 Days taken for Flowering to fruit set

The data on the mean number of days taken for flowering to fruitset are presented in Table 3 and are shown graphically in Fig.5. The mean number of days taken for flowering to fruit set ranges from 14.00 to 21.67.

Bushes treated with NAA 25 ppm recorded less number of days to flowering to fruit set (14.00) followed by GA₃ at 50 ppm (14.33) were on par and while control recorded more number of days (21.67). NAA 50 ppm (16.00 days), GA₃ at 100 ppm (16.17 days) were on par but significantly superior than kinetin 15 ppm, kinetin 30 ppm which in term on par with each other. Ethrel 250 ppm and ethrel 500 ppm were on par with control.

It is evident from the data that the growth regulators exerted significant positive influence on the number of days taken to flowering to fruit set shoots.

NAA, GA₃ at lower concentrations and kinetin higher concentration recorded less days to flowering to fruit set compared to higher concentrations except kinetin on Phalsa.

4.5 Number of fruits per node

Mean number of fruits produced per node varied significantly with different growth regulator treatments (Table 4 and are shown graphically in Fig.6) and ranged from 7.45 to 25.29.

Bushes treated with NAA at 25 ppm recorded significantly maximum number of fruits (25.29) per node followed by GA₃ at 50 ppm (24.53) while minimum number of fruits per node (7.45) recorded in ethrel 500 ppm. GA₃ 100 ppm recorded significantly more number of fruits (23.50) per node over NAA 50 ppm (20.78). Both the kinetin treatments 15 ppm and 30 ppm increased number of fruits per node (18.10) and (18.26) respectively were on par with each other but significantly superior over ethrel 250 ppm (9.27).

In general all the treatments resulted in more number of fruits per node as compared to control except ethrel.

A perusal of the data indicated a clear trend that lowers concentrations of NAA, GA₃ and higher concentration kinetin being more effective in increasing number of fruits per node in Phalsa.

4.6 Number of fruits per shoot

Mean number of fruits produced per shoot varied significantly with different growth regulator treatments (Table 4 and are shown graphically in Fig.7) and ranged from 81.96 to 279.93.

Bushes treated with NAA at 25 ppm recorded significantly maximum number of fruits (279.93) while minimum number of fruits per shoot (81.96) recorded in ethrel 500 ppm. However, GA₃ at 50 ppm (264.28) differed significantly from other treatments. GA₃ 100 ppm recorded significantly more number of fruits (260.20) per shoot than NAA 50 ppm (227.21), kinetin 30 ppm (203.12) and kinetin 15 ppm (196.24). On the other hand, ethrel 250 ppm recorded less number of fruits per shoot was significant over control.

In general all the treatments resulted in more number of fruits per node as compared to control except ethrel.

A perusal of the data indicated a clear trend that lowers concentrations of NAA, GA₃ and higher concentration kinetin being more effective in increasing number of fruits per shoot in Phalsa.

4.7 Number of fruits per plant (in hundreds)

Mean number of fruits produced per plant varied significantly with different growth regulator treatments (Table 5 and are shown graphically in Fig.8) and ranged from 11.52 to 50.62.

NAA at 25 ppm recorded significantly maximum number of fruits (50.62) per plant than other treatments and minimum number of fruits per plant (11.52) was recorded in the ethrel 500 ppm. GA₃ at 50 ppm recorded 49.64 numbers of fruits plant was superior to GA₃ 100 ppm (49.43) and NAA 50 ppm (46.48). Both the kinetin treatments 15 ppm and 30 ppm increased number of fruits (40.41) and (40.83) per plant were significant over

control. On the other hand, ethrel 250 ppm recorded less number of fruits per plant (13.77) was significant over control. In general all the treatments resulted in more number of fruits per plant as compared to control except ethrel.

A perusal of the data indicated a clear trend that lowers concentrations of NAA, GA₃ and higher concentration kinetin being more effective in increasing number of fruits per plant in Phalsa.

4.8 Days to first picking

The data on the mean number of days taken for first picking as influenced by growth regulators are presented in Table 5 and are shown graphically in Fig.9. The number of days taken to first picking ranged from 96.00 to 101.67.

Bushes treated with GA₃ 50 ppm recorded significantly less number of days (96.00) compared to all the treatments and plants under control recorded more number of days to first picking (101.67). NAA 25 ppm recorded 97.17days to first picking was on par with NAA at 50 ppm (97.33 days). Ethrel 500 ppm (98.33days) was) on par with GA₃ at 100 ppm (98.50days) and ethrel 250 ppm (98.50 days) and superior over control. Kinetin 30 ppm (99.67 days) and kinetin 15 ppm (100.50 days) were on par received less number of days for first picking compared to control.

It is evident from the data that the growth regulators exerted significant positive influence on the number of days taken for first picking.

NAA and GA₃ at lower concentrations and kinetin and ethrel at higher concentrations induced early ripening and pickings compared to higher concentrations in Phalsa.

4.9 Fruiting duration

The data on the mean fruiting duration as influenced by growth regulators are presented in Table 6 and are shown graphically in Fig.10.

Bushes sprayed with GA₃ 50 ppm recorded least fruiting duration (18.17 days) which was on par with NAA 25 ppm (18.50 days) while control recorded more fruiting duration (23.17days) followed by Kinetin 30 ppm (22.00 days) which was on par with Kinetin 15 ppm (21.67 days). Ethrel 500 ppm (19.67 days) and ethrel 250 ppm (20 days) are on par and superior to NAA 50 ppm and GA₃ 100 ppm which were in turn on par with each other recorded fruiting duration (20.83days).

Both NAA and GA₃ at lower concentrations than their respective higher concentration and kinetin and ethrel at higher concentration were more effective in reducing fruiting duration.

4.10 Crop duration

The data on the mean Crop duration as influenced by growth regulators are presented in Table 6 and are shown graphically in Fig.11.

Bushes sprayed with GA₃ 50 ppm recorded less crop duration (115.17days) which was on par with NAA 25 ppm (116.67days).The control bushes recorded more crop duration (124.83days). Crop duration recorded in NAA 50 ppm (117.67days), ethrel 500 ppm (118.00 days), ethrel 250 ppm (118.50 days) and GA₃ 100 ppm (119.33) which were on par with each other but superior than control and was recorded in both and are on par but significantly superior than kinetin 30 ppm (122.50 days), Kinetin 15 ppm (121.33days).

Both NAA and GA₃ at lower concentrations than their respective higher concentration and kinetin and ethrel at higher concentration were more effective in reducing fruiting duration.

4.11 100 Fruit weight (g)

It is seen from the data presented in Table 7 and are shown graphically in Fig.12 that the fruit weight ranged from 54.12g to 60.55g.

Phalsa responded to different treatments and recorded maximum 100 fruit weight (61.48g) sprayed with GA₃ at 100 ppm followed by GA₃ at 50 ppm (59.33g) and minimum was recorded with NAA at 50 ppm (55.12g) which was on par with NAA at 25 ppm (55.51g). Fruits in control recorded a weight of (57.14g) and ethrel 250 ppm (57.08g) both which were on par. Fruit weight recorded (57.89g) with kinetin 15 ppm and (58.03g) kinetin 30 ppm which was on par, among ethrel treatments 250 ppm recorded higher fruit weight (57.08g) than 500 ppm concentration (56.40g).

Both the concentrations of GA₃ were superior to other treatments. Among NAA treatments 25 ppm recorded higher fruit weight than 50 ppm concentration. Kinetin both the treatments were superior to NAA and ethrel treatments.

Thus it is clear that only GA₃ was effective in enhancing the weight of the fruits more so at higher concentration where as NAA and ethrel failed to do so.

4.12 Yield per plant (Kg)

Data on yield per plant presented in Table 8 and are shown graphically in Fig.13 clearly show significant differences between growth regulators with respect to yield. The yield per plant varied from 0.645 kg to 3.04 kg.

Bushes treated with GA₃ at 100 ppm produced significantly more yield (3.05 kg) than other treatments and control. Less yield was recorded with ethrel 500 ppm 0.645 kg followed by ethrel 250 ppm (0.784 kg). Yield recorded with NAA 25 ppm (2.76 kg) was on par with GA₃ at 50 ppm (2.88kg) but significantly superior over kinetin 15 ppm (2.34kg) and Kinetin 30 ppm (2.38kg) which in turn on par with each other. However, NAA 50 ppm recorded significantly superior yield (2.56 kg) over control.

Concentration of growth regulators differ significantly in improving fruit yield over control except ethrel. Significant differences were observed among the growth regulators with respect to mean yield.

GA₃ at both the levels was highly effective in increasing the yield per plant over other treatments. Bushes treated with Kinetin 15 ppm and Kinetin 30 ppm produced yield (2.34kg) and (2.38kg) which was on par but superior over control.

4.13 Yield per hectare (t ha⁻¹)

Data on yield per hectare presented in Table 8 and are shown graphically in Fig.14 clearly show significant differences between growth regulators with respect to yield per hectare. The yield per hectare varied from 1.60 tonnes to 7.63 tonnes.

Bushes treated with GA₃ at 100 ppm produced significantly more yield (7.63 t ha⁻¹) followed by GA₃ at 50 ppm (7.25 t ha⁻¹) than control and other treatments. Yield was least (1.60 t ha⁻¹) in ethrel 500 ppm followed by ethrel 250 ppm (1.95 t ha⁻¹).

However, NAA at 25 ppm and 50 ppm recorded significantly superior yield (6.89 t ha⁻¹) and (6.40 t ha⁻¹) over control. Bushes treated with Kinetin 15 ppm and Kinetin 30 ppm produced yield per hectare (5.85 t ha⁻¹) and (5.95 t ha⁻¹) which was on par.

Concentration of growth regulators differ significantly in improving fruit yield except ethrel concentrations. Significant differences were observed among the growth regulators with respect to mean yield per hectare. GA₃ at both the levels was highly effective in increasing the yield per hectare over other treatments.

4.14 Total soluble solids (%)

Significant difference in TSS of Phalsa fruits were noticed due to the application of the growth regulators is presented in Table 9 and is shown graphically in Fig.15. The TSS varied from 19.80 per cent to 25.72 per cent.

Maximum TSS (25.72 %) was recorded with ethrel 500 ppm followed by ethrel 250 ppm (25.10%) and minimum was recorded in control (19.80%). Gibberellic acid at 100 ppm recorded TSS (24.83%) followed by GA₃ at 50 ppm (24.31%) was superior NAA 25 ppm (23.05 %), NAA 50 ppm (21.68%), kinetin 30 ppm (21.04%) and Kinetin 15 ppm (20.56%). NAA 25 ppm and kinetin 30 ppm were superior over NAA 50 ppm and kinetin 15 ppm respectively.

In general it was found that ethrel, kinetin and Gibberellic acid treatment at higher concentration and NAA at lower concentration was more effective in improving TSS of Phalsa.

4.15 Titratable acidity (%)

From the data recorded on the titratable acidity of Phalsa fruits are presented in Table 9 and are shown graphically in Fig.16. It was observed that the acidity ranged from 2.55 per cent to 2.26 per cent with GA₃ 100 ppm while other treatments recorded intermediate values.

Highest GA₃ treatment at 100 ppm was more effective in reducing acidity (2.26%) when compared to control (2.55%). Lower acidity (2.34%) was recorded with ethrel 250

ppm which was on par with higher concentration ethrel 500 ppm (2.40%). Other treatment recorded TSS, NAA 50 ppm (2.44%), NAA 25 ppm (2.45%), Kinetin 30 ppm (2.46%) and Kinetin 15 ppm (2.48%) which were on par and superior over control.

In general it was observed that acidity of Phalsa fruits was less influence by growth regulators and only negligible decreases were observed at lower concentrations. The acidity was decreased in all the cases as compared to control. It was noted that GA₃ at higher concentrations and ethrel at lower concentrations reduced acidity in fruits significantly.

4.16 Reducing sugars (%)

The data on reducing sugar per cent of Phalsa fruits with different concentrations of growth regulators are presented in Table 10 and are shown graphically in Fig.17. The reducing sugars content ranged from 18.25 per cent to 18.91 per cent.

Maximum content of reducing sugars (18.91 %) was observed with GA₃ at 100 ppm followed by ethrel 500 ppm (18.79 %). GA₃ 50 ppm recorded (18.71 %) which was on par with ethrel 250 ppm (18.67 %) but significantly superior to NAA 25 ppm (18.52%) found to be superior to NAA 50 ppm (18.46%), kinetin 30 ppm (18.40%) and kinetin 15 ppm (18.34%). NAA 25 ppm and kinetin 30 ppm were superior over NAA 50 ppm and kinetin 15 ppm respectively.

All the growth regulators increased the per cent age of reducing sugars over control satisfactory.

In general, Phalsa responded to the application of GA₃ found to the best followed by ethrel followed by NAA followed by kinetin in increasing the reducing sugar.

4.17 TSS: acidity

The data on TSS: acidity ratio of Phalsa fruits with different concentrations of growth regulators are presented in Table 10 and are shown graphically in Fig.18. The TSS: acidity ratio ranged from 7.77 per cent to 10.75per cent.

Maximum TSS: acidity ratio (10.98 %) was observed with GA₃ 100 ppm followed by ethrel 250 ppm (10.73%), ethrel 500 ppm(10.72%), GA₃ 50 ppm(10.66%) which were on par but significantly superior NAA 25 ppm (9.41%), NAA 50 ppm (8.87%), kinetin 30 ppm (8.56 %) and Kinetin 15 ppm (8.28 %). Both the kinetin and ethrel treatments were on par with each other.

In general all the growth regulators increased the per cent age of reducing sugars over control satisfactory.

It was noted that GA₃ at higher concentrations and ethrel at lower concentrations increasing the TSS: acidity ratio in fruits significantly over control.

4.18 Pulp weight (100 Fruits) (g)

It was noticed from the data presented in the Table 11 and Fig. 19 that the effect of different growth regulators sprayed on Phalsa, was significantly different with respect to fruit pulp weight. The average weight of fruit pulp ranged from 40.25g to 51

Bushes treated with GA₃ at 100 ppm produced significantly higher pulp weight (51.45g) over other treatments followed by GA₃ at 50 ppm (50.78g) but on par with each other. On the other hand, minimum pulp weight was recorded (40.25g) in control. Bushes treated with NAA at 25 ppm recorded pulp weight (47.57g) and NAA 50 ppm (46.26 g) were significantly superior over Kinetin 15 ppm (43.31g), Kinetin 30 ppm (44.10 g), ethrel 500 ppm (42.52g) and ethrel 250 ppm (43.14g). Pulp weight recorded in ethrel 500 ppm was on par with ethrel 250 ppm and Kinetin 15 ppm. Bushes treated with Kinetin 30 ppm recorded pulp weight was on par with Kinetin 15 ppm but significantly superior over control. However, no significant differences were observed among the two levels of individual chemical treatments except NAA.

However GA₃ at 50 ppm differed significantly from other treatments. All the growth regulators resulted in improving pulp weight as compared to control. An overall view of the data indicated that GA₃ and kinetin improved fruit pulp weight at higher concentrations, while NAA and ethrel at lower concentrations.

4.19 Stone weight (100 Fruits) (g)

It was noticed from the data presented in the Table 12 and Fig. 20 that the effect of different growth regulators sprayed on Phalsa, was significantly different with respect to fruit stone weight. The average stone weight ranged from 10.81 g to 8.83 g.

Bushes treated with GA₃ at 100 ppm produced significantly minimum stone weight (8.83g) and maximum stone weight was recorded (10.81g) in control. NAA 25

ppm recorded stone weight (9.12g) followed by GA₃ 50 ppm (9.38g), NAA 50 ppm (9.65g), kinetin 30 ppm (10.10g), kinetin 15 ppm (10.35g), ethrel 500 ppm (10.52g) and ethrel 250 ppm (10.41g).

Bushes treated with Kinetin 15 ppm was on par with ethrel 250 ppm but superior over control.

All the growth regulators resulted in reducing stone weight as compared to control. GA₃ and NAA were significantly more effective in reducing the stone weight. GA₃ and NAA at both the concentrations reduced stone weight over control. More appropriately GA₃ at higher concentrations were effective in reducing stone weight of Phalsa, while NAA at lower concentrations.

4.20 Pulp to stone ratio

It was noticed from the data presented in the Table 12 and Fig. 21 that the effect of different growth regulators sprayed on Phalsa, was significantly different with respect to pulp to stone ratio. The average pulp to stone ratio ranged from 3.72 to 5.85.

Bushes treated with GA₃ at 100 ppm produced significantly higher pulp to stone ratio (5.85) followed by GA₃ at 50 ppm (5.41). On the other hand, less pulp to stone ratio was recorded (3.72) in control. Bushes treated with NAA at 25 ppm recorded pulp to stone ratio (5.22) which was superior to NAA 50 ppm (4.79) and both were significantly superior over Kinetin 15 ppm (4.18), Kinetin 30 ppm (4.26) and ethrel 250(4.36) ppm.

Bushes treated with Kinetin 15 ppm was on par with Kinetin 30 ppm and ethrel 250 ppm but significantly superior over control.

All the growth regulators resulted in higher pulp to stone ratio as compared to control.

Although GA₃ was found to be effective in improving the ratio followed by NAA over control other kinetin and ethrel are not much effective in improving over NAA and GA₃ but superior to control.

On critical evaluation of the entire data, it was noticed that GA₃ treatment recorded higher values of pulp to stone ratio while the minimum values of pulp to stone ratio was associated with control fruits.

Both the levels of GA₃ were statistically of the same order and superior to other treatments. Among NAA treatments lower concentrations was more effective than higher concentration in improving pulp to stone ratio in Phalsa.

An overall view of the data indicated that GA₃ and kinetin improved pulp to stone ratio at higher concentrations, while NAA and ethrel at lower concentrations.

4.21 Shelf life (hrs)

The data on shelf life of Phalsa fruits are presented in Table 13 and are shown graphically in Fig.22. The data revealed that the average shelf life ranged from 36.72 hrs to 51.46 hrs.

Highest shelf life (51.46 hrs) was recorded with kinetin 30 ppm which significantly superior to other treatments followed by kinetin 15 ppm (49.38 hrs) and least shelf life was rescored in control (36.12 hrs). GA₃ 100 ppm recorded shelf life (48.40hrs) superior over GA₃ 50 ppm (46.52hrs), NAA 50 ppm (44.50 hrs) and NAA 25 ppm (43.11hrs) significantly superior to ethrel 250 ppm (41.08hrs) and ethrel 500 ppm (39.53hrs).

Higher concentrations of kinetin, GA₃and NAA improved the shelf life of Phalsa where as ethrel at higher concentration reduced it.

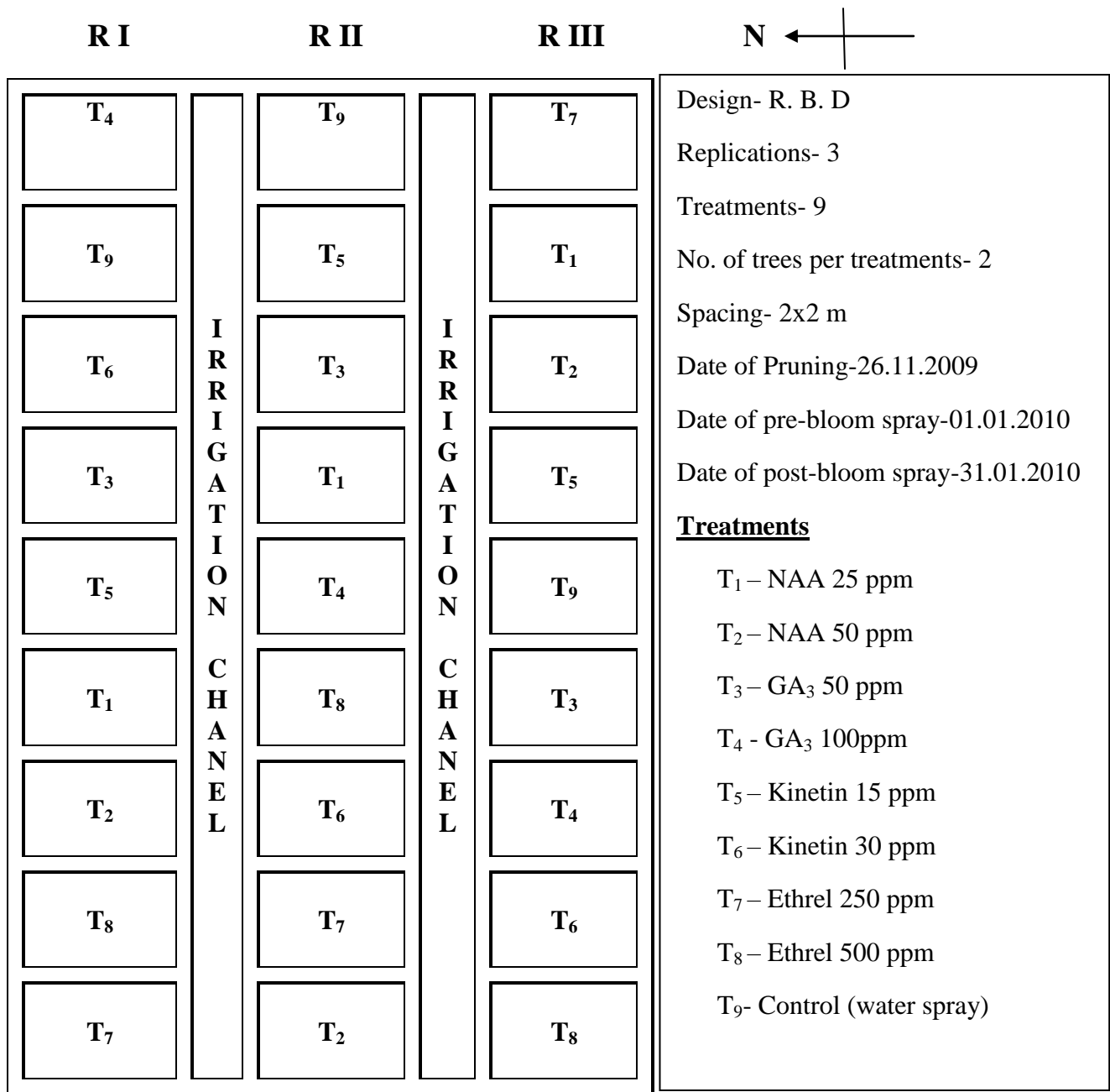


Fig 1: Lay out plan of the experiment

Table 2: Effect of growth regulators on number of flower per shoot and Days to 50 per cent flowering of Phalsa

| S.No. | Treatments | Number of flower Per shoot | Days to 50 per cent flowering |
|-------------------|-------------------------|---------------------------------------|--------------------------------------|
| 1. | NAA 25 ppm | 394.26 | 51.17 |
| 2. | NAA 50 ppm | 362.31 | 54.33 |
| 3. | GA ₃ 50 ppm | 382.39 | 53.33 |
| 4. | GA ₃ 100 ppm | 370.73 | 55.83 |
| 5. | Kinetin 15 ppm | 347.15 | 57.83 |
| 6. | Kinetin 30 ppm | 353.33 | 57.17 |
| 7. | Ethrel 250 ppm | 360.53 | 56.67 |
| 8. | Ethrel 500 ppm | 354.97 | 56.33 |
| 9. | Water spray (Control) | 332.34 | 60.33 |
| S. Em ± | | 1.19 | 0.76 |
| C.D. at 5% | | 3.59 | 2.29 |

Table 3: Effect of growth regulators on fruit set percentage and Flowering to fruit set (days) of in Phalsa

| S.No. | Treatments | Fruit set (%) | Flowering to fruit set (Days) |
|-------------------|-------------------------|----------------------|--------------------------------------|
| 1. | NAA 25 ppm | 71.02 | 14.00 |
| 2. | NAA 50 ppm | 62.64 | 16.00 |
| 3. | GA ₃ 50 ppm | 69.57 | 14.33 |
| 4. | GA ₃ 100 ppm | 63.17 | 16.17 |
| 5. | Kinetin 15 ppm | 56.50 | 18.33 |
| 6. | Kinetin 30 ppm | 57.72 | 18.17 |
| 7. | Ethrel 250 ppm | 27.71 | 20.33 |
| 8. | Ethrel 500 ppm | 23.32 | 20.83 |
| 9. | Water spray (Control) | 50.29 | 21.67 |
| S. Em ± | | 0.37 | 0.57 |
| C.D. at 5% | | 1.47 | 1.73 |

Table 4: Effect of growth regulators on number of fruits per node and number of fruits per shoot in Phalsa

| S.No. | Treatments | No. of fruits per node | No. of fruits per shoot |
|--------------|-------------------------|-------------------------------|--------------------------------|
| 1. | NAA 25 ppm | 25.29 | 279.93 |
| 2. | NAA 50 ppm | 20.78 | 227.21 |
| 3. | GA ₃ 50 ppm | 24.25 | 264.28 |
| 4. | GA ₃ 100 ppm | 23.21 | 260.20 |
| 5. | Kinetin 15 ppm | 18.10 | 196.24 |
| 6. | Kinetin 30 ppm | 18.26 | 203.12 |
| 7. | Ethrel 250 ppm | 9.27 | 98.54 |
| 8. | Ethrel 500 ppm | 7.45 | 81.96 |
| 9. | Water spray (Control) | 17.02 | 174.87 |
| | S. Em ± | 0.33 | 0.70 |
| | C.D. at 5% | 1.01 | 2.12 |

Table 5: Effect of growth regulators on number of fruits per plant in Phalsa (in hundreds) and Days to first picking of Phalsa

| S.No. | Treatments | No. of fruits per plant (In hundreds) | Days to first picking (Days) |
|-------------------|-------------------------|--|---|
| 1. | NAA 25 ppm | 50.62 | 97.17 |
| 2. | NAA 50 ppm | 46.48 | 97.33 |
| 3. | GA ₃ 50 ppm | 49.64 | 96.00 |
| 4. | GA ₃ 100 ppm | 49.43 | 98.50 |
| 5. | Kinetin 15 ppm | 40.41 | 100.50 |
| 6. | Kinetin 30 ppm | 40.83 | 99.67 |
| 7. | Ethrel 250 ppm | 13.77 | 98.50 |
| 8. | Ethrel 500 ppm | 11.52 | 98.33 |
| 9. | Water spray (Control) | 37.73 | 101.67 |
| S. Em ± | | 0.03 | 0.53 |
| C.D. at 5% | | 0.08 | 1.13 |

Table 6: Effect of growth regulators on Fruiting duration and crop duration in Phalsa

| S.No. | Treatments | Fruiting duration (Days) | Crop duration (Days) |
|-------------------|-------------------------|-------------------------------------|---------------------------------|
| 1. | NAA 25 ppm | 18.50 | 116.67 |
| 2. | NAA 50 ppm | 20.83 | 117.67 |
| 3. | GA ₃ 50 ppm | 18.17 | 115.17 |
| 4. | GA ₃ 100 ppm | 20.83 | 119.33 |
| 5. | Kinetin 15 ppm | 21.67 | 121.33 |
| 6. | Kinetin 30 ppm | 22.00 | 122.50 |
| 7. | Ethrel 250 ppm | 20.00 | 118.50 |
| 8. | Ethrel 500 ppm | 19.67 | 118.00 |
| 9. | Water spray (Control) | 23.17 | 124.83 |
| S. Em ± | | 0.37 | 0.57 |
| C.D. at 5% | | 1.12 | 1.73 |

Table 7: Effect of growth regulators on average fruit weight of Phalsa

| S.No. | Treatments | 100 Fruit weight (g) |
|-------------------|-------------------------|---------------------------------|
| 1. | NAA 25 ppm | 55.51 |
| 2. | NAA 50 ppm | 54.12 |
| 3. | GA ₃ 50 ppm | 59.33 |
| 4. | GA ₃ 100 ppm | 61.48 |
| 5. | Kinetin 15 ppm | 57.89 |
| 6. | Kinetin 30 ppm | 58.03 |
| 7. | Ethrel 250 ppm | 57.08 |
| 8. | Ethrel 500 ppm | 56.40 |
| 9. | Water spray (Control) | 57.14 |
| S. Em ± | | 0.20 |
| C.D. at 5% | | 0.60 |

Table 8: Effect of growth regulators on yield attributes of Phalsa

| S.No. | Treatments | Yield/plant (Kg) | Yield/ha. (Tonnes) |
|-------------------|-------------------------|-----------------------------|-------------------------------|
| 1. | NAA 25 ppm | 2.76 | 6.89 |
| 2. | NAA 50 ppm | 2.56 | 6.40 |
| 3. | GA ₃ 50 ppm | 2.88 | 7.25 |
| 4. | GA ₃ 100 ppm | 3.05 | 7.63 |
| 5. | Kinetin 15 ppm | 2.34 | 5.85 |
| 6. | Kinetin 30 ppm | 2.38 | 5.95 |
| 7. | Ethrel 250 ppm | 0.784 | 1.95 |
| 8. | Ethrel 500 ppm | 0.645 | 1.60 |
| 9. | Water spray (Control) | 2.16 | 5.24 |
| S. Em ± | | 0.05 | 0.11 |
| C.D. at 5% | | 0.15 | 0.33 |

Table 9: Effect of growth regulators on T.S.S content and acidity of Phalsa

| S.No. | Treatments | T.S.S (%) | Titrateable acidity (%) |
|-------------------|-------------------------|----------------------|------------------------------------|
| 1. | NAA 25 ppm | 23.05 | 2.45 |
| 2. | NAA 50 ppm | 21.68 | 2.44 |
| 3. | GA ₃ 50 ppm | 24.31 | 2.33 |
| 4. | GA ₃ 100 ppm | 24.83 | 2.26 |
| 5. | Kinetin 15 ppm | 20.56 | 2.48 |
| 6. | Kinetin 30 ppm | 21.04 | 2.46 |
| 7. | Ethrel 250 ppm | 25.10 | 2.33 |
| 8. | Ethrel 500 ppm | 25.72 | 2.40 |
| 9. | Water spray (Control) | 19.80 | 2.55 |
| S. Em ± | | 0.10 | 0.02 |
| C.D. at 5% | | 0.31 | 0.06 |

Table 10: Effect of growth regulators on reducing sugars content and TSS to acidity ratio of Phalsa

| S.No. | Treatments | Reducing sugars (%) | TSS: acidity |
|-------------------|-------------------------|--------------------------------|---------------------|
| 1. | NAA 25 ppm | 18.52 | 9.41 |
| 2. | NAA 50 ppm | 18.46 | 8.87 |
| 3. | GA ₃ 50 ppm | 18.71 | 10.43 |
| 4. | GA ₃ 100 ppm | 18.91 | 10.98 |
| 5. | Kinetin 15 ppm | 18.34 | 8.28 |
| 6. | Kinetin 30 ppm | 18.40 | 8.56 |
| 7. | Ethrel 250 ppm | 18.67 | 10.73 |
| 8. | Ethrel 500 ppm | 18.79 | 10.72 |
| 9. | Water spray (Control) | 18.25 | 7.77 |
| S. Em ± | | 0.01 | 0.11 |
| C.D. at 5% | | 0.05 | 0.32 |

Table 11: Effect of growth regulators on pulp weight (100 Fruit) of**Phalsa**

| S.No. | Treatments | Pulp weight (100 Fruits) (g) |
|-------------------|-------------------------|---|
| 1. | NAA 25 ppm | 47.57 |
| 2. | NAA 50 ppm | 46.26 |
| 3. | GA ₃ 50 ppm | 50.78 |
| 4. | GA ₃ 100 ppm | 51.45 |
| 5. | Kinetin 15 ppm | 43.31 |
| 6. | Kinetin 30 ppm | 44.10 |
| 7. | Ethrel 250 ppm | 43.14 |
| 8. | Ethrel 500 ppm | 42.52 |
| 9. | Water spray (Control) | 40.25 |
| S. Em ± | | 0.39 |
| C.D. at 5% | | 1.18 |

Table 12: Effect of growth regulators on stone weight and pulp to stone of Phalsa

| S.No. | Treatments | Stone weight (100 Fruits) (g) | pulp: stone ratio |
|-------------------|-------------------------|--|--------------------------|
| 1. | NAA 25 ppm | 9.12 | 5.22 |
| 2. | NAA 50 ppm | 9.65 | 4.79 |
| 3. | GA ₃ 50 ppm | 9.38 | 5.41 |
| 4. | GA ₃ 100 ppm | 8.83 | 5.85 |
| 5. | Kinetin 15 ppm | 10.35 | 4.18 |
| 6. | Kinetin 30 ppm | 10.10 | 4.26 |
| 7. | Ethrel 250 ppm | 10.41 | 4.36 |
| 8. | Ethrel 500 ppm | 10.52 | 4.04 |
| 9. | Water spray (Control) | 10.81 | 3.72 |
| S. Em ± | | 0.03 | 0.05 |
| C.D. at 5% | | 0.08 | 0.14 |

Table 13: Effect of growth regulators on Shelf life (Hours) of Phalsa

| S.No. | Treatments | Shelf life (Hours) |
|--------------|-------------------------|-------------------------------|
| 1. | NAA 25 ppm | 43.11 |
| 2. | NAA 50 ppm | 44.50 |
| 3. | GA ₃ 50 ppm | 46.52 |
| 4. | GA ₃ 100 ppm | 48.40 |
| 5. | Kinetin 15 ppm | 49.38 |
| 6. | Kinetin 30 ppm | 51.46 |
| 7. | Ethrel 250 ppm | 41.08 |
| 8. | Ethrel 500 ppm | 39.53 |
| 9. | Water spray (Control) | 36.12 |
| | S. Ed ± | 0.43 |
| | C.D. at 5% | 1.30 |



Plate 2: A field view of the experimental plot



Plate 1: Field operations (pruning, irrigation channel, growth and new flushes of Phalsa bush)



NAA 25 ppm



NAA 50 ppm



GA₃ 50 ppm



GA₃ 100 ppm



Kinetin 15 ppm



Kinetin 30 ppm



Ethrel 250 ppm



Ethrel 500 ppm



Control

Plate 3: Plate view of Phalsa fruits under different treatments



Plate 4 (a): GA₃ 100 ppm treated Phalsa bush (heavy bearing)



Plate 4 (b): Ethrel 500 ppm treated Phalsa bush (Low bearing)



NAA 25 ppm



NAA 50 ppm



GA₃ 50 ppm



GA₃ 100 ppm



Kinetin 15 ppm



Kinetin 30 ppm



Ethrel 250 ppm



Ethrel 500 ppm



Control

Plate 5 (a): Effect of different growth regulators on shelf life (at the regaining) of Phalsa fruit



NAA 25 ppm



NAA 50 ppm



GA₃ 50 ppm



GA₃ 100 ppm



Kinetin 15 ppm



Kinetin 30 ppm



Ethrel 250 ppm



Ethrel 500 ppm



Control

Plate 5 (b): Shelf life of Phalsa fruit after 36.12 hrs (control) of storage

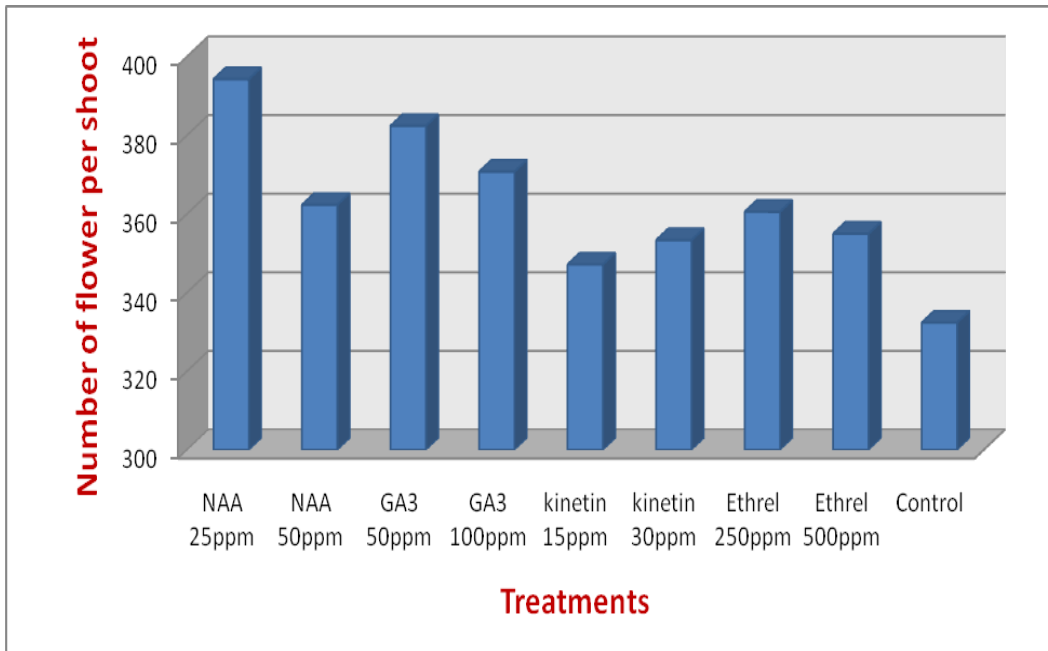


Fig 2: Effect of Growth regulators on number of flower per shoot

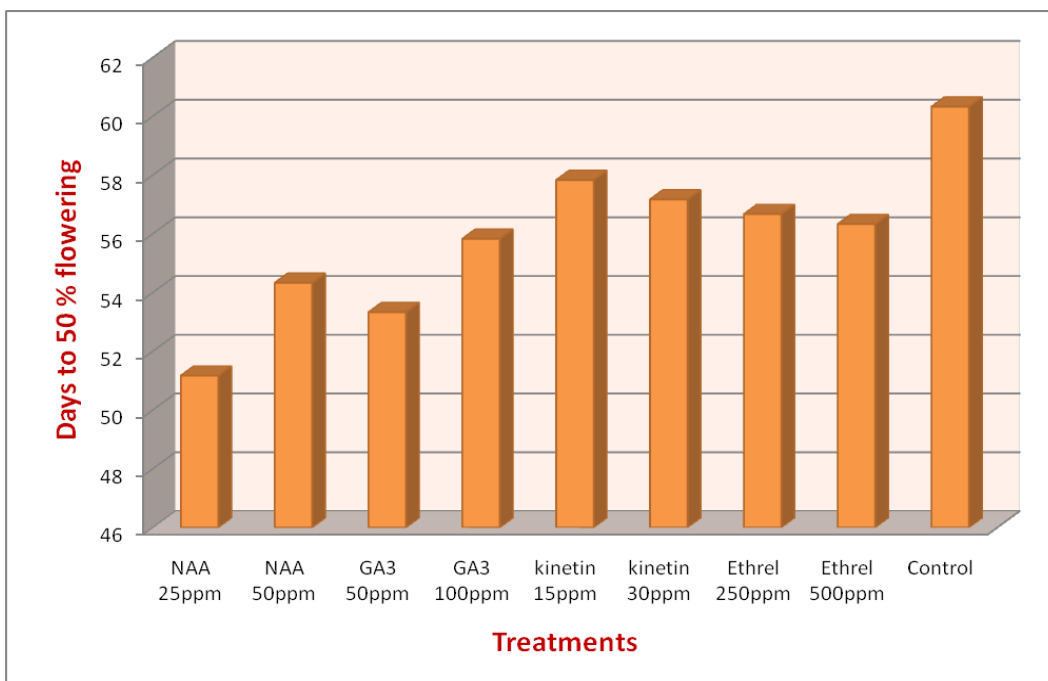


Fig 3: Effect of Growth regulators on days to 50%flowering

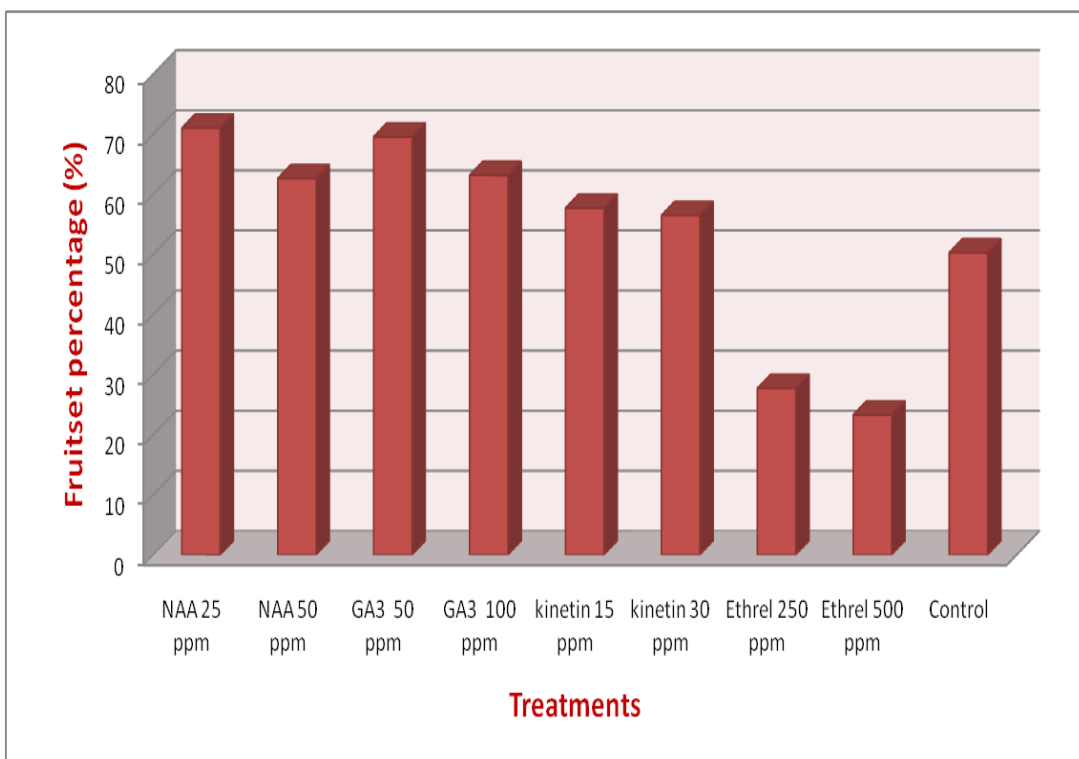


Fig 4: Effect of Growth regulators on fruit set percentage

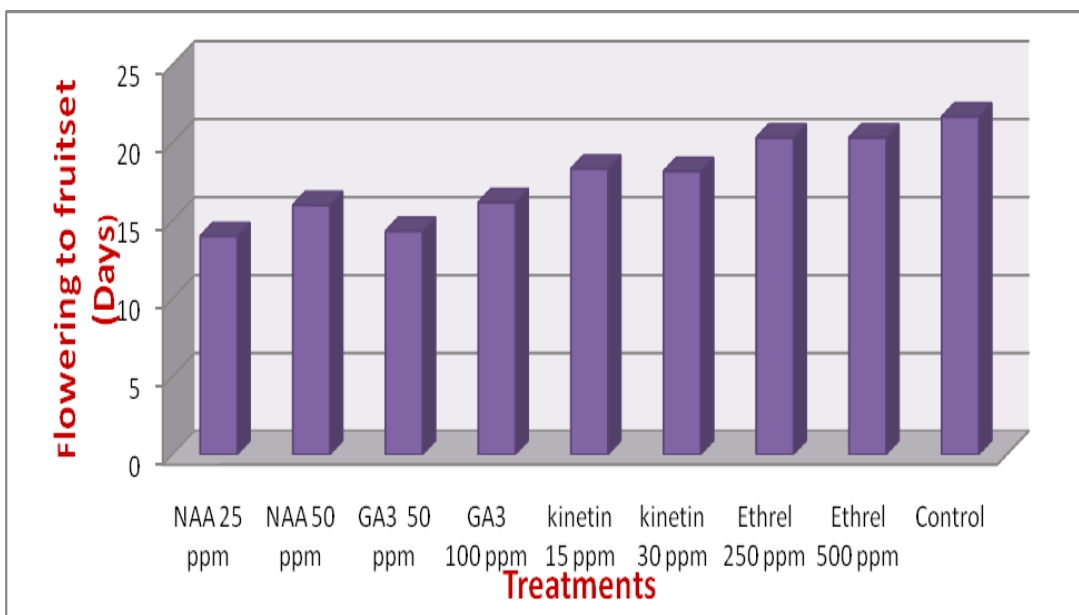


Fig 5: Effect of Growth regulators on flowering to fruit set (Days)

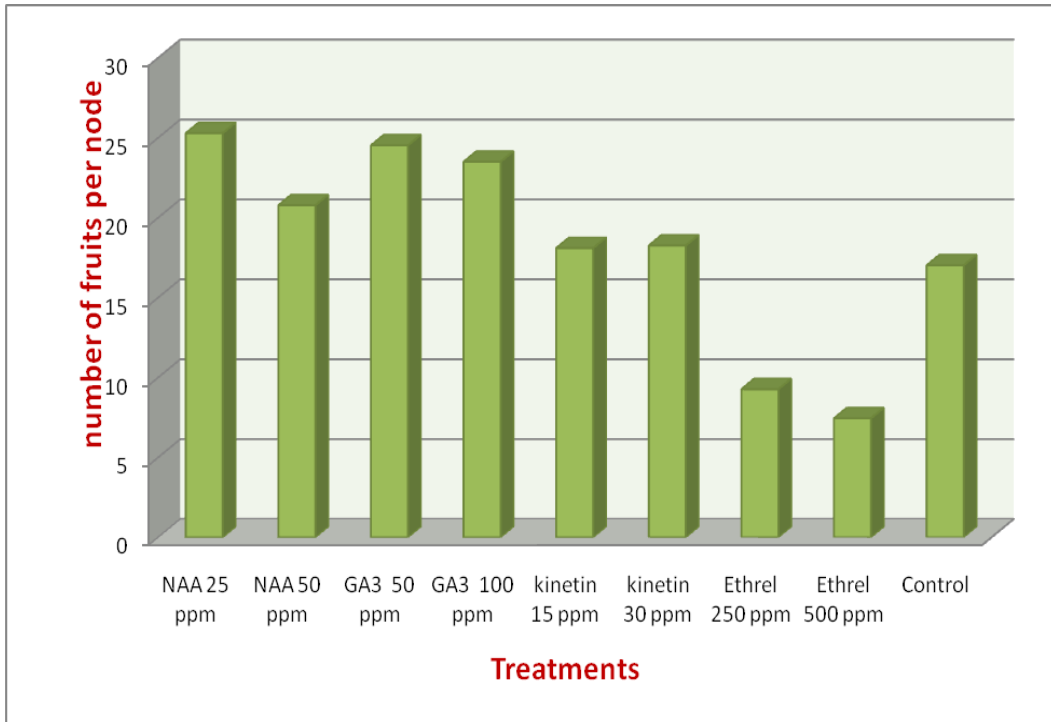


Fig 6: Effect of Growth regulators on number of fruits per node

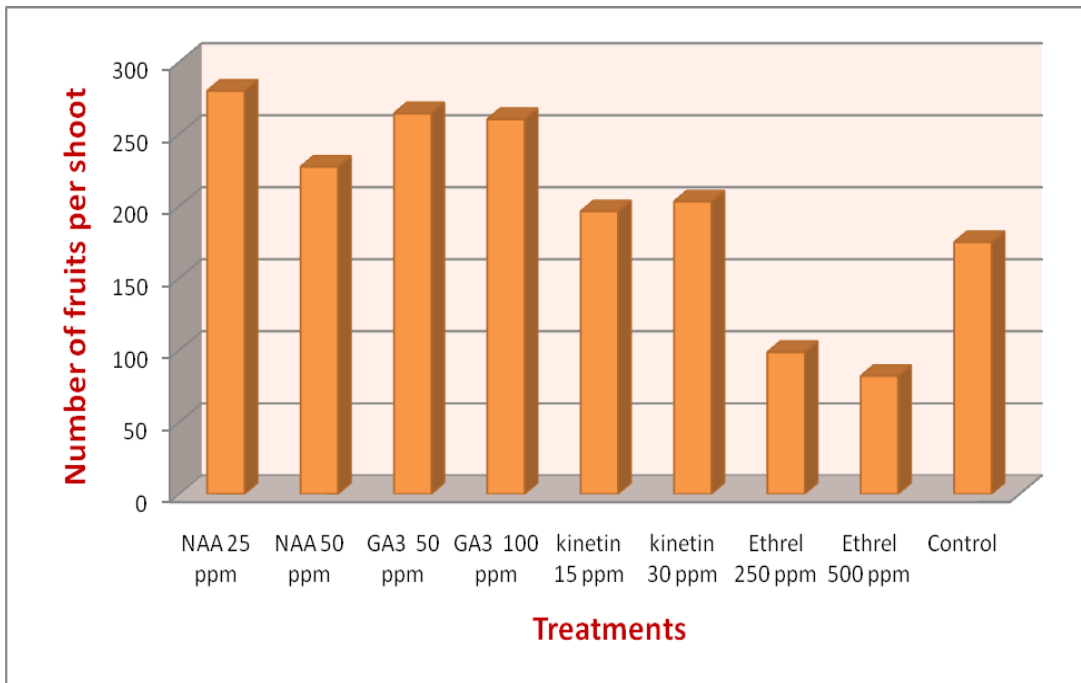


Fig 7: Effect of Growth regulators on number of fruits per shoot

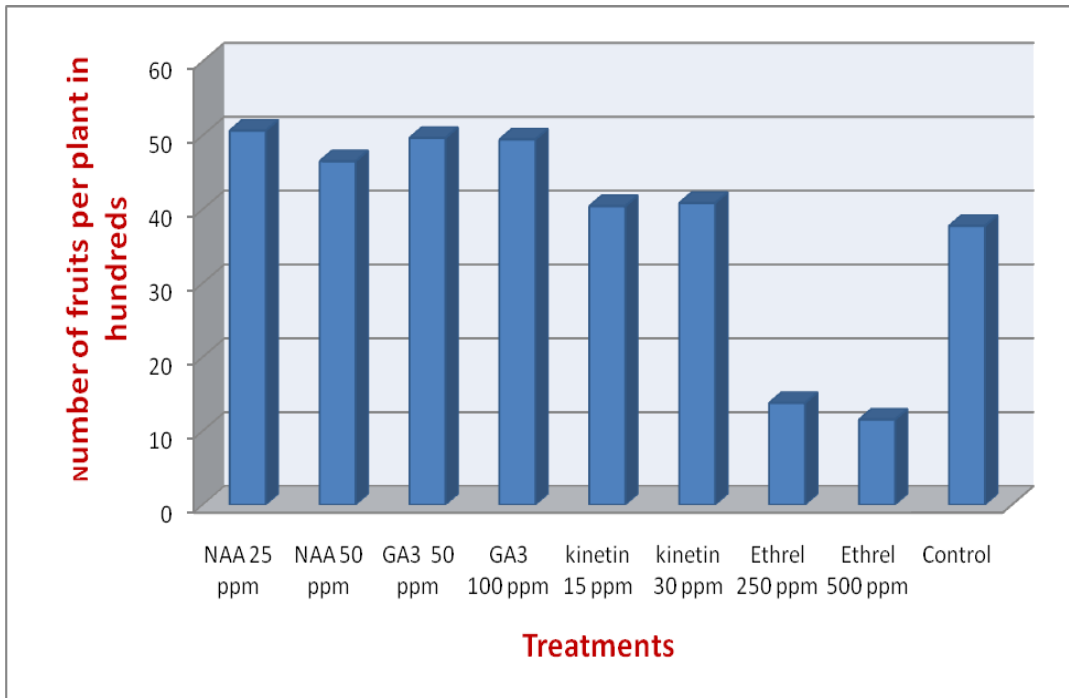


Fig 8: Effect of Growth regulators on number of fruits per plant (In hundreds)

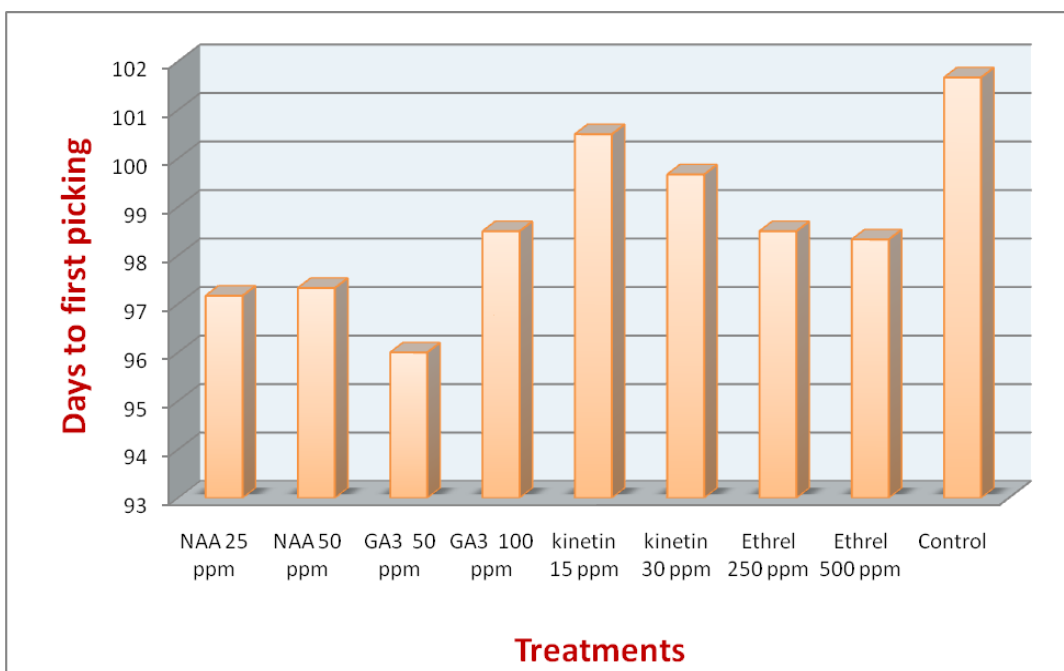


Fig 9: Effect of Growth regulators on days to first picking

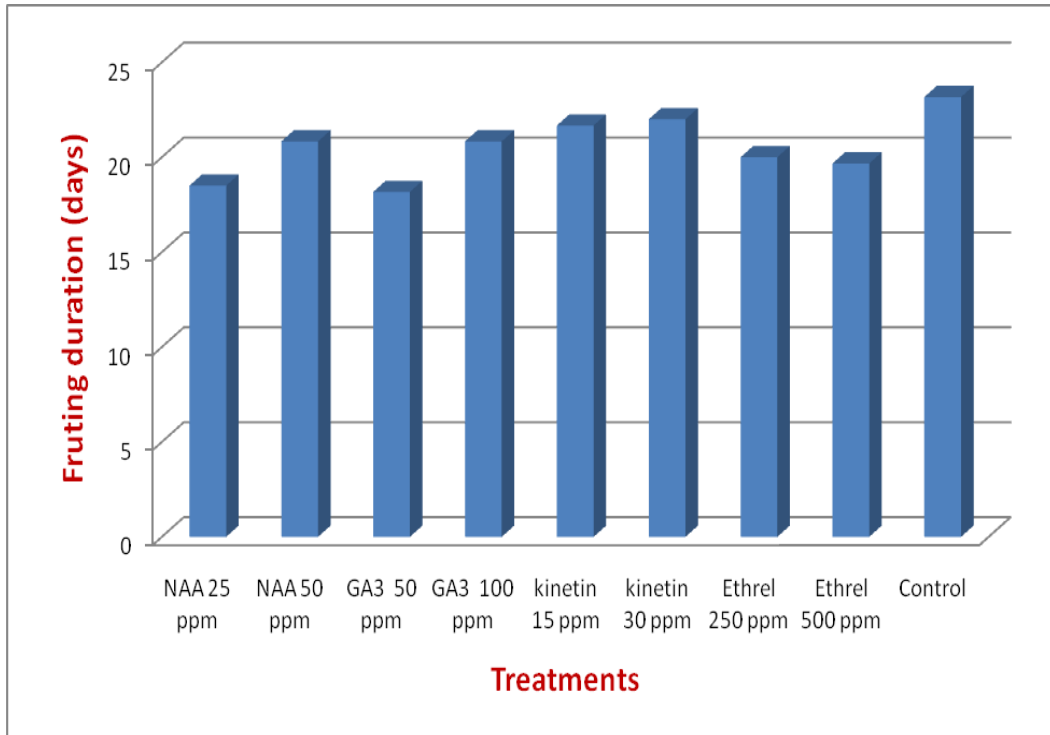


Fig 10: Effect of Growth regulators on fruiting duration (days)

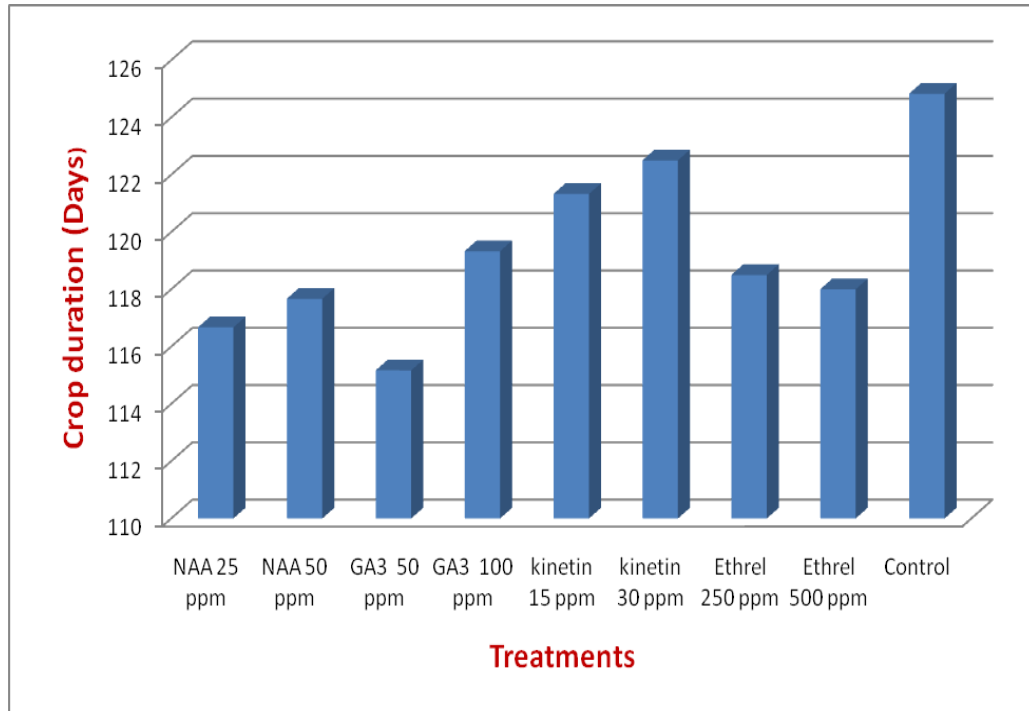


Fig 11: Effect of Growth regulators on crop duration (days)

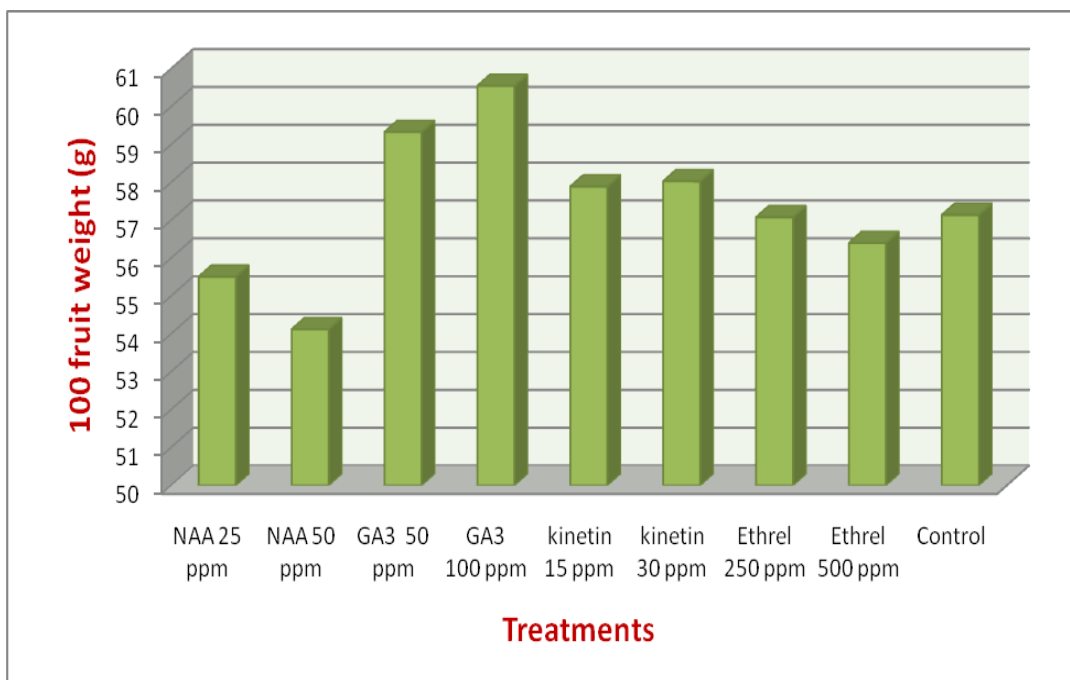


Fig 12: Effect of Growth regulators on 100 fruit weight

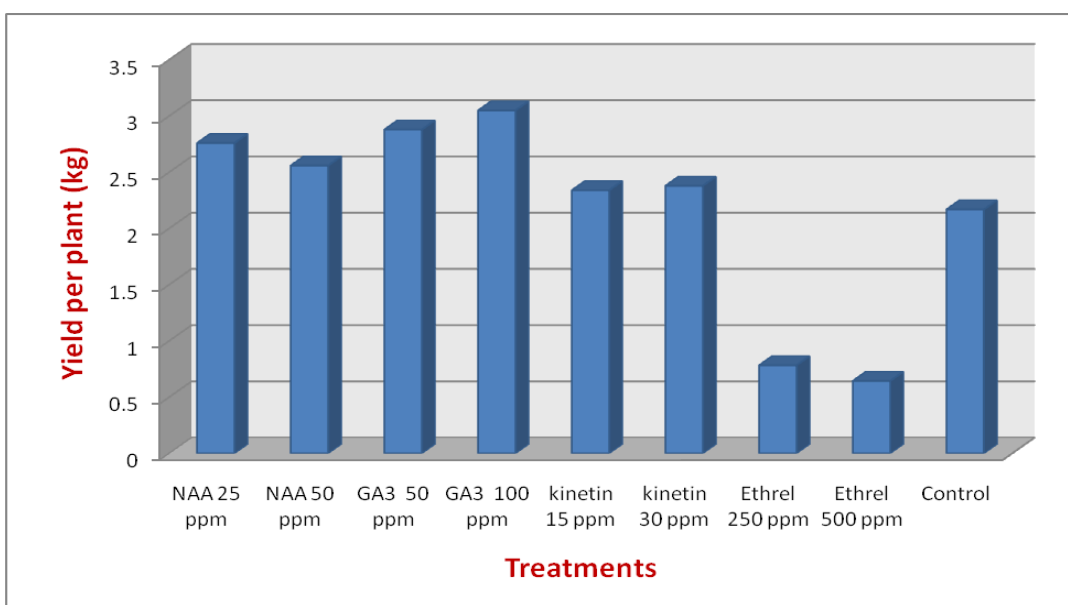


Fig 13: Effect of Growth regulators on yield per plant

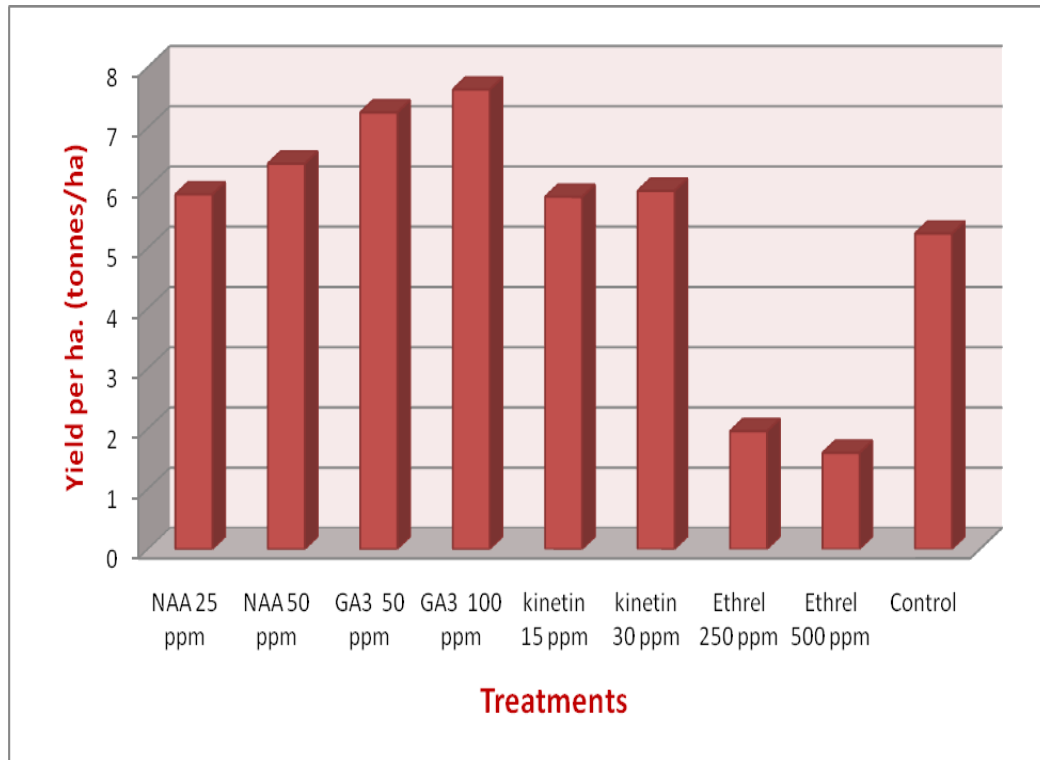


Fig 14: Effect of Growth regulators on yield per hectare

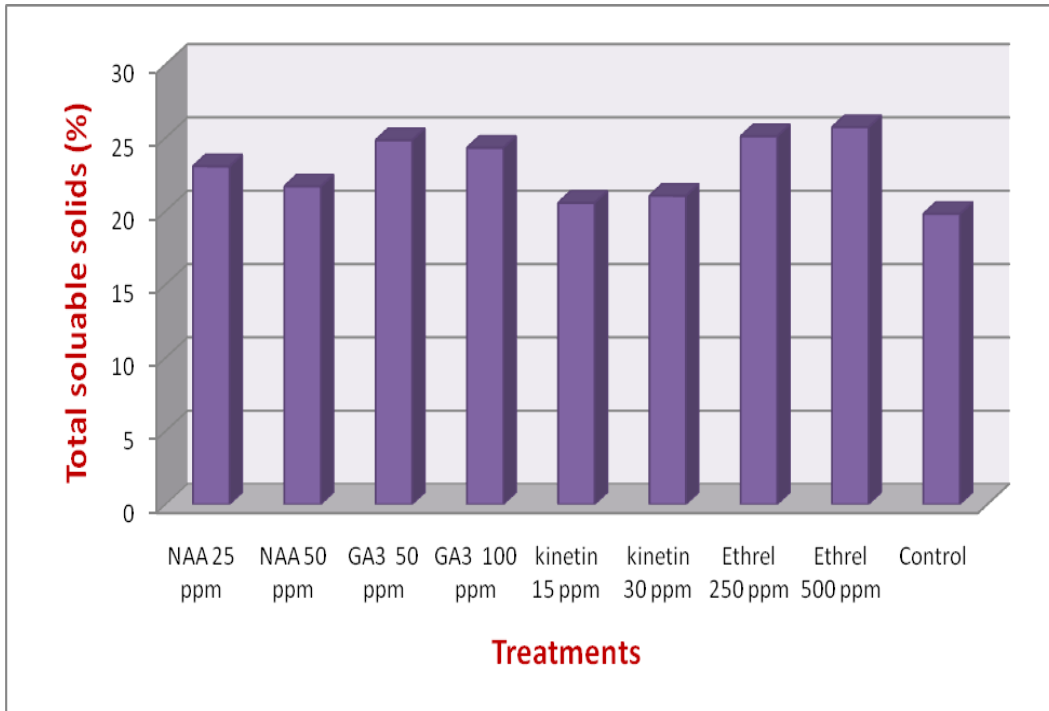


Fig 15: Effect of Growth regulators on Total soluble solids content

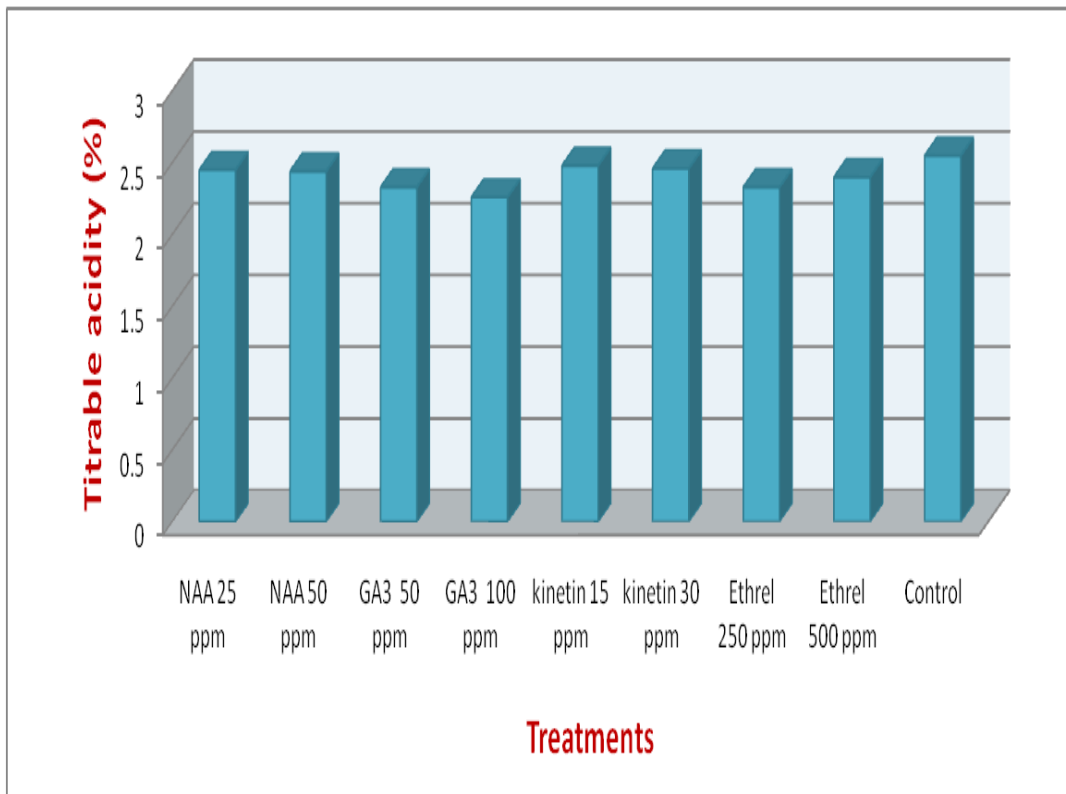


Fig 16: Effect of Growth regulators on titrable acidity

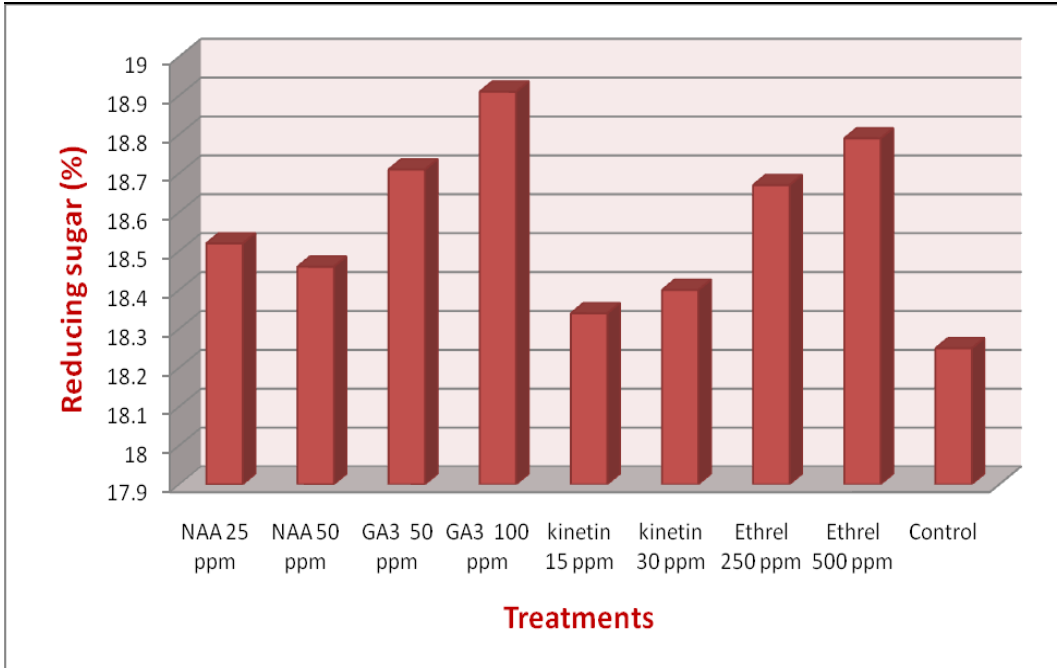


Fig 17: Effect of Growth regulators on reducing sugar

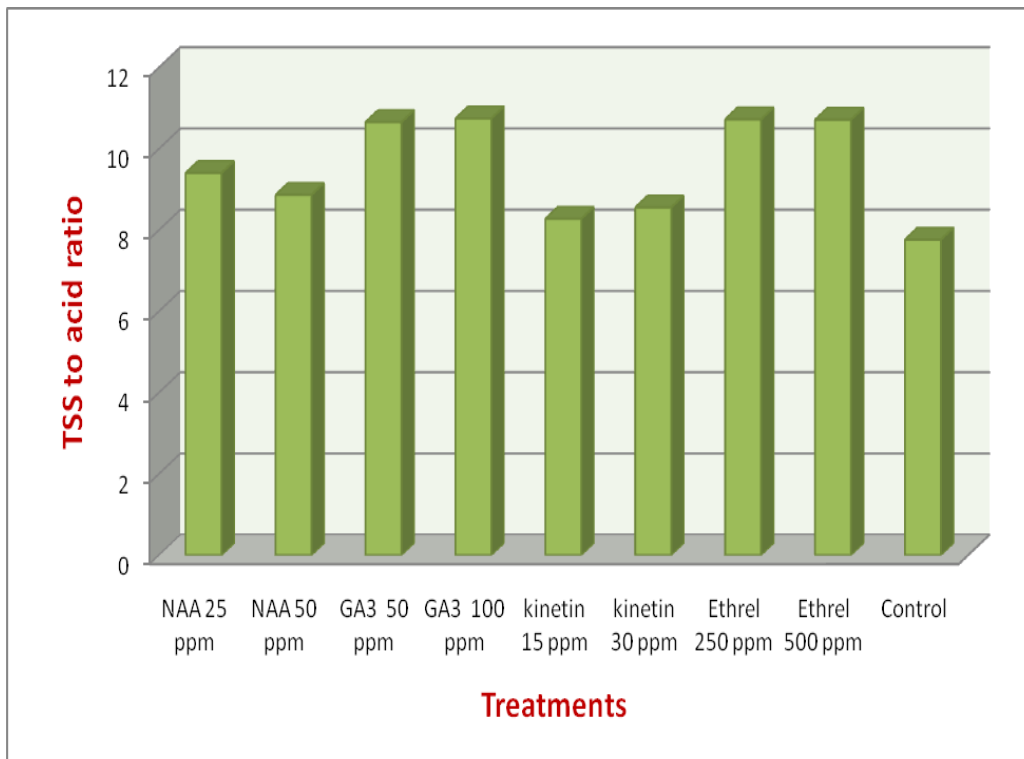


Fig 18: Effect of Growth regulators on TSS to acid ratio

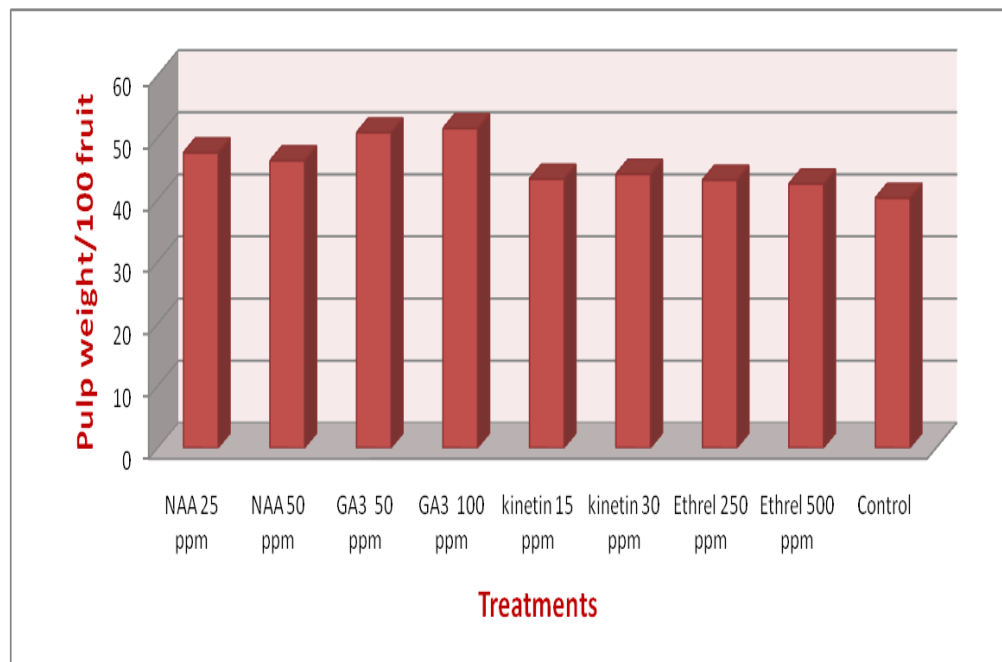


Fig 19: Effect of Growth regulators on pulp weight

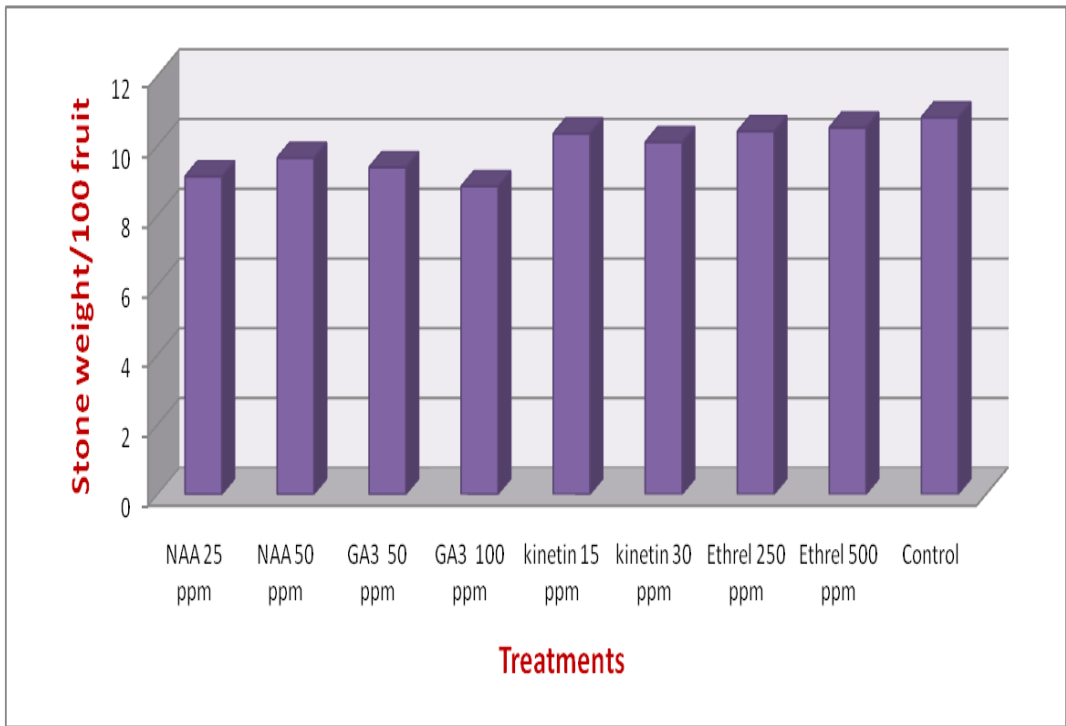


Fig 20: Effect of Growth regulators on stone weight

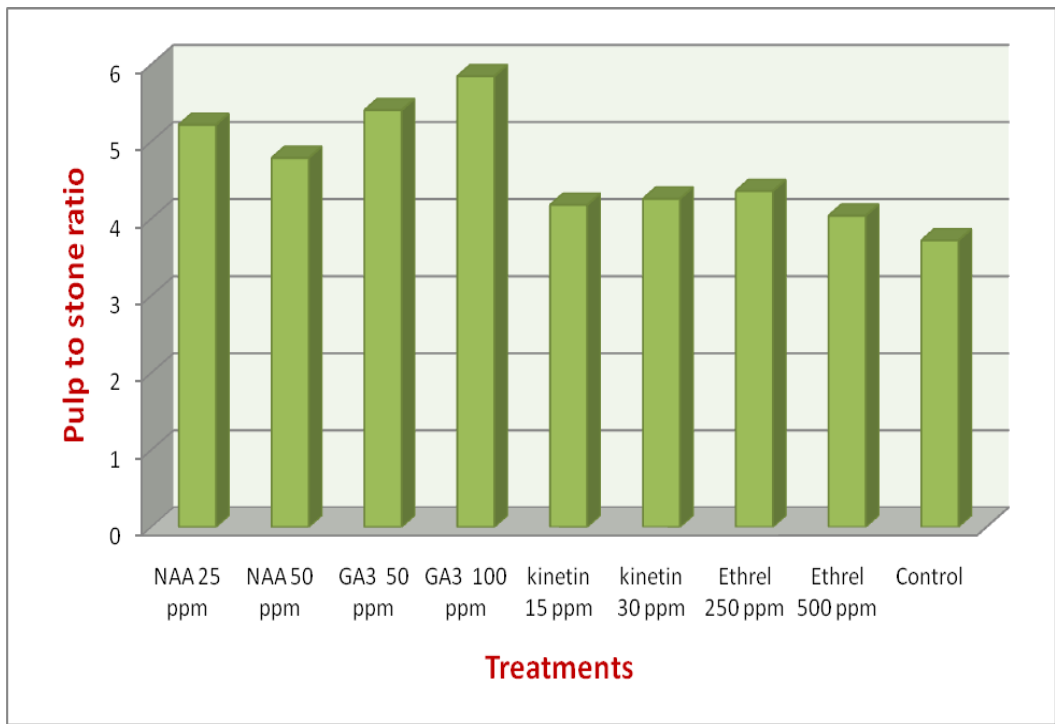


Fig 21: Effect of Growth regulators on pulp to stone ratio

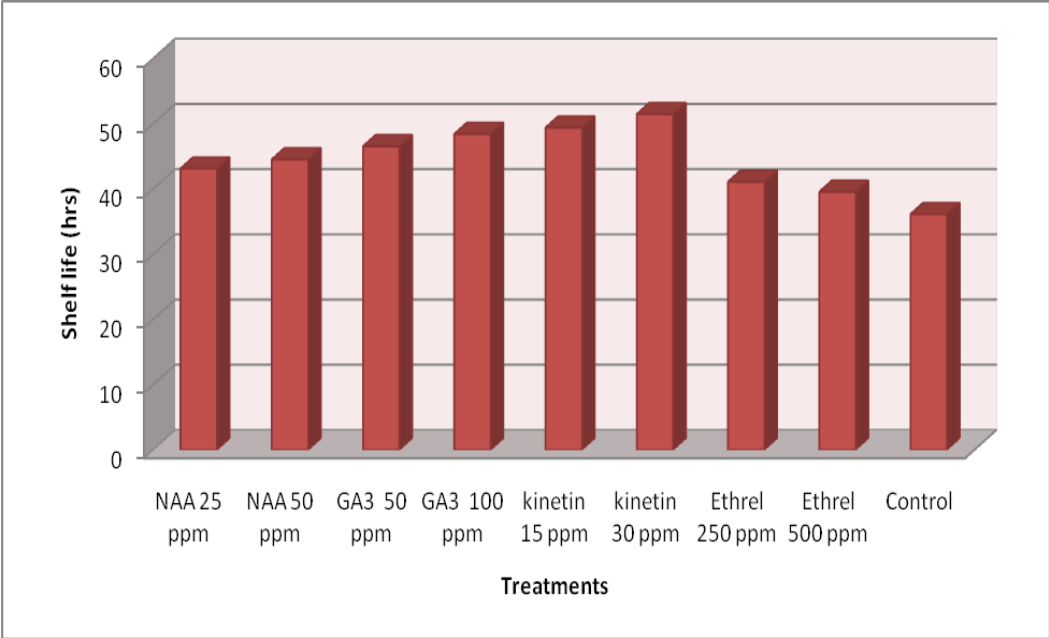


Fig 22: Effect of Growth regulators on shelf life of Phalsa fruits

Chapter V

Discussion

CHAPTER – V

DISCUSSION

An endeavour is made in this chapter to discuss the results of the present investigation in the light of the available literature.

Growth regulators have become powerful tools to modify several physiological processes in plants which are extensively and profitably used in horticultural crops. They are mainly used in increasing size and weight of fruits which ultimately results in increased yields. They are also used for increasing pulp content and improving quality of fruits. Positive response of fruits to exogenous application of growth regulators has been reported by several workers.

Effect of growth regulators on flowering, fruitset, yield and quality in Phalsa (*Grewia sub-inaequalis* DC) was studied under this experiment and the result obtained under each are discussed below.

5.1 Flowering

A perusal of the results in the forgoing pages has clearly brought out the beneficial effects of the growth regulators in Phalsa particularly on number of flowers per shoot and days to 50 per cent flowering (Table 2). Significant results were recorded in case of number of flowers per shoot also in days to 50 per cent flowering.

NAA 25 ppm recorded significantly higher number of flowers per shoot (394.26). Number of flowers per shoot of Phalsa was enhanced by NAA followed by GA₃, ethrel and kinetin treatments. Lower flower number per shoot was recorded with the control.

A further perusal of data (Table 2) indicated that the lower concentrations were more effective than the higher concentrations indicating that higher concentration was less effective to number of flowers per shoot which is opposite to kinetin.

Higher number of flowers per shoot was obtained with NAA 25 ppm was superior to NAA 50 ppm. The theory of florigen proposed by Chailakhyan (1936) is the foremost to explain the basis of flower induction in different crops. Florigen a hypothetical substance consists of two components, gibberellin and anthesin, both of which are presumed to be required for flowering. The superiority of NAA at lower concentration over other growth regulators may possibly due to auxin causes photoperiodic induction of flowering. Exogenous application of auxin after photo inductive cycle, it increases floral differentiation. Auxin interferes with the photoperiodic reaction which occurs in the leaves and hinders the synthesis of florigen, play an important role in floral induction (Kumar and Purohit, 2001).

Similar results were reported with NAA in pineapple plants (Borah and Mohan 1993), in mango (Brahmachari *et al.*, 2006), in Sapota (Nambisan *et al.*, 2007).

GA₃ at 50 ppm produced flowers per shoot was superior to GA₃ 100 ppm. This might be due to affect of lower concentration of GA on the expression of floral stimulus

at the shoot apex rather than leaves. GA increases the mitotic activity in sub apical meristems and thus become more responsive to photo inductive conditions.

Similar results were reported with application of GA₃ in Sapota (Kadam *et al.*, 2005), in Zebda mango trees (Shaban 2009).

The mean number of days taken to 50 per cent flowering also significantly influenced by different concentrations of growth regulators (Table 2). Bushes treated with NAA 25 ppm took significantly lesser number of days (51.17) followed by GA₃ at 50 ppm (53.33).

Among the growth regulators, NAA promoted earliness in flowering however GA₃ at higher concentrations delayed the flowering. Activity of higher concentration of GA₃ to delay flowering correlates with effectiveness for promoting stem elongation (King *et al.*, 1993).

The difference of number of days taken for 50 per cent flowering due to the application of growth regulators was significant. Lower concentration were more effective than the higher concentrations indicating that higher concentration was less effective to mean number of days taken to 50 percent flowering. When growth regulators were considered for evaluation, it was observed that the order of merit was NAA followed by GA₃, Ethrel and Kinetin.

The effect of NAA and GA₃ imparted earliness in days to 50 per cent flowering. All the treatments exhibited earliness in 50 per cent flowering than control (Table 2). It

might be the increased synthesis of cytokinin and auxin in the root tissue by their enhanced activity due to the application of GA₃ and NAA and their simultaneous transport to the auxiliary buds would have resulted in a better sink for the mobilization of photo- assimilates at a faster rate. This would have helped in the early transformation from the vegetative phase to reproductive phase. The induction of early flower bud initiation might be influenced by triggering of such metabolic processes and narrowing of the carbon: nitrogen ratio by the significant accumulation of carbohydrates (Kannan *et al.*, 2009).

The result on earliness in 50 per cent flowering in this experiment goes with the reports by Singh and Mukherjee (2000).

Apart from this it might be due to the early production of florigine in GA₃ treated plant as GA₃ is a component of florigine which is required for formation of flowers in plant system (Devadanam *et al.*, 2007)

Similar findings with NAA recorded earliest 50 percent flowering in mango (Brahmachari *et al.*, 2006). Application of GA₃ 50 ppm resulted early flowering compared to 100 ppm GA₃ in Sapota (Kadam *et al.*, 2005). Early flowering was recorded with NAA 10 ppm compared to 25 ppm and 50 ppm concentrations in the pineapple plants (Borah and Mohan 1993).

5.2 Fruit set

Application of growth regulators, improved fruit set significantly but the response was variable with the growth regulators and their concentrations. When all the growth regulators were considered for evaluation, it was observed that the order of merit was NAA followed by GA₃, Kinetin, control and Ethrel.

A further perusal of data (Table 3) indicated that the lower concentrations in each case were more effective than higher concentrations, indicating that the higher concentration was detrimental to fruit set in case of NAA, GA₃ and ethrel. Kinetin both the concentrations did not varied much to fruit set and ethrel concentrations resulted lower fruit set and not effective than NAA, GA₃, Kinetin and control. Application of NAA at 25 ppm resulted in significantly higher fruit set of 71.02 per cent, the increase being 41.22 per cent over control. It may be assumed that the application of synthetic hormones brings about fruit set by providing the hormonal stimulus for fruit set and growth that would normally occur with pollination.

The effectiveness of growth regulators was in the order of NAA followed by GA₃. The superiority of NAA over GA₃ may be due to the fact that in fruit set, auxin are more directly involved than gibberellins, which are reported to effect fruitset indirectly through stimulation of production of auxin in the plant body (Paleg, 1965). It was also stated that the effect of NAA and GA₃ on fruit set seems to be through their pollen germination and pollen tube growth (Singh and Randhawa, 1961). It was suggested that increase of the fruit set after GA₃ was due to the increased availability of nutrients and photosynthates

from the leaves. This suggestion was on the fact that within 5 to 16 days of GA₃ application the total content of N, P, K in the nearby leaves decreased while the same increased in fruits, (Garcia-Martinez and Garcia-Papi, 1979). The effect of GA on enhancing fruit set might be partly due to GA mediated increase in auxin synthesis in ovaries as visualized by Sastry and Muir (1963).

The results of increased in fruitset are in agreement with the findings of Prasad and Bajpai (1963) who also observed fruit set with NAA sprays in Phalsa. Similar results were reported by Randhawa *et al.*, (1959), Randhawa and Singh (1962), Rao and Rao (1963) and Singh *et al.*, (1966) with GA₃ in Phalsa. Reddy (1977) also reported that improved fruit set in Phalsa with Celestane (NAA) and GA₃ sprays. Prasad (1990) also reported improved fruitset with lower concentration of NAA and GA₃.

NAA, GA₃ at lower concentrations and kinetin higher concentration recorded less days to flowering to fruit set compared to higher concentrations except kinetin in Phalsa. Bushes treated with NAA 25 ppm recorded significantly lesser number of days to flowering to fruit set (14.00) followed by GA₃ at 50 ppm (14.33). The treatment NAA found to be effective in reducing the number of days required for fruitset from flowering. NAA treated plants were able to synthesize more C: N ratio for early initiation of reproductive phase or this might be due to accumulation of net photosynthates (Shetty and Manohar, 2008).

The nutrient diversion hypothesis postulates the induction, whatever the nature of the involved factors, is a means of modifying the source/sink relationships within the

plant in such a way that the shoot apex receives a higher concentration of assimilates than under non-inductive conditions. Conversely, agents promoting assimilate supply to the meristem will appear as floral promoters. The theory of photo assimilates diversion to the apical bud, presented by Sachs *et al.*, (1979) is the basis for the carbohydrate-regulated flowering. It seems, however, there is greater sophistication in control than can be developed from mere assimilate diversion to receptor meristems.

Spraying of ethrel during post bloom stage at higher concentration causes abscission and increases more number of fruits to drop resulted low fruitset in Phalsa. Higher concentration of ethrel resulted reduction of fruitlets ultimately caused low fruitset compared to other treatments. Abscission resulting from the action of ethylene seen to indicate that the participation of an ethylene-enhanced enzyme activity in the action mechanism involved. Ethylene and auxin balance in the separation zone is very important. The ability of ethylene against abscission increases with a decrease in auxin concentration in the separation zone. This is phytoogerontological effect of ethylene. This phytoogerontological effect of ethylene postulated by Abeles *et al.*, (1971) that ethylene enhanced abscission depends in the synthesis of RNA and protein in the plant body.

Phalsa is a bushy plant and continuous growing habit in nature. Simultaneous vegetative growth and reproductive growth on the bush resulted further fruitset in Phalsa.

5.3 Fruiting

Flowers and fruits are borne in leaf axils in clusters in Phalsa. The number of fruits per cluster varies depending upon the nutrition, irrigation, climatic factors etc. it is desirable to increase the number of fruits per node for higher yields. Under normal conditions the number of fruits will be less due to the failure of pollination as stated above. For that reason the exogenous application of growth substances are beneficial.

Lowers concentrations of NAA, GA₃ and higher concentration kinetin being more effective in increasing number of fruits per node in Phalsa. In the present study it was observed that NAA was highly effective in enhancing the number of fruits per node as compared to GA₃ (Table 4). NAA at lower concentration was more effective than its higher concentration. Next to NAA, GA₃ was better.

Reduced fruit drop also might have contributed increased number of fruits per node. The increase in the number of fruits per node might be due to the reduction of fruit drop with NAA and GA₃ treatments, which might have resulted in the increased fertilization and reduction in embryo abortion. Another possible reason may be delayed formation of abscission layers in flowers and fruits. Auxin inhibits abscission of fruits by preventing physiological breakdown of calcium pectate of middle lamella (Van-Overbeek, 1952).

Considering the concept of hormonally regulated metabolic movement, it seems that the application of GA₃ to flowers could create more effective metabolic 'sinks' in the

fruit forming tissues, enabling these tissues to compete better for metabolites and fruit development (Moore and Ecklund, 1975)

The receptivity of stigma was very short duration (Randhawa and Singh 1962) which may also be the reason for poor fruit set in control.

Similarly number of fruits per shoot and plant enhanced by NAA followed by GA₃ (Table 4 and table 5). Exogenous application of those growth regulators increased fruit retention by increasing their level, or by antagonizing adverse effect of endogenous abscission hormones (Sarkar and Ghosh, 2004). Increase in fruit retention and increase in photosynthetic efficiency of plant through which the increased number of fruits per plant (Kachave and Bhosle, 2007). NAA and GA₃ at different concentration improve the internal physiology of developing fruit in terms of better supply of water, nutrients and other compound vital for their proper growth and development which results more number of fruits per plant (Pandey, 1999)

Similarly increased number of fruits with NAA and GA₃ also reported by Das and Manapatra (1975), Rathod and Amin (1981) in Sapota and Khan *et al.*, (1993) in mango, Harish Kumar and Singh (1985) in Perlette grapes, NAA in Sapota (Chavan *et al.*, 2009) and in grape (Mohammed and Hulmani, 2000), fruit number per tree was significantly increased by NAA compared to GA₃ when applied at pea stage of Sapota (kadam *et al.*, 2005).

Spraying of ethrel during post bloom stage caused abscission resulted physiological breakdown of calcium pectate of middle lamella and thinning of fruitlets which ultimately resulted less number of fruits per plant. It may be due to ethrel lowered the auxin supply from the leaf to the abscission zone, inhibiting auxin synthesis and promoting auxin destruction (Walkins, 1984).

Decreased in number of fruits per plant with ethrel was supported by Rema and Sharma, (1993) in Phalsa, in Late Valencia oranges (Hutton, 1992). Ethrel significantly increases in fruit thinning of Muntakhab Al-Latifiya plum cultivar (*Prunus salicina* L.) (Mohammad and Mohammad 1990), in Elstar apple trees (Rooijen 1992), in Flordaprince peaches (Abdel-Hamid 1999).

5.4 Days to first picking, fruiting duration and cropping duration

The fruits from bushes treated with growth regulators came to harvest earlier than control (Table 5). NAA and GA₃ at lower concentrations and kinetin and ethrel at higher concentrations induced early ripening and pickings compared to higher concentrations in Phalsa. The effectiveness of growth regulators in this respect was in the order GA₃ followed by NAA, Ethrel and Kinetin.

The fruit from GA₃ 50 ppm treatment comes to picking about 5.67 days earlier than those of control. Early maturation of GA₃ treated fruit may be due to early completion of setting, acceleration of fruit growth rate and early conversion of starch and cellulose into sugars (Nanda and Purohit 1965).

A similar trend as above was noticed in respect of the fruiting duration and crop duration (Table 6). Treated bushes harvesting of fruits was over within 19.17 to 22.00 days whereas fruits from control bushes were available for a longer time (23.17days). This might be due to early picking of ripe fruits and less interval between the pickings. Crop duration in treated bushes was 115.17 days to 122.50 days whereas control was longer (124.83days) indicating the possibility of shorter duration and thereby reducing the harvesting costs, as it is well known that in Phalsa the cost of harvesting is high due to irregular and prolonged ripening.

GA₃ 50 ppm and NAA 25 ppm sprayed at pre bloom and full bloom stage came to harvest earlier than control in Phalsa (Prasad 1990). Similarly, NAA was also effective in advancing maturity of litchi fruits (Sharma *et al.*, 1986) and grapes (Siddique and chakrawar, 1980). Cutuli (1970) reported that GA₃ spray delayed maturity in lemons; Marei and Bondok (1974) and Asif *et al.*,(1983) in dates, early maturity was observed in fig (Rane, 1962 and Gaikwad.,(1975) and grapes (weaver, 1960; Rao *et al*; 1962 and Thilak, 1983). Moti (1971) also observed early maturity of grapes due to NAA and GA₃ sprays.

5.5 Fruit yield attributes

Fruit weight has shown positive response to the application of growth regulators (Table 7). Both the concentrations of GA₃ were superior to other treatments. Among NAA treatments 25 ppm recorded higher fruit weight than 50 ppm concentration. Kinetin both the treatments were superior to NAA and ethrel treatments. Thus it is clear that only

GA₃ was effective in enhancing the weight of the fruits more so at higher concentration where as NAA and ethrel failed to do so.

Application of GA₃ has escalated the fruit weight while the application of NAA depressed it. The beneficial effect of GA₃ in increasing fruit weight seems to be through enhanced mobilization of food reserves (Nanda and Purohit, 1965). The probable reason behind the increase in fruit weight might be rapid cell division and cell enlargement and accumulation of more sugars and water under the influence of exogenous application of growth promoting substances (Ruby Rani and Brahmachari, 2004).

The reduction in the fruit weight was maximum with NAA 50 ppm, which may be due to very high fruit set (Table 3) resulting in competition among the developing fruitlets for food. The cell enlargement is regulated either by gibberellins or auxins or both. The increase in the fruit size with growth regulators is presumably, primarily due to the augmentation of the native supply of those plant hormones which in the present studies have also been found to greatly increase fruit size when given at the time of pre bloom and post bloom.

Reddy (1977) and Prasad (1990) also reported that fruit weight was increased due to GA₃ sprays in Phalsa. In grapes similar results were obtained with GA₃ application in respect to individual berry weight and bunch weight (Al-Dujaili *et al.*, 1987; Hallbrooks and Mortenson, 1988).

The results obtained in respect of NAA are also agreement with the findings of Reddy (1977) who reported that Celemone sprays (NAA) did not increase fruit weight in Phalsa. Prasad (1990) reported reduction in fruit weight due to NAA application which is in conformity to the present findings.

Augmentation of yield is the ultimate goal of the grower. Growth regulators have proved effective in enhancing the yields of crops substantially, making it worthwhile to utilize the application of growth regulators. Significant yield increases were observed due to treatments with growth regulators as compared to control. The effectiveness of growth regulators was in the order: GA₃ followed by NAA, Kinetin, control and Ethrel. Application of GA₃ resulted in highest yield per bush. However, the higher concentration of GA₃ at 100 ppm resulted in significantly higher yield (Table 8). The increase in the yield due to GA₃ treatment due to increase in fruit set and fruit weight (Table 3 and 7). There was an increase of 45.24 per cent yield with application of 100 ppm of GA₃ over control. The increase in the fruit due to GA₃ might have contributed to higher yields per bush over NAA treatments and control. The higher fruit yield might be due to GA₃ mediating process for faster translocation and mobilization of stored metabolites or photosynthates from source points (Singh *et al.*, 2003).

Increased yield due to GA₃ application of Phalsa was also reported by Randhawa *et al.*, (1959), Singh *et al.*, (1966), Reddy (1977) and Moti sikh (1986). GA₃ treatments proved to increase the total yields in other fruits like citrus (Bredell, 1986), guava (Rajput and Singh, 1977) and fig (Joshi, 1964). Galston and Purves (1960) have pointed out that

different plant growth substances are required for integrated plant growth. Hinney *et al.*, (1975) reported that gibberellins display a remarkable diversity of physiological effects. Hence when GA₃ is sprayed at suitable concentrations, the physiological processes are geared up and results in quick growth and increased yields.

Fruit yield was reduced due to the application of ethrel at post bloom stage in Phalsa. This may be due to the ethylene mediated events in the abscission zone occurs as a dissolution of middle lamella, hydrolysis of cell wall and a localized cell enlargement which facilitates separation from the plant body (Abeles, 1973). Rema and Sharma, 1993 reported that full bloom spray of ethrel twice at 7 days interval at 240 ppm and 480 ppm induced abscission but total yield was higher at 480 ppm compared to control and lower at 240 ppm than control. However, the results obtained in the present study with respect to NAA also are in agreement with the findings of Reddy (1977) and Prasad (1990) in Phalsa.

5.6 Fruit quality attributes

Growth regulators are known to influence not only fruitset, yield etc, but also the quality parameter of fruits. A perusal of the literature shows that there are several instances wherein the growth regulators have positively influenced the Physico-chemical parameters and in fact improved the quantity. Further improvement of quantity has no meaning without the improvement in quality. In the present studies positive influence of growth regulators tried was noticed.

Significantly higher content of TSS was obtained when the bushes were sprayed with ethrel followed by GA₃, NAA and kinetin (Table 9). The increase in the TSS content due to chemical treatments ranged from 20.56 (Kinetin 15 ppm) to 25.72 (ethrel500 ppm) per cent over control

Increased in the TSS by ethrel may be due to quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from the leaves to the developing fruits (Tripathi and Sukhla, 2007). Rema and Sharma (1991) also reported that a significant increase in fruit total soluble solids after treatment with 480 ppm ethrel sprayed during full bloom compared to 240 ppm in Phalsa.

Spray application of NAA and GA₃ probably improved the internal physiology of leaves thereby causing better translocation of vital component in the fruit development and assimilation as well as utilization of photosynthates in developing fruits leading to improved quality in terms of TSS (Pandey, 1999). GA₃ is well known to increase the percentage of TSS through the induction of synthesis of alpha- amylase which causes hydrolysis of starch (Krishnamurthy 1981). The enhancement in TSS content might be due to rapid hydrolysis of polysaccharides into soluble sugars and also due to increased mobilization of carbohydrates from the source to sink under the influence of applied growth regulators (Koruna *et al.*, 2007).

Higher concentration of ethrel and GA₃ and lower concentration of NAA were more effective in improving TSS in Phalsa. Similar results also reported by Rema and Sharma *et al.*, (1993) that ethrel at higher concentration increases TSS sprayed at full

bloom stage in Phalsa. The result obtained in respect of GA₃ are in accordance with results obtained by Randhawa *et al.*, (1959), Rao and Rao (1963), Reddy(1977), Moti Singh(1986) and Prasad(1990) increase of Phalsa and by Daulta(1982) in grapes.

Phalsa fruit are reported to contain 2.0 to 2.5 per cent acidity (Aykrowyd, 1963). The effectiveness of growth regulators was in the order: GA₃ followed by Ethrel, NAA and Kinetin. However, the treatments did not differ significantly either among themselves except GA₃ but all the treatment was significant over control (Table 9). The acidity of the fruit under the influence of growth regulators applied declined because it might have converted fastly into sugar and their derivatives ((Koruna *et al.*, 2007) or due to faster degradation of organic acids (Dutta *et al.*, 2008). Prasad (1990) also reported similar results with GA₃ in Phalsa. Sharma and Dhillon (1984) reported that titrable acidity decreased with Ga₃ application in litchi.

In general, increasing in the concentration of ethrel increased the acidity of fruits but it was still much lower than the control fruits in Phalsa. This result lends support from the findings of Rema and Sharma (1993).

The response of the content of reducing sugars to the growth regulators was also significant (Table 10). The content of reducing sugars was higher with of GA₃. The effectiveness of growth regulators was in the order: GA₃ followed by ethrel, NAA and Kinetin. Increased in reducing sugar with higher concentration of GA₃ was reported by Prasad (1990) in Phalsa and phaniprasasd (1980) in guava, Thilak (1980) in Thompson Seedless grapes. Gibberellins have been shown to act through auxin synthesis hence the

exogenous application of GA might have supplemented the endogenous auxin and causes greater influx of sugars in the fruits (Mohammed and Hulamani, 2001). Reducing sugar per cent age (18.67 %) was also improved with 500 ppm ethrel in Phalsa. Present finding was confirmed with the findings of Rema *et al.*, (1993) with ethrel in Phalsa.

The response of growth regulators on TSS: acidity ratio was significantly increased over control (Table 10). The effectiveness of growth regulators on TSS: acidity ratio was in the order: GA₃ followed by ethrel, NAA and Kinetin. Highest ratio was observed with the application of GA₃ which is due to the increase in TSS and decrease in acidity. This might be due to early and rapid degradation of acid and its conversion into sugars (Koruna *et al.*, 2007). Increased in TSS to acidity ratio with GA₃ was conformity with the findings of (Thilak, 1980) in Thompson seedless and (Mohammed and Hulamani, 2001) in Arkavati grapes.

The pulp weight per 100 fruits of Phalsa responded significantly to the spraying of growth regulators. However, interestingly the response varied with the chemicals and levels. Pulp weight increased after the application of GA₃ at both the levels, highest being with 100 ppm (Table 11). The increase in the pulp weight may be due to the cell multiplication and cell enlargement or may be enhanced uptake of water and accumulation of sugar and other food reserves in greater amount as well as increased volume of intercellular spaces in the pulp of fruit due to GA₃. This finding substantiate the earlier reports on this aspects (khan *et al.*, 1976, Singh and Lal,1980) in litchi, (Ruby Rani and Brahmachari,2004) in mango and Prasad and Bajpai (1963) who also observed

similar responses of Phalsa with the fruits application of GA₃. In respect of NAA, there was a rise in pulp weight with the lower concentration. The increase in the pulp weight due to NAA was also reported in mango (Zora Singh and Dhillon, 1986).

Bigger seed with thin pulp is decidedly a disadvantage in Phalsa reduction in seed content is desirable. Growth regulators are known to reduce the seed weight. The effectiveness of growth regulators was in the order GA₃ followed by NAA, Kinetin and ethrel. This is obvious from the results of the present investigation (Table 12). All the treatments have reduced the seed content but to a variable extent. The reduction was highest in the fruits from the bushes treated with GA₃ 100 ppm followed by NAA 25 ppm. NAA and GA₃ were found effective in producing parthenocarpic fruits in multiseeded fruits but in single seeded fruits they reduced the size and weight of the seed (Sharma and Dhillon, 1984). Such reduction in stone content by GA₃ was also reported in papaya (Shanmugavelu *et al.*, 1973). The decrease in seed content was associated with increase in concentration of GA₃. These results are in agreement with the findings of Rao and Rao (1963) who observed that parthenocarpic fruits with the increase in the concentration of GA₃. These results are in accord with Islam and Siddique (1973) in guava, Shanmugavelu *et al.*, (1973) in papaya. Babu and Lavania (1885) in citrus, Dass and Randhawa (1970) and Yadav *et al.*, (1977) in grapes and Sharma and Dhillon (1984) in litchi.

Naphthalene acetic acid treatments also recorded significant decrease in the seed content. Similar results were reported by Reddy (1977) in Phalsa. Rangaswamy and

Kaliaperumal (1960) in guava and Bal *et al.*, (1980) in ber. In the contrary, Zora Singh and Dhillon (1986) and Syamal and Chhonkar (1984) reported increased seed weight in mango and Aonla respectively.

Pulp to stone ratio was highest under GA₃ treatments, which may be ascribed to the higher pulp weight of fruits. NAA recorded lower ratio because of lower pulp weight (table 12). When the different levels were considered for evaluation, it was observed that higher level were effective in case of GA₃, ethrel and kinetin, while it is reverse with NAA treatments. The effectiveness of growth regulators in the order: GA₃ followed by NAA, ethrel and Kinetin.

5.7 Shelf life

A perusal of the result presented in the Table 13 indicated that Higher concentrations of kinetin, GA₃ and NAA improved the shelf life of Phalsa where as ethrel at higher concentration reduced it.

Maximum shelf life was obtained with Kinetin treatment at 30 ppm (51.46 hrs) followed by kinetin at 25 ppm, GA₃ at 100 ppm. Both the kinetin treatment was effective in improving shelf life. The increased in the shelf life due to kinetin application may be attributed to efficacy of kinetin to increase endogenous kinins, stimulates protein synthesis as well as nucleic acid synthesis thereby delaying the senescence and reduce the physiological loss of weight during storage. Similar results were reported by earlier

worker in grapes (Dedolph *et al.*, 1961, Randhawa *et al.*, 1976 and Dhillon., 1985), in apple (Mir *et al.*, 1996).

GA₃ 100 ppm was effective in increasing shelf life (48.40 %) of the fruits. This result is similar with the findings of Sudhavani and Ravisankar, 1998 in mango, Ray *et al.*, 2002 in sapota. This may be due to the action of GA₃ in counteracting the senescence that could be initiated by ethylene and abscissic acid (Sacher J A 1973). GA₃ improve the shelf life of many fruits by inhibiting bio synthetic pathway of enzyme, which are classified as non- specific ethylene inhibitors and lower physiological loss of weight ,decay loss and slower down the degradation of enzymes in fruits (Ben. Arie *et al.*, 1995).

Chapter VI

Summary

CHAPTER - VI

SUMMARY

A field experiment entitled “effect of growth regulators on flowering, fruitset, yield and quality in Phalsa (*Grewia sub-inaequalis* DC)” carried out during 2009-2010 in Model Orchard at College of Horticulture, Rajendranagar, Hyderabad. Treatments studied were NAA (25 and 50 ppm), GA₃ (50 and 100 ppm), Kinetin (15 and 30 ppm) and Ethrel (250 and 500 ppm). Altogether there were 9 treatments including control. Each treatment was replicated thrice in Randomized Block Design. The growth regulators were applied twice i.e., first spray was given at the time of pre bloom and again at post bloom stage. The results obtained in the study are summarized hereunder.

Maximum number of flowers per shoot was obtained with NAA 25 ppm followed by GA₃ 50 ppm. Flower number per shoot was also significantly increased with GA₃ 100 ppm. Lower concentration of growth regulators was more effective than their higher concentration except kinetin in increasing flower number per shoot of Phalsa. The overall view of entire data indicated that number of flowers per shoot of Phalsa was enhanced by NAA followed by GA₃, ethrel, kinetin over control. Among the treatments NAA25 ppm proved to be best for increasing number of flowers per shoot of Phalsa.

Phalsa bushes treated with NAA 25 ppm took significantly lesser number of days to 50 per cent flowering shoots per bush followed by GA₃ 50 ppm were on par. Other treatments also results early 50 percent flowering shoot per bush compared to control but

NAA and GA₃ at lower concentrations compared to higher concentrations was most effective to early flowering in Phalsa.

Higher fruit set was recorded with NAA 25 ppm followed by GA₃ 50 ppm were on par but significantly superior over control. Kinetin both the concentration increases fruitset but less effective compared to NAA and GA₃. Minimum fruit set was recorded with ethrel 500 ppm. Application of NAA and GA₃ and at lower concentrations and kinetin at higher concentrations were more effective in improving fruit set.

Bushes treated with NAA 25 ppm took significantly lesser number of days for flowering to fruit set followed by GA₃ 50 ppm were on par. Days for flowering to fruitset was earlier with NAA and GA₃ at lower concentrations. Kinetin both the concentrations recorded earlier flowering to fruitset but not much effective than NAA and GA₃. Ethrel 250 ppm and ethrel 500 ppm were on par with control.

Maximum number of fruits per node was recorded with bushes treated with NAA 25 ppm followed by GA₃ 50 ppm. GA₃ 100 ppm recorded significantly more number of fruits per node over control. Both the kinetin concentrations increased number of fruits per node but less effective than NAA and GA₃. Minimum number of fruits produced per node was recorded in ethrel 500 ppm followed by ethrel 250 ppm.

Similarly lower concentrations of NAA, GA₃ and higher concentration kinetin being more effective in increasing number of fruits per shoot and number of fruits per

plant in Phalsa whereas ethrel at higher concentrations reduced number of fruits per shoot and number of fruits per plant.

Bushes treated with GA₃ 50 ppm recorded significantly lesser number of days to first picking. NAA and GA₃ at lower concentrations induced early ripening and pickings compared to higher concentrations and Kinetin and ethrel at higher concentrations took lesser days to first picking than control but not much effective than NAA and GA₃ in Phalsa.

Bushes sprayed with GA₃ 50 ppm recorded less fruiting duration was on par with NAA 25 ppm. Ethrel both the concentrations recorded less fruiting duration but less effective than lower concentrations of NAA and GA₃. Both the kinetin concentrations are less effective than other growth regulators. Both NAA and GA₃ at lower concentrations than their respective higher concentration and kinetin and ethrel at higher concentration were more effective in reducing fruiting duration.

Bushes sprayed with GA₃ 50 ppm recorded less crop duration on par with NAA 25 ppm. Less crop duration was observed with ethrel both the concentrations and kinetin both the concentration was not much effective in reducing the crop duration in Phalsa. Both NAA and GA₃ at lower concentrations than their respective higher concentration and kinetin and ethrel at higher concentration were more effective in reducing crop duration.

GA₃ 100 ppm recorded maximum 100 fruit weight in Phalsa. Minimum fruit weight was recorded with NAA 50 ppm followed by NAA 25 ppm which was on par with each other. Kinetin and ethrel both the treatments do not varied each other on increasing the fruit weight. Fruit weight recorded in control was superior to NAA.

The higher yield per plant was recorded with GA₃ 100 ppm followed by GA₃ 50 ppm. Least yield was recorded with ethrel 500 ppm followed by ethrel 250 ppm. However, NAA at 25 ppm and 50 ppm recorded higher yield but not superior than GA₃ treatments. Kinetin both the treatment increased the fruit yield but not superior than NAA and GA₃.

The maximum yield per hectare was recorded with bushes treated with GA₃ 100 ppm followed by GA₃ 50 ppm. Minimum yield was recorded with ethrel 500 ppm followed by ethrel 250 ppm. NAA 25 ppm and 50 ppm recorded significantly higher yield but not superior than GA₃ treatments. Kinetin both the treatments increased the fruit yield but not superior than NAA and GA₃.

Highest TSS was recorded with ethrel 500 ppm followed by ethrel 250 ppm , GA₃ at 100 ppm. NAA and kinetin both the treatments improved the TSS over control. In general it was found that ethrel, kinetin and Gibberellic acid treatment at higher concentration and NAA at lower concentration was more effective in improving TSS of Phalsa.

All the growth regulator treatments were found effective in reducing the acidity of Phalsa particularly GA₃. GA₃ 100 ppm was more effective in reducing acidity than at lower concentration 50 ppm. Lower acidity was recorded with ethrel 250 ppm which was on par with ethrel 500 ppm. Other treatment did not varied much each other but superior than control.

Maximum content of reducing sugars was observed with GA₃ 100 ppm followed by ethrel 500 ppm. GA₃, ethrel and kinetin at higher concentration and NAA at lower concentration found superior in increasing the reducing sugar per cent.

Maximum TSS: acidity ratio was observed with GA₃ 100 ppm followed by ethrel 250 ppm. Kinetin at higher concentration and NAA at lower concentration found superior than control in increasing the TSS to acid ratio in Phalsa. It was noted that GA₃ at higher concentrations and ethrel at lower concentrations increasing the TSS: acidity ratio in fruits.

Higher pulp weight was recorded is bushes treated with GA₃ 100 ppm followed by GA₃ 50 ppm. NAA and ethrel at lower concentration and kinetin at higher concentration found to increased pulp weight in Phalsa. However, no significant differences were observed among the two levels of individual chemical treatments except NAA.

Minimum stone weight was recorded is bushes treated with GA₃ 100 ppm followed by NAA 25 ppm. Kinetin and ethrel both the concentrations were less effective than NAA and GA₃ in reducing the stone weight in Phalsa fruit. Though all the chemicals

reduced stone weight in treated fruits, only GA₃ and NAA were significantly more effective in reducing the stone weight.

Higher pulp to stone ratio was recorded in bushes treated with GA₃ at 100 ppm followed by GA₃ 50 ppm. NAA at lower concentration than its higher concentration was more effective in increasing the pulp to stone ratio. Kinetin and ethrel both the concentrations were less effective than NAA and GA₃ in increasing the pulp to stone ratio in Phalsa fruit. It was noticed that GA₃ treatments recorded higher values of pulp to stone ratio in Phalsa.

Highest shelf life of the fruits was recorded with kinetin 30 ppm followed by kinetin 15 ppm. GA₃ 100 ppm and NAA 50 ppm recorded higher shelf life but less effective than kinetin treatments. Higher concentrations of kinetin, GA₃ and NAA improved the shelf life of Phalsa whereas ethrel at higher concentration reduced it.

Conclusion

From the above study it is concluded that pre and post bloom sprays of GA₃ 100 ppm was found to be superior in improving yield and quality of Phalsa fruits compared to NAA, kinetin and ethrel treatments. Spraying of GA₃ 100 ppm increased fruit weight resulted in higher yield per bush and also improved quality of fruits by increasing the TSS, reducing sugar, TSS to acid ratio, pulp weight and pulp to stone ratio and reducing the acidity and stone weight over other treatments. Spraying of NAA 25 ppm was effective in increasing flower number, fruitset, number of fruits per plant and reducing

days to 50 per cent flowering, fruiting and crop duration but less effective in increasing the yield and quality over GA₃ treatments of Phalsa. Pre bloom and post bloom spraying of kinetin 30 ppm improved the shelf life of Phalsa fruits whereas ethrel 500 ppm and 250 ppm improved TSS content of the fruits but resulted lower yield compared to all the treatments.

Future line of work

- Effect of growth regulators to induce seedlessness in Phalsa.
- Effect of post bloom and pre harvest spray of benzyl adenine and micro nutrients (Calcium and Zinc) on shelf life of Phalsa fruits.
- Effect of pre bloom and full bloom spray of NAA, GA₃, 2, 4-D and their combination on yield and quality of Phalsa.

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The pattern of 'Literature cited' presented above is in accordance with the 'Guidelines for thesis presentation for Andhra Pradesh Horticultural University'.

Appendices

APPENDIX-I

Weekly meteorological data during crop growth period from November 2009 to April 2010.

| WEEK NO. | PERIOD | <u>TEMPERATURE</u> (°C) | | R.H. (%) | | RAIN- FALL (mm) | RAINY DAYS | SUN- SHINE (hrs.) | WIND SPEED (km/hr) | EVAPO- RATION (mm) | MEAN TEMP. (°C) |
|-------------|-----------|----------------------------|------|-------------|------|-----------------------|---------------|-------------------------|--------------------------|--------------------------|-----------------------|
| | | MAX. | MIN. | I | II | | | | | | |
| 48 | 26-02 DEC | 28.5 | 12.4 | 79.3 | 74.0 | 0.0 | 0.0 | 8.9 | 2.3 | 6.9 | 20.4 |
| 49 | 03-09 | 29.1 | 14.0 | 84.1 | 39.4 | 0.0 | 0.0 | 8.2 | 2.1 | 6.2 | 21.6 |
| 50 | 10-16 | 28.8 | 14.4 | 87.4 | 40.0 | 0.0 | 0.0 | 8.0 | 2.8 | 6.4 | 21.6 |
| 51 | 17-23 | 28.5 | 15.6 | 88.0 | 44.7 | 0.0 | 0.0 | 7.5 | 3.7 | 6.1 | 22.0 |
| 52 | 24-31 | 27.7 | 12.9 | 86.8 | 44.4 | 5.0 | 1.0 | 5.3 | 3.0 | 5.5 | 20.3 |
| 1 | 01-07 JAN | 28.8 | 12.1 | 79.3 | 35.9 | 0.0 | 0.0 | 8.9 | 2.4 | 6.0 | 20.5 |
| 2 | 08-14 | 27.7 | 17.8 | 85.3 | 60.1 | 9.6 | 1.0 | 4.4 | 3.0 | 5.0 | 22.8 |
| 3 | 15-21 | 28.0 | 13.6 | 86.6 | 36.7 | 0.0 | 0.0 | 6.1 | 2.9 | 4.8 | 20.8 |
| 4 | 22-28 | 28.0 | 11.8 | 85.4 | 35.1 | 0.0 | 0.0 | 8.9 | 2.7 | 5.9 | 19.9 |
| 5 | 29-04 FEB | 29.4 | 13.7 | 81.9 | 33.6 | 0.0 | 0.0 | 8.6 | 4.0 | 5.9 | 21.6 |
| 6 | 05-11 | 31.0 | 15.1 | 76.3 | 31.0 | 0.0 | 0.0 | 9.1 | 3.4 | 6.5 | 23.1 |
| 7 | 12-18 | 33.5 | 17.7 | 78.1 | 28.6 | 0.0 | 0.0 | 8.8 | 4.7 | 6.6 | 25.6 |
| 8 | 19-25 | 35.3 | 20.2 | 81.4 | 29.4 | 0.0 | 0.0 | 8.4 | 3.9 | 6.1 | 27.8 |
| 9 | 26-04 MAR | 31.4 | 15.8 | 65.9 | 42.3 | 0.0 | 0.0 | 7.8 | 2.7 | 6.0 | 23.6 |
| 10 | 05-11 | 37.0 | 20.7 | 74.3 | 33.7 | 0.0 | 0.0 | 8.2 | 3.5 | 7.1 | 28.9 |
| 11 | 12-18 | 35.9 | 19.3 | 76.6 | 39.3 | 2.0 | 0.0 | 6.7 | 3.2 | 6.7 | 27.6 |
| 12 | 19-25 | 38.1 | 19.8 | 66.0 | 40.7 | 0.0 | 0.0 | 8.0 | 3.1 | 6.9 | 29.0 |
| 13 | 26-01 APR | 38.3 | 22.1 | 71.9 | 49.4 | 3.6 | 1.0 | 6.9 | 3.6 | 7.1 | 30.2 |

