CHEMICAL REGULATION OF CROPPING IN MANGO

By

RANDEEP. K. R.

Department of Pomology and Floriculture

COLLEGE OF HORTICULTURE

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RANDEEP. K. R.

THESIS

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Department of Pomology and Floriculture

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2012

DECLARATION

I, hereby declare that the thesis entitled "**Chemical regulation of cropping in mango**" is a bonafide record of research work done by me during the course of research and that it has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara **Randeep. K. R.**

Date: **(2008-12-105)**

CERTIFICATE

Certified that this thesis, entitled "**Chemical regulation of cropping in mango**" is a record of research work done independently by **Mr. Randeep. K. R. (2008-12-105)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara

Date:

Dr. T. Radha

(Major Advisor, Advisory Committee)
Professor
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur.

.

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mr. Randeep. K. R. (2008-12-105)**, a candidate for the degree of **Master of Science in Horticulture** agree that the thesis entitled "**Chemical regulation of cropping in mango**" may be submitted by him in partial fulfillment of the requirement for the degree.

Dr. T. Radha

(Major Advisor, Advisory Committee)
Professor
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur.

Dr. P.K. Rajeevan

Professor and Head
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur

Dr. N. K. Parameswaran

Associate Professor
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur

Dr. K. Nandini

Professor and Head
Department of Plant Physiology
College of Horticulture
Vellanikkara, Thrissur.

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Dedicated

To

My

Beloved Family

Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.) is the most important fruit crop grown in almost all the tropical and subtropical regions of the world. The fruits are valued for high nutritive and medicinal values apart from the captivating flavour, attractive appearance and irresistible taste owing to which it is known as the 'King of fruits'. In India, mango is the choicest fruit having great socio-economic significance. It has been designated as the 'National fruit' of the country because of its wide adaptability, richness in variety and popularity among the people. India is the largest producer of mango in the world contributing more than half of the total global production. It is grown in an area of 2.30 million hectares with an annual production of 15.20 million tons, the average productivity being 6.60 t/ha (NHB, 2012).

Mango is an inevitable component of every homestead in Kerala and has a close relationship with the culture of people. Though we have mango trees almost throughout the state, it is yet to attain a commercial status here. The fact that Kerala contributes the first mangoes in Indian markets every year, points out the significance of this crop in the state. The low rainfall areas of Palakkad district are now becoming predominantly a mango-growing tract. Commercial orchards have come up in this area mostly with selected commercial varieties such as Alphonso, Bennet Alphonso, Neelum, Bangalora, Banganapally and Kalapady.

Area under mango in Kerala is 0.63 lakh ha with an annual production of 3.73 lakh tons (FIB, 2012). Average productivity worked out comes to 5.85 t/ha. Low yield of mango in the state is mainly due to the lack of scientifically managed commercial orchards, alternate and non-flowering behaviour of the crop, excessive fruit drop and lack of information on the performance of commercial varieties introduced from other growing regions.

As in any other crop, flowering process is of vital importance to mango productivity as yield is directly dependent upon its success or failure. Scientists still consider flowering and cropping of mango as an unpredictable and complex phenomenon. One can encounter with problems such as sparse, alternate, irregular and absence of flowering which ultimately lead to poor yields. Each fruit tree in the commercial orchard does not bear equal crops year after year. Varietal nature, climatic variations in a particular year, plant water stress, management problems, pests and diseases as well as physiological changes occurring in trees during floral induction period are the main reasons for erratic bearing accounting for low productivity of mango. Alteration in cropping habit of mango is used as a synonym for poor yields. In mango, growth flushes are very erratic occurring up to 3-4 times per year on individual stems, depending upon cultivar and growth conditions mainly. New shoots tend to flower only after 8-10 months of growth by which they attain proper physiological maturity (Pandey, 1989). Therefore, bienniality/irregularity in flowering would ensue because of inability of one shoot to bear vegetative growth and flower in the same year.

Several chemicals and plant growth regulators like ethephon, potassium nitrate and triazoles particularly paclobutrazol were found effective to regulate the flowering and fruiting in mango by inhibiting vegetative growth of shoots and promoting flowering. Amongst them paclobutrazol is being widely used to increase flowering, enhance yield and control the alternate bearing habit in commercial mono embryonic varieties of almost all the mango growing countries including India. Paclobutrazol having anti-gibberellin activity induce flowering even in the ‘off’ year season by regulating the synthesis of gibberellins, which can also be used for advancing the harvesting of fruits from late varieties by about one month. Application of ethephon (ethrel) has been found to stimulate the differentiation of floral buds thereby increasing flowering, in turn leading to higher yields (Ataide and Jose, 2000). Potassium nitrate is commercially used in countries like Philippines for regular flowering and fruiting of their popular poly embryonic varieties.

Excessive fruit drop is another serious problem faced by mango growers resulting in low yields. Of the many problems adversely affecting the economic potentialities of mango production, enormous shedding of flowers and immature fruitlets has been considered to be one. Our knowledge regarding the intensity and periodicity of shedding, causes of fruit drop and factors affecting the abscission of developing fruitlets in mango is essentially limited. Application of auxins externally was found to prevent abscission in many fruit trees. In mango also beneficial effects of auxins especially NAA has been proved to reduce excessive fruit drop with great success and is being recommended as a regular practice in many places.

However, little systematic research has been conducted on these aspects and recommendations evolved to suit for Kerala conditions for the problem. This becomes more significant with the typical alternate bearing nature of the superior and commercial variety Alphonso under cultivation in the state also. Inconsistency of cropping in mango remains as the most serious problem faced by growers which in turn result in their failure to meet the market demands regularly. Since floral manipulation can be considered as one of the reliable methods to overcome this situation, the present study entitled '**Chemical regulation of cropping in mango**' was taken up to explore the possibilities of growth regulators/chemicals for tackling sparse flowering, alternate/erratic bearing and excessive fruit drop as observed in commercially cultivated mango varieties under Kerala conditions.

Review of Literature

2. REVIEW OF LITERATURE

Scientists still consider flowering and cropping of mango as an unpredictable complex phenomenon. Problems in mango culture mainly include sparse, alternate, irregular and absence of flowering ultimately leading to low yield. These conditions may be occurring due to different reasons such as varietal nature, climatic conditions, management problems, pests and diseases etc.

Irregular bearing is manifested mainly due to inability of once fruited shoots to differentiate flower buds directly for the next flowering season. A measure tried to manage this problem was by way of stimulating the sub apical buds of fruited shoots to develop flowers directly instead of undergoing the vegetative phase and development of new shoots. This unique school of thought was materialized with the use of bio regulators. Among the different bio regulators used for induction of flowering in mango, paclobutrazol produced early and profuse flowering. Potassium nitrate has been used to induce flowering in several countries with good success. Ethrel is another hormone proved to be beneficial for induction of flowering in mango. Excessive fruit drop is a serious problem resulting in low yield in mango. Drop to the tune of 99% has been reported in different varieties. Control of excess fruit drop also is obviously a method to increase yield from mango. For this purpose, use of different chemicals and hormones has been tried with fruitful results.

Literature is rich revealing lot of works with respect to the effect of different bio regulators and chemicals on flowering and fruiting in mango varieties. An attempt has been made in this chapter to review the available related literature under appropriate subtitles.

2.1. Effect of paclobutrazol (PBZ) on regulation of cropping in mango

The large tree size of mango creates a major problem for growers of this crop, especially in orchard management which in turn results in low orchard efficiencies. Control of tree growth with growth retardants provides an attractive proposition in the absence of suitable dwarfing rootstocks for mango. Paclobutrazol ((2RS, 3RS)-1- (4-chlorophenyl) – 4 - 4-dimethyl-2- (1, 2, 4- triazol-1-yl) - pentan-3-ol) is acknowledged to be specific inhibitor of gibberellin biosynthesis, with reduced inter-node extension as the main morphological effect (Rademacher et al., 1984).

Exogenous application of GA as well as endogenous high levels of gibberellins has proved a major hindrance in the way of flower bud differentiation in a number of temperate as well as tropical fruits including mango (Kachru et al., 1971; Tomer, 1984). In mature mango trees, flowering is associated with reduced vegetative growth often induced by lower activity of gibberellins (Voon et al., 1991). These findings have contributed greatly towards better understanding of this phenomenon. Considering the above inhibitory role of GA for flower development in mango, paclobutrazol, owing to its anti gibberellin activity (Quinlan and Richardson, 1984; Webster and Quinlan, 1984; Erez, 1986) could induce or intensify flowering by blocking the conversion of Kaurene to Kaurenoic acid, the precursor of gibberellins.

Research findings of many workers (Burondkar and Gunjate, 1993; Singh, 2000; Singh and Singh, 2003a; Singh et al., 2004; Singh, 2008) indicated that soil application of paclobutrazol suppressed the vegetative growth and enhanced flowering and fruiting in mango.

2.1.1. Effect of PBZ on flowering

Soil applications of paclobutrazol on mangoes (1-20 g / tree) reportedly reduce internode lengths and cause earlier and enhanced flowering in young and old trees when compared to non-treated trees (Hasdiseve and Tongumpai, 1986; Haw, 1986).

Kulkarni (1988a) found that PBZ induced early and increased flowering in two mango cultivars Dashehari and Banganapalli under Indian conditions. He also found small sized panicles in these treatments which he attributed to either an increase in the number of panicles or negative effect of paclobutrazol. Burondkar and Gunjate (1991) reported that PBZ as soil application increased the number of perfect flowers in Alphonso mango and narrowed sex ratio.

Soil application of PBZ was found to reduce the canopy density and tree size and also increased the number of flowering shoots (Charnvichit and Tongumpai, 1991). Stronger and persistent influence of PBZ as an anti-gibberellin might be responsible for its high effectiveness in promoting flowering (Kurian and Iyer, 1992). Kurian et al. (1992) observed reduced cytokinin levels in leaves with inhibition of bud initiation in plants treated with soil drenches of PBZ.

According to Winston (1992), soil treatments of PBZ were more effective in flowering and cropping than foliar application, with collar drenches more effective than drip line treatment. PBZ at rates >1g per tree caused unacceptable flower compaction in 3-5 year old Kensington Pride trees and 2g per tree caused unacceptable growth reduction. Application of 5-10 g/tree of this chemical as soil drench at the collar region was reported to increase flowering in Alphonso mango also by Burondkar and his co workers (1993). Soil applied PBZ (10 g /tree) significantly narrowed the sex ratio in Alphonso (Kurian and Iyer, 1993). However, as per Ram and Tripathi (1993), PBZ treatments had no significant effect on panicle length and sex ratio in Dashehari mango under Pantnagar conditions.

Elevated levels of phenolic compounds were also found in resting apical buds of PBZ treated trees (Kurian et al., 1994). They suggested that the lower cytokinin activity and high phenolic levels in buds contributed to inhibition of shoot initiation and enhanced flowering by altering assimilate portioning and patterns of nutrient supply for new growth.

Soil application of 10 g PBZ mixed with five litres of water in the ring of 15 cm depth dug 60 cm away around the tree trunk in August resulted in appreciable flowering during the ‘off’ year of Alphonso under Karnataka conditions (Rao et al., 1997).

Results of study conducted in Kerala Agricultural University to find out the effect of PBZ on flowering of old, unproductive mango trees clearly indicated the existence of varietal response to this chemical. The optimum concentration of PBZ was 4 g per tree per year for responsive varieties (Radha et al., 1998).

Vijayalakshmi and Srinivasan (1999) reported that, application of PBZ was significantly superior in increasing the leaf area compared to other treatments like potassium nitrate, urea and ethrel, recording an average area of 94.89 cm^2 as against 63.65 cm^2 in control. According to them, increase in leaf area has overcome the limitation of depletion for reserve food materials, resulting in high levels through which the breaking up of alternate bearing tendency in Alphonso has been achieved.

The length of panicle was found to be reduced significantly over control by PBZ treatments in Alphonso mango (Shinde et al., 2000). According to Singh (2000), soil application of PBZ (40 g/tree) was found to be effective for controlling inter-nodal length and size of panicle in mango cv. Dusheri. These treatments also increased the percentage of hermaphrodite flowers. Experiment conducted by Vijayalakshmi and Srinivasan (2002) at Tamil Nadu Agricultural University, Coimbatore in Alphonso showed that soil application of PBZ (2.5 g/tree) produced maximum number of flowers per panicle. This treatment also improved the proportion of hermaphrodite flowers (30.59 %) and found to be effective in increasing the length of panicle to an extend of 31.57 cm. Contradictory to this, Singh and Singh (2003a) reported significant effect of PBZ on length of panicles and average panicle length was reduced as a consequence of both soil and spray treatments.

According to a study in mango cv. Langra, earliest panicle emergence (162 days) was observed on trees applied with PBZ @ 3.75 and 5.0 g/tree. The maximum number of flowering shoots/m^2 (30.32) and percentage of flowering shoots (96.15%) were recorded in trees applied with PBZ at 5.0 g/tree (Baghel et al., 2004).

On studying the effect of different plant bio-regulators on promotion of flowering in Dusehri, Singh et al. (2004) reported substantial increase in the number of panicles/m^2 with PBZ @ 5g and 10 g/tree. Inflorescence length and breadth also significantly reduced with different doses of PBZ as compared to control. They have observed that sex ratio could be manipulated by application of GA inhibitors such as paclobutrazol, which favoured more number of hermaphrodite flowers in mango cv. Dusehri.

Karuna and Mankar (2008) showed that soil application of PBZ suppressed the vegetative growth and stimulated profuse flowering in Langra mango. Singh (2008) showed that PBZ @ 1.25 g/tree was most effective to reduce the tree vigour by restricting the vegetative shoot growth, size and spread of Neelum grafts.

Protacio et al. (2009) observed that paclobutrazol treated trees had longer inflorescences in Carabao mango and he attributed this to the influence of PBZ on assimilate partitioning in favour of the reproductive shoot rather than acting as a growth retardant. Nafees et al. (2010) reported that paclobutrazol treatments suppressed the emergence of vegetative shoots, shoot length, leaf number and canopy volume, which promoted intense flowering in different mango cultivars.

2.1.2. Effect of PBZ on fruit set and drop

Profuse flowering, increased fruit set and retention as a consequence of soil application of PBZ @ 5 g/tree have been reported by various research workers (Sarkar et al., 1988; Goguey, 1990; Burondkar and Gunjate, 1993; Desai and Chundawat, 1994)

It was reported by Shinde et al. (2000) that different doses of PBZ, irrespective of their application time, significantly increased the fruit set per panicle over control in Alphonso.

Research findings of Singh and Singh (2003a) indicated that soil application of PBZ @ 5 g per tree was most effective to induce more number of flowering shoots (35.18 %) and to improve the fruit set (56.17%) and retention (3.97%) during 'off' years in mango cv. Bombai. Higher number of fruit set per panicle and reduced fruit drop were noticed with PBZ treatments in Langra variety when compared with other growth regulators and nutrients (Karuna et al., 2007; Karuna and Mankar, 2008).

Studies of Nafees et al. (2010) showed that percentage of fruit setting was significantly higher in trees drenched with different doses of paclobutrazol. The least fruit drop was observed with 12 g PBZ and highest value was recorded in control trees. Paclobutrazol treatments resulted in enhanced flowering, increased fruit set and retention at marble and maturity stages per panicle in Alphonso, Kesar and Rajapuri (Tandel and Patel, 2011).

2.1.3. Effect of PBZ on yield and fruit quality

Paclobutrazol as collar drench significantly increased both fruit number and total fruit weight at harvest, compared with control and foliar application. The response increased with increasing rate of PBZ. Average fruit weight and TSS were unaffected by different doses of the chemical (Winston, 1992).

As per Burondkar and Gunjate (1993), PBZ treatments in Alphonso recorded significantly more yield over control while, mean weight of fruit was unaffected with these treatments. None of the treatments impaired or improved any of the fruit quality attributes.

On 25 year old Alphonso trees, application of PBZ @ 0.75 g and 1.25 g per meter on crown diameter basis applied at 90 days and 120 days before bud break, significantly increased flowering (68.48 to 80.60%) and fruit yield (92.82 to 117.87 kg/tree) as compared to control (30.03 kg/tree) (Shinde et al., 2000).

Vijayalakshmi and Srinivasan (2000) reported the superiority of PBZ over other treatments in improving the quality attributes of Alphonso fruits. An increase in TSS of 16.33^0 Brix, 13.66% of total sugars, 2.54% of reducing sugars and reduced acidity of 0.25% were observed in the fruits collected from the treated trees. A high sugar/acid ratio of 53.63 was also recorded in these fruits. In Neelum variety, soil drenching of PBZ with a basal application of 1:1:1.5 kg of N, P and K per tree enhanced the flower and fruit production. A dose of 1.25g at 90 days before bud break resulted in maximum number and weight of fruits per tree both in 'off' season and main season (Anbu et al., 2001b).

Studies conducted at CISH, Lucknow revealed that application of paclobutrazol as soil drench with a dose of 0.80 g per tree produced higher number of fruits in Dashehari compared to control. However, in Chausa and Langra maximum yield was obtained in 1.20 g treated trees. Trials conducted at FRS, Sangareddy and RFRS, Vengurla showed that application of 1.25 g PBZ at 120 days before bud break recorded highest yield compared to control in Benishan and Alphonso (Anon., 2002).

According to Singh and Singh (2003a), highest yield during 'off' year was recorded under soil application of PBZ @ 5 g per tree followed by 10 g per tree. These treatments also improved the quality of fruits in terms of higher TSS, sugars, ascorbic acid and reduced acidity in mango cv. Bombai. Singh and Singh (2003b) obtained the similar results with PBZ at same concentration in Dashehari variety.

Maximum yield per tree (68.12 kg), yield per hectare (106.25 q/ha), and yield increase over the control (29.85%) were reported in trees applied with PBZ @ 5 g/tree in combination with 20 ppm NAA (Baghel et al., 2004). Overall improvement in flowering and yield parameters by paclobutrazol treatments were reported by Yeshitela et al. (2004b) in Tommy Atkins mango.

Positive response to soil application of 5 g PBZ resulting in induction of regularity of bearing in varieties like Alphonso and Kesar in Gujarat and Maharashtra has been reported. This treatment induced more floral shoots and improved the yield and fruit quality during 'off' year (Singh et al., 2005).

According to Singh and Ranganath (2006), PBZ @ 1.25 g/liter/tree applied once in mango cv. Banganapalli was found to increase flowering, fruit set, retention, yield and brought slight improvement in fruit weight and total soluble solids.

Paclobutrazol @ 7.5 g/tree improved fruit yield and quality in mango cv. Langra during both 'off' and 'on' years. However, there was no significant effect on individual fruit and pulp weight (Karuna et al., 2007). Similar results in Langra variety were also reported by Karuna and Mankar (2008). It was reported by Singh (2008) that maximum yield could be obtained with PBZ @ 0.60 g/tree in Neelum mango. Average fruit weight was significantly maximum with same treatment however increasing levels of the chemical could not produce further improvement in this parameter. There was no significant effect of these treatments on peel and stone weight, TSS, acidity and carotenoids of fruits.

Heading back of old Alphonso mango trees and application of paclobutrazol @ 7.5 g/tree was found beneficial for early flowering and enhanced fruit yield (Mistry and Patel, 2009). Application of PBZ @ 5 g/tree increased the yield per tree in Alphonso, Kesar and Rajapuri varieties. Whereas, this treatment neither improved nor impaired the reducing sugars, total sugars, acidity and total soluble solids in any of the cultivars (Tandel and Patel, 2011).

2.1.4. Effect of PBZ on carbohydrate and nitrogen content

Subhadrabandhu et al. (1997) observed that paclobutrazol at all concentrations had an effect on higher total non structural carbohydrates (TNC) content, higher reducing sugar content (RS) and higher total nitrogen (TN) in both leaves and shoots of Khiew Sawoey mango. TNC in the leaves accumulated to the maximum level at the time before first flowering in these treated trees. At the time of flowering, carbohydrate content and total nitrogen were gradually decreased. There was no clear difference in C/N ratio in leaves of PBZ treated trees and the control trees.

Paclobutrazol promoted early accumulation of TNC within current year shoots prior to ‘off’ and ‘on’ season flowering due to inhibition of vegetative growth (Phavaphutanon et al., 2000). A decrease in leaf TNC slightly before stem TNC in the current year shoots during ‘on’ season flowering indicated that stored carbohydrates in leaves may be more readily utilized than those in stems.

Protacio et al. (2000) reported that paclobutrazol by preventing the gibberellin synthesis could promote early flowering in mango. In their experiment, a significant decline in gibberellic acid like contents of shoots from PBZ treated trees became apparent two months after the treatment. Starch content increased in stems of treated trees, suggesting that PBZ promotes flowering by increasing the starch accumulation.

Application of paclobutrazol at different doses, both as soil drench and sprays were effective in suppressing vegetative growth of trees. Consequently, trees from these treatments had higher TNC in their shoots before flowering. Application of PBZ did not affect the macro nutrient levels (N, P, K and Ca) of leaves. There was no increased mobilization of major elements to the leaves, either from the soil or from other plant parts, due to PBZ treatment (Yeshitela et al., 2004b).

According to Protacio et al. (2009), predicted increase in starch levels in PBZ treated trees was observed in leaves compared to shoot buds and stems since leaf is the ultimate storage destination of starch. Paclobutrazol is known to be an effective anti gibberellin compound (gibberellin prevents the accumulation of starch because it promotes starch breakdown and mobilization). Once the GA level in the shoots falls beyond a threshold hypothesized, starch accumulation will take place in the process and significant increase in starch content was noticed two months after treatment. These series of events will finally lead to the formation of floral initials.

2.2. Effect of potassium nitrate (KNO_3) on crop regulation in mango

Potassium nitrate can enhance flowering especially in tropical regions where cold temperature for floral induction may not be sufficient. The role of KNO_3 in mango flowering has been proposed to be floral inductive (Barba, 1974). The NO_3^- anion is the active component of KNO_3 (Bueno and Valmayor, 1974).

Flower induction by potassium nitrate spray may be due to the effect on ethylene synthesis as per various authors (Lieberman et al., 1965; Beevers and Hageman, 1969; Dutcher, 1972; Maity et al., 1972). According to Kulkarni (1988b), KNO_3 effect is indeed one that merely involves the bud break of preexisting floral buds and not a shift from vegetative to reproductive structures. This view is contrary to the findings of Dutcher and Valmayor (1974) who showed the absence of dormancy between floral differentiation and inflorescence expansion in mango. Other researchers (Tongumpai et al., 1989; Davenport, 2007) observed the necessity of additional factors apart from the application of KNO_3 for mango flowering.

2.2.1. Effect of KNO_3 on flowering

Foliar application of nitrogenous compounds increased the number of male and hermaphrodite flowers, which further improved the potential fruit set in mango (Harley et al., 1942; Singh, 1974; Tiwari and Rajput, 1976).

Bondad et al. (1978) speculated that KNO_3 might play a role in the induction of floral differentiation probably through the nitrate assimilatory pathway. In their experiment, maximum panicle size was observed in treatments sprayed with KNO_3 and they explained that increase in panicle length of mango is a normal response to foliar application of nitrogen.

Bondad and Linsangan (1979) found that the results for KNO_3 sprays were influenced by the physiological age of growth flushes, since aged vegetative flushes responded better to KNO_3 applications than young flushes. They have reported that concentrations of potassium nitrate between 1 and 8 % stimulated flowering of seedling 'Carabao', 'Pahutan' trees and 'Pico' trees within one week after sprays were applied. KNO_3 concentrations of 2-4 % or 1-2 % NH_4NO_3 were found to be effective for initiating floral buds in different mango cultivars (Nunez-Elisea, 1985; Nunez-Elisea and Caldeira, 1988).

Fierro and Ulloa (1991) indicated a significant increase in number of panicles formed when KNO_3 treatments were applied in the initial stages of vegetative flush growth (i.e. three months before normal blooming period) in comparison with applications made at a later stage. They also observed that trees that had low or no production in the previous season seem to respond better to the applications of KNO_3 than trees that were productive. According to them, mechanism responsible for KNO_3 induction appears to be hormonally mediated. Despite poor correlation between KNO_3 application and panicle formation, hormones may establish a metabolic gradient that enhances panicle formation and uniform distribution of panicles. Goguey (1993) asserted that the response of plants to different flower inducing treatment differs according to variety, climatic conditions and geographical location. Rojas (1993) observed increased percentage of flowering shoots, mixed panicles and vegetative shoots with KNO_3 (6%) spray in 10 year old mango cv. Haden.

Foliar sprays of potassium nitrate, potassium sulphate, waxol-calcium suspension at 0.3 % and 0.6 % were applied thrice at bi weekly intervals to the post harvest flush in trees of mango cv. Sensation. All potassium nitrate sprays were effective in inducing flowering (Mckenzie, 1994). In the low and mid-latitude tropics, receptive trees respond by initiating floral buds within 2 weeks after KNO_3 application. The effective concentration ranges from 1-10 % whereas, the optimum concentration varies with the age of the trees and climate (Davenport and Nunez-Elisea, 1997). They also found that mango trees respond to potassium nitrate applications when they are located in tropical conditions, but not in the subtropics.

Shongwe et al. (1997) tested the efficiency of KNO_3 and methanol when applied during the ‘off’ season on mango varieties (Julie, Graham and Tommy Atkins). Both chemicals produced higher water use efficiency (WUE) and they concluded that the ability of KNO_3 and methanol to affect flowering is related to their relative effect on WUE. KNO_3 treatment increased the panicle size over methanol treatment and control. Davenport (2000) explained that, for successful stimulation of flowering, nitrate salt must be applied after the resting buds of mango have reached sufficient age to overcome any inhibitory influence they may have on the flowering response.

Protacio (2000) suggested a model for potassium nitrate induced flowering in mango in which it acts by elevating nitrogen levels over a nitrogen threshold there by synchronizing bud break from apices with existing floral initials. He discussed the need of nitrogen for flowering in mango. KNO_3 application triggers flowering by exceeding the threshold for nitrogen concentration. He mentioned that, in a mango tree that has already flowered or in the grafted trees, KNO_3 spray is an agent that initiates flowering from competent tissues ready to flower. It can, therefore, be stated that KNO_3 may be a stimulus for floral induction.

Vijayalakshmi and Srinivasan (2002) reported improvement of male to hermaphrodite flower ratio by potassium nitrate (1%) applied during the ‘off’ year in mango cv. Alphonso.

While evaluating the effects of potassium nitrate application alone or in combination with urea at different concentrations on flowering of Tommy Atkins mango grown in Ethiopia, all treated trees produced a significantly higher number of panicles than the control. Application of 4% KNO_3 + 0.5 g urea produced about twice as many panicles than control. Except for 2% KNO_3**,** all other treatments produced significantly higher % of hermaphrodite flowers than control (Yeshitela, 2004). KNO_3 promoted bud initiation for vegetative growth in non inductive temperature conditions and reproductive growth in the inductive conditions. The minimum inductive period at 10/15°C required for complete floral induction and development was found to be 35 days for both Tommy Atkins and Keitt. KNO_3 (3%) sprayed on Tommy Atkins after exposure to 35 days produced the longest inflorescence and longest flushes (Yeshitela et al., 2004a).

Hima (2007) has reported that foliar feeding of nitrate treatments including KNO_3 elevated the leaf nitrogen content and this nitrogen supplementation improved the floral intensity and growth rate of various floral parameters such as number of branches, length and girth of inflorescences. It can also be assumed that the sink effects of developing inflorescences on leaf/shoot nitrogen have been well compensated by this supplemental nitrogen. She also reported that KNO_3 sprays at 1% and 2% concentration could result in flowering of shoots within 10 and 9 days after application as against 24 days gap in control of Prior variety. Floral intensity and inflorescence size were also maximum in the same treatments.

2.2.2. Effect of KNO_3 on fruit set and drop

Singh (1987) stressed the importance of nitrogen for fruit growth and development. Sharma et al. (1990b) reported that potassium nitrate sprays significantly increased fruit set, retention and yield and also reduced fruit drop at Jabalpur conditions. Oosthuyse (1996) obtained increased fruit set, retention and yield through spraying of 2-4% KNO_3 at flowering in Tommy Atkins. Potassium nitrate (2%) sprayed at mustard stage improved the fruit set and retention of fruits until maturity in mango cv. Neelum (Anbu et al., 2001a).

Burondkar (2005) reported that nutrients including KNO_3 have significant influence on fruit retention and reduced the fruit drop in Alphonso. Presence of nitrogen in potassium nitrate may be responsible for this effect as it is one of the essential nutrients required for the retention of fruits.

On studying the effect of different forms of potassium based foliar sprays on flowering and fruiting in Banganapalli for two years, Bhagwan et al.(2009) could not find significant difference among treatments with respect to percent shoots flowered during first year as well as fruit set per panicle during both years. However during second year treatments, except KNO_3 @ 1% at 90 days before bud break, significantly influenced the percent shoots flowered compared to control.

Application of KNO_3 (1%) along with KH_2PO_4 (1%) during bud break stage recorded the maximum fruit set per panicle at marble stage, which might be due to increased fruit retaining capacity according to Venkatesan et al. (2009).

2.2.3. Effect of KNO_3 on yield and fruit quality

Singh (1980) suggested that growth regulators and nitrogen treatments could be beneficial for improving the fruit quality. Sharma et al. (1990b) observed that in cultivar Langra, maximum number of fruits/plant, non reducing sugars (14.15%), ascorbic acid content (68.5 mg/100 g pulp) and lowest acidity (0.267%) were resulted with KNO_3 (3%) + urea (4%).

According to Oosthuyse (1993), out of various treatments (KNO_3, urea, GA_3, CPPU and boron) the only treatment to increase fruit retention, average fruit mass, yield and monetary return was application of KNO_3. On five year old Haden trees at Venezuela, 36 g/l potassium nitrate was effective to maintain the high yield during two consecutive years, but control trees exhibited low yield and strong biennial bearing (Sergent et al., 1997).

According to Ataide and Jose (2000), 3% KNO_3 treated Tommy Atkins trees recorded higher number of fruits per tree without affecting the average fruit weight. It promoted higher production per tree and greater benefit/cost ratio.

Burondkar et al. (2002) studied the effect of different sources and doses of potassium on yield and quality of 'Alphonso' mango and reported that trees which received recommended dose of NPK as soil application when supplemented with KNO_3 (1%) foliar sprays, registered maximum yield (74.59 kg/tree) over rest of the treatments. This treatment also improved TSS of fruits.

In mango cv. Tommy Atkins, KNO_3 (4%) + urea (1g/tree) produced a higher fruit set at pea stage and yield per tree. Feeding of nitrogen through spraying of KNO_3 and urea is believed to be the reason for greater flowering and yield from sprayed trees. There was no significant difference with respect to the average weight of fruit at harvest between treated and untreated trees. Fruit quality was not affected by any of the treatments (Yeshitela, 2004). A detailed study on the effect of dormancy breakers on flower bud forcing in mango, indicated the positive effect of KNO_3 treatments in increasing yield and yield parameters (Hima, 2007).

According to Bhagwan et al. (2009), KNO_3 treatments did not show significant influence on yield during first year. However, during second year, KNO_3 (1%) at 60 days before bud break was found more effective in improving the yield partially due to its effect on mango fruit retention and KNO_3 (1%) at 90 days before bud break recorded the minimum yield. Average fruit weight and fruit quality was unaffected by these treatments during both years. On the contrary, Saravanaperumal et al. (2009) reported substantial improvement in yield and fruit quality as a result of combination spray of KNO_3 (1%) + KH_2PO_4 (1%) before bud break (December-January).

2.3. Effect of ethrel on mango cropping

Rodriguez (1932), investigating smoke-induced flowering in pineapple, first proposed that ethylene, generated by burning material, may stimulate flowering in plants. Dutcher (1972) later confirmed that smoke from smudge fires contained ethylene which stimulated flowering in mango trees. The suggestion that ethylene was generated by burning material and subsequent use of ethephon (Ethrel) to promote mango flowering led to hypothesis that endogenous ethylene plays an integral role in floral inductive process (Bondad, 1976; Chadha and Pal, 1986). Numerous investigators have shown ethrel (2-chloro ethyl phosphonic acid) to be an effective floral promoter of mango under specific conditions of low-latitude tropics (Singh and Singh, 1963; Chacko and Randhawa, 1971; Bondad, 1972; Maity et al., 1972; Sen et al., 1973; Chen, 1985). Saidha et al. (1983) reported an increase in internal leaf ethylene production as the season of floral initiation approached. Ethylene production by flowering shoots was up to five fold that of vegetative ones. However, experimental results of Davenport and Nunez-Elisea (1990) indicated that there was no measurable increase in ethylene production over basal, background levels when bud made the transition from rest to inflorescence development. Requirement of other factors apart from the application of ethrel to stimulate flowering was suggested by some workers (Ramina et al., 1986; Davenport, 1993). Discrepancy of results between these studies could be explained by differences in cultivars or environment.

2.3.1. Effect of ethrel on flowering and fruiting

Chacko et al. (1972) studied the effect of ethrel on flower induction and control of biennial bearing tendency in Langra variety. They observed that spraying ethrel advanced flowering by 15 to 20 days in Langra during the ‘on’ year. During ‘off’ year, treatment with 200 ppm ethrel induced early and profuse flowering whereas, untreated trees failed to flower. Percentage of male and hermaphrodite flowers in the panicles of ethrel treated and untreated Langra trees did not show much difference indicating that flowering induced by ethrel would result in normal fruit setting under favourable conditions.

According to Dutcher (1972), the ethylene generating agent, ethrel, applied at 125-200 ppm, induced flowering in Carabao mango in Philippines, within six weeks after treatment. Pandey et al. (1973) stressed the beneficial effect of ethrel in regulating flowering in mango cv. Dashehari. It was found that 87.5 per cent of buds differentiated to fruit buds compared to 5 per cent in control by spraying 240 ppm ethrel.

Chacko et al. (1974) observed that 4-5 sprays of 200 ppm ethrel at an interval of 15-20 days starting from September, on ‘off’ year Langra trees, produced normal flower panicles in place of growth flush produced by untreated branches. Tree vigour, sex ratio and fruit set were found to be unaffected by ethrel treatment.

Rao et al. (1976) studied the chemical induction of axillary flowering on shoots of mango cv. Alphonso and found that 65.8 per cent shoots flowered when sprayed with 250 ppm ethrel. Ravishankar (1978) obtained profuse flowering in ‘off’ year by application of 250 ppm ethrel. The treatment also caused the production of multiple panicles in leaf axils. Nunez Elisea et al. (1980) sprayed ten year old Haden mango with ethrel and found that flowering was increased by 55 %. Singh and Dhillon (1986) in their studies with plant regulators to control floral malformation and to improve productivity reported that, hermaphrodite flowers (%) in healthy panicles were the highest with Ethrel @ 300 ppm.

Ethrel treatments increased the carbohydrate content and C/N ratio of mango shoots which resulted in better flowering compared to control. Total nitrogen content was unaffected by various treatments at different phenological stages of the crop. Ethrel treatment at various concentrations induced early flowering, produced more number of inflorescence per square meter of canopy and increased fruit yield in different mango varieties when compared to control. However, the percentage of male and hermaphrodite flowers was not found to be much affected by ethrel treatment (Suma, 1987).

Exogenous application of ethrel was found to enhance the fruit drop in mango cv. Amrapalli (Singh et al., 1995). However, Karuna et al. (2007) observed that ethrel treatments alone and in combination with urea improved the fruit set, retention, yield as well as quality attributes of mango fruits during two consecutive years. Whereas, Tandel and Patel (2011) reported that chemicals including ethrel did not show significant influence on the quality parameters in Alphonso, Kesar and Rajapuri.

2.4. Effect of growth regulators/chemicals on regulation of fruit drop in mango

The natural fruit drop in mango is rather too high, amounting to about 99% at various stages of growth. The fruit drop is heavy during first three weeks of fruit set when the rate of fruit development is rapid and it continues up to the 5^{th} week as an early report by Naik and Rao (1943). Most of the fruit drop in mango occurs at setting and can be attributed mainly to the competition between young developing fruitlets, although the role of other unfavourable factors like incidence of pests and diseases, ovule abortion etc. cannot be ignored (Chadha, 1963). Naturally occurring hormones play a major role in fruit growth and drop of mango. Deficiency of auxins, gibberellins and cytokinins coupled with a high level of growth inhibitors i.e. abscissic acid and ethylene cause fruit drop (Ram, 1983). An increase in auxin level corresponds with a period of rapid growth while a high level of inhibitor corresponds with high rate of fruit drop (Prakash and Ram, 1984; Murti and Upreti, 1995). Application of NAA (Gokhale and Kanitkar, 1951; Singh et al., 1959; Gill, 1960; Rao, 1961; Srivastava, 1962; Jagirdar and Choudhari, 1967), 2, 4-D and GA_3 (Singh et al., 1986) have been reported to be effective in reducing the fruit drop in mango. Exogenous application of these growth regulators/chemicals increases their concentration in the panicle and antagonizes adverse effects of endogenous inhibitors, which promotes the abscission of fruitlets.

2.4.1. Effect of NAA on fruit drop, yield and quality

Literature shows lot of controversial results/ effects of NAA application on different yield parameters of mango.

Chadha and Singh (1963) did not observe any significant difference due to application of NAA, 2, 4-D and 2, 4, 5-T on fruit drop and quality parameters like ascorbic acid, TSS and acidity in mango. Whereas, Prasad and Pathak (1972) reported that application of NAA at different doses increased the fruit retention, size, weight and quality of fruits. Lowest concentration of NAA (25 ppm) was found to be the most effective.

However, Jorwekar (1976) observed no significant effect by growth regulator treatments including NAA on physical characters of Alphonso fruits with single application. Fruit quality was improved by NAA treatment both with single application as well as with two applications.

Aravindakshan et al. (1979) observed that NAA treatment at different concentrations significantly improved fruit set in mango. Maurya and Singh (1979) sprayed different type of synthetic auxins each at concentration of 20 and 40 ppm and observed that fruit retention and quality were considerably improved with NAA 40 ppm. A 300-400% increase in fruit set has been reported when NAA (40 or 50 mg/l) was sprayed at the pre-anthesis stage (Ram, 1983). Singh and Ram (1983) reported that NAA (40 ppm) gave the best fruit retention when applied at pre bloom stage. Baghel et al. (1987) reported increased fruit mass with a combination spray of NAA and urea to pre-anthesis panicles.

Control of fruit drop was best achieved by NAA treatments especially at 40ppm regardless of the stage of fruit development or variety (Suma, 1987). Maximum fruit weight and fruit girth was recorded in the same treatment irrespective of varieties. Regarding quality characters of fruits, NAA treatments produced the best results. However, acidity of fruits were found to be unaffected by NAA treatments. Sharma et al. (1990a; b) reported the beneficial effects of NAA on improving the physical and chemical characters of fruits in mango cv. Langra.

Spraying NAA (500ppm) at full bloom stage during the ‘on’ year resulted in moderate deblossoming with the least reduction in crop load in ‘on’ year. This consequently favoured moderate flowering and cropping in the following year which otherwise would have been an ‘off’ year (Srihari and Rao, 1996). Increased number of mature fruits/panicle, number of mature fruits/tree and yield as well as TSS in fruit juice by the foliar application of NAA @ 40 ppm was reported by Rawash et al. (1998).

A significant reduction in fruit drop was observed when NAA (30 ppm) was sprayed on eight years old mango trees (cv. Khirsapat) compared to other auxin treatments and control (Ibrahim et al., 1999). On the contrary, Notodimedjo (2000) conducted experiment in East Java to study the effect of foliar applications of plant growth regulators at 14 days after bloom and found that NAA treatments did not show significant influence on fruit retention and yield.

A trial was conducted to study the effects of foliar application of urea, KNO_3 and NAA at different concentrations on fruit retention, yield and quality characters of Bombai mango. Fruit retention (2.88 %) was reported to be highest with NAA 40 ppm. Maximum T.S.S (21.03 %) and minimum acidity (0.28 %) also were recorded by the same treatment (Gupta and Brahmachari, 2004).

2.5. Carbohydrate and nitrogen contents in relation to flowering in mango

The role of carbohydrate and nitrogen contents and carbohydrate/nitrogen ratio in relation to flower bud initiation has been first suggested by Kraus and Kraybill (1918) in tomato. Seasonal changes in the carbohydrate reserves and nitrogen content of mango shoots and their relationship with flower-bud initiation have been studied and well explained by earlier workers (Naik and Shaw, 1937; Sen, 1946; Mallik, 1953). A study on nitrogenous constituents in the mango stem and leaves showed that the total nitrogen content was higher in the stem and leaves of trees which were expected to initiate flower buds irrespective of varieties they belonged to (Chacko, 1968). Sucrose levels reaching the apical bud are central to modern theories of floral induction (Bernier et al., 1993). The available evidence indicates that nitrogen and carbohydrate reserve play an important role-if not the primary role in flower bud initiation.

In almost all the mango varieties studied except in Baramasia, it was found that higher starch reserve, total carbohydrates and C/N ratio in the shoots favoured flower initiation (Singh, 1960). He concluded that bearing habit of mango cannot be predicted exclusively based on mineral analysis of the shoots. According to Mishra and Dhillon (1978), an 'off' year was characterized by lower C/N ratio and starch/N ratios, while Suryanarayana (1978) could not find any relation between nitrogen content and C/N ratio with flower bud formation or number of flowers.

Changes in the chemical composition of leaves in mango cv. Dashehari during different stages of flowering and fruit growth were studied by Pathak and Pandey (1978) and reported that level of all nutrients including nitrogen were higher before flowering and lowered during flowering and fruit growth. Major utilization of these elements, particularly nitrogen took place during the flowering and fruiting period.

Both *in vitro* and *in vivo* studies clearly invoke the important role for carbohydrates in floral transition. As a rule, sugar levels that are optimal for vegetative growth and morphogenesis are far below than those required for reproductive development. Apparently all steps of flower initiation require relatively high carbohydrate levels (Bernier et al., 1981).

Chacko and Ananthanarayanan (1982) made a comparative study of carbohydrates, proteins and amino acids in the bark of juvenile and mature mango plants at the time of flower initiation. There was an increased accumulation and metabolism of these constituents in the mature plants as compared to juvenile plants. The inability of juvenile plants to form flower buds under natural conditions could hence be attributed to lack of sufficient reserves and their possible hormone directed redistribution and mobilization.

Chacko et al. (1982) reported that 30 leaves (the maximum available on a single shoot) could not support the growth of a single fruit to normal size in the 'on' year. Therefore fruit development depended not only on current assimilates but also to great extent on the reserves. Utilization of reserve metabolites from vegetative organs during the 'on' year could contribute to biennial or erratic bearing.

Chacko (1984) reported that total nitrogen content was higher in the stem and leaves of mango trees during flowering. Growth of a tree and the production of fruit depend upon the ability of a tree to produce and store carbohydrates. Robbertse and Wolstenholme (1992) reported that starch levels will start to accumulate during the summer flush up to flowering. Later, the levels will decline but starch is used to fuel the mango flowering, fruit set and growth.

The phenomenon of biennial or alternate bearing in tropical/subtropical tree crops arises primarily from the depletion of starch reserves of the tree during fruit production and development. This drain in the tree resources leaves it unable to rapidly replenish its reserves in order to meet the demand of the new cycle of vegetative growth, flowering, fruit set and fruit development (Davie and Stassen, 1997).

While studying the seasonal uptake and utilization of nitrogen by Sensation mango trees under South African conditions, it was identified by Stassen and Janse-Van-Vuuren (1997) that nitrogen in the tree is mainly utilized during inflorescence development period and fruit growth stages.

Barooah (2004) opined that in fruit plants, nitrogen and carbohydrate reserves play an important role in flower bud initiation. Accumulation of these compounds may create favourable conditions for the synthesis and action of substances responsible for floral induction. Urban et al. (2008) observed that leaves close to developing inflorescences had low nitrogen content when compared to leaves on vegetative shoot.

2.6. Effect of weather parameters on mango flowering

Although, the flowering stimuli of fruit trees are relatively less specific than those of herbaceous plants, temperature has been found to be the main factor on the flower formation of several fruit trees. In mango, floral induction is followed by flower bud differentiation and emergence of the panicle. Besides nutritional and hormonal factors, environmental factors, temperature and rainfall, influenced this process of mango flowering (Chacko, 1984).

According to Van-Der-Meulen et al. (1971), a growth check of sufficient duration is necessary for synchronous floral induction in mango especially under tropical conditions which means that, stems must be in rest for sufficient time generally, 4-5 months to be induced to flower in the absence of cool temperatures. Ravishanker et al. (1979) reported that peak of flower bud differentiation under the prevailing conditions occurred from November last to December with flowering during January-February. Additionally, heavy rains and high humidity conditions during the flower bud initiation, as found in tropical regions of Kerala stimulated vegetative growth. Thus, it appeared that year to year variations in temperature and rainfall could be important in deciding the time of mango flowering in a given locality. They also found that low temperature appears to exert a depressing effect on the further development of floral buds of mango.

Wolstenholme and Hofmeyer (1985) reported that vegetative growth and fruiting in mango trees are largely antagonistic and that excessive vegetative growth especially in absence of a dry period is likely to cause poor yields. Shu and Sheen (1987) showed that the longest period required for flower induction was when trees exposed to a temperature regime of 19^0C day/ 13^0C night for more than three weeks. It is clear that mango growth and development are strongly influenced by the environment as temperatures below 15^0 C readily promote floral induction; whereas vegetative growth is generally promoted by warmer temperatures (Whiley et al., 1989).

Studies in mango revealed the existence of a floral stimulus, which is continuously synthesized in leaves during exposure to cool, inductive temperatures (Davenport and Nunez-Elisea, 1990). Unlike other plants requiring vernalization for induction, mango leaves appear to be the only site where the putative floral stimulus is produced (Davenport and Nunez-Elisea, 1992). The putative temperature regulated floral stimulus is short lived and its influence lasts only for 6-10 days (Nunez-Elisea and Davenport, 1992).

Attainment of floral induction does not necessarily ensure initiation of floral morphogenesis. That means growth of induced buds in the presence of cool temperature is essential for floral induction, because induced apical buds that resumed growth after trees were transferred to warm temperatures out doors, produced a vegetative flush instead of an inflorescence. There is a certain threshold level where the buds are sufficiently induced for flowering and after attaining that level, they cannot be reverted to vegetative growth. Therefore it is decisive that buds are induced beyond the threshold level so that floral differentiation can occur. Temperature near 30^0C apparently counteracted floral development causing induced buds to continue vegetative development instead of initiating inflorescence (Nunez-Elisea and Davenport, 1995).

It was found by Robbertse and Manyaga (1998), that there is difference in the number of cold units (days) required by different mango cultivars for floral induction. As per Murti and Upreti (2004), it is predominantly the effect of high temperature, especially the night temperature, which prevailed during October to December during flower induction and differentiation periods, possibly accentuated by slightly higher rainfall in October-December that culminated in poor flowering in mango in 1998 under Bangalore conditions. Renisha (2011) reported that unfavourable climatic conditions hampered the flowering and fruiting in mango under Kerala conditions during 2009-10 and 2010-11.

2.7. Heat units

Mango fruit growth is affected by many factors. However, the predominant condition influencing growth rates of fruits and its quality is, of course, climate. Singh et al. (2011) stated that temperature is the primary climatic variable which interferes in the process of fruit development. Many scientists have reported that heat units form important criteria for calculation of fruit maturity and quality of fruits.

A field trial was conducted at two different locations (Vengurla and Deogad) with an objective to estimate the heat units required for the maturation of three commercial mango varieties. Alphonso recorded minimum duration (111 and 93 days) and heat units (718 and 701 degree days) at both locations followed by Kesar (118 and 98 days; 773 and 799 degree days) and Ratna (127 and 112 days; 849 and 866 degree days) at respective places (Burondkar et al., 2000).

According to Shinde et al. (2001), total heat units required for maturation of fruits was more or less equal at Vengurla and Rameshwar and it varied in Alphonso, Kesar and Ratna as 752-803, 843-898 and 932-977 DD respectively. Experiment conducted by Anila (2002) to study the performance of selected varieties and hybrids in mango, revealed that maximum heat units were required for H-151 (1493.55 DD) followed by Ratna (1491.10 DD). Prior required a heat unit of 1415.07 DD. Alphonso, Muvandan and Neelum were the varieties, which required the least amount of heat units.

An experiment was conducted to ascertain the requirement of heat units for quality fruit production of mango cultivar Dashehari during the development and maturity stage of the fruit. Studies revealed that for those fruits harvested on 84 days after set, total heat unit and mean daily heat unit were 811.70 DD and 10.33 DD respectively. On the other hand, fruits harvested on 94 days after set received total heat units of 948.45 DD and mean heat units of 10.64 DD. Fruits of 103 and 114 days after set received 1081.50 DD and 1237.93 DD total heat units respectively, whereas values of corresponding mean daily heat units were 10.99 DD and 11.36 DD (Singh et al., 2011).

Materials and Methods

3. MATERIALS AND METHODS

The experiment on 'Chemical regulation of cropping in mango' was carried out in 17 year old trees of mango orchard attached to the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the year 2008-2010. The orchard is located at an altitude of 22.25 metres above M.S.L at $10^0$32' North latitude and $76^0$16' East longitude with warm humid tropical climate. Varieties selected for the study were:

1. Alphonso- superior commercial variety with alternate bearing habit.
2. Prior- a locally important early variety with irregular bearing habit.

The experiment was laid out in Randomized Block Design (RBD) with three replications and eight treatments. Treatments were superimposed on the selected trees of two varieties during 2008-09 and 2009-10. Lay out plan of the experiment in Prior and Alphonso varieties are furnished in Fig. 1 and general view of the experimental site is given in Plate 1.

3.1. Treatments

T_1: Ethrel (200ppm) + Urea (1%) spray during September-October.

T_2: T_1 + NAA (30ppm) spray at fruit set.

T_3: Potassium nitrate (3%) spray during September-October.

T_4: T_3 + NAA (30ppm) spray at fruit set.

T_5: Paclobutrazol (5g /tree) as soil drench in drip circle during September- October.

T_6: T_5 + NAA (30ppm) spray at fruit set.

T_7: T_5 + Potassium nitrate (3%) spray after 90 days.

T_8: Control (no treatment).

Fig. 1. Lay out of the experiment

Design – RBD

No. of replications - 3

No. of treatments – 8

LEGEND

T1	- Ethrel (200 ppm) + Urea (1%)	T5	- Paclobutrazol 5.0 g /tree
T2	- T1 + NAA (30 ppm)	T6	- T5 + NAA (30 ppm)
T3	- KNO_3 (3 %)	T7	- T5 + Potassium nitrate(3%)
T4	- T3 + NAA (30 ppm)	T8	- Control (No treatment)

Plate 1. General view of the experimental site

Prior

Alphonso

3.2. Preparation of chemicals and method of application

3.2.1. Cultar- Cultar is available in liquid formulation with active ingredient in the form of paclobutrazol (23% W/W or 25%W/V). It is marketed by Syngenta Crop Protection Private Limited. 20 ml of cultar was mixed with 10 liters of water (Paclobutrazol @ 5 g per tree) and applied to the soil at 60 cm apart from tree trunk in a circular band as per the treatment specifications (Plate 2).

3.2.2. Ethrel- Ethrel (2-chloro ethyl phosphonic acid) is available in liquid formulations with ethephon (39%) as active ingredient. It is marketed by Bayer Crop Science Limited. 0.05 ml of ethrel was diluted with 1 liter of water to get 200 ppm solution and applied as foliar spray using a rocker sprayer as per the technical programme (Plate 3).

3.2.3. NAA- NAA (Naphthalene-1-acetic acid) is available in powder form with 99% concentration and it is marketed by SISCO Research Laboratories Private Limited. 30 mg of NAA per liter of water was applied at full bloom stage in selected treatments.

3.2.4. Potassium nitrate- Potassium nitrate (KNO_3) is available in powder form with 98% concentration. It is marketed by Merck Specialties Private Limited. Spray solution was prepared by dissolving 30 g of potassium nitrate per liter of water and was applied to trees using a rocker sprayer as per the treatment details.

All cultural practices and need based plant protection measures were adopted as per Package of Practices (POP) recommendations of KAU and Irrigation was given to T_5, T_6 and T_7 trees after treatment imposition, at bi weekly intervals up to flowering.

Plate 2. Soil application of paclobutrazol

Plate 3. Spray application of chemicals

3.3. Observations

3.3.1. Biometric parameters

Biometric parameters such as tree height, girth, spread, shoot length with number of leaves and internodal length were recorded before and after the experiment.

3.3.1.1. Tree height

Tree height was recorded by measuring the distance from ground level to the top of canopy using the meter scale and was expressed in meters.

3.3.1.2. Tree girth

Tree girth was measured by taking the circumference of tree at 1.5m above the ground level using a measuring tape and expressed in meters.

3.3.1.3. Tree spread

Tree spread in East-West and North-South directions were measured using a measuring tape and average values were worked out and expressed in meters.

3.3.1.4. Shoot length and number of leaves per shoot

Ten mature shoots were selected at random from each replication and shoot length was measured using a meter scale and expressed in centimeters. Total number of leaves per shoot was counted and recorded.

3.3.1.5. Internodal length

Distance between the two nodes on the shoot was measured using a meter scale and expressed in centimeters.

3.3.2. Flowering characters

Flowering characters such as season of flowering, floral intensity, percentage of hermaphrodite flowers, inflorescence length and breadth were recorded for various treatments.

3.3.2.1. Season of flowering

Peak flowering season of each tree under different treatments of Prior and Alphonso was noticed and recorded as season of flowering.

3.3.2.2. Floral intensity

Intensity of flowering was recorded as number of inflorescences per square meter area of the canopy. This was counted from the four sides of a tree with the help of an aluminium frame of 1m x 1m size and the average was calculated.

3.3.2.3. Percentage of hermaphrodite flowers

Ten inflorescences per replication were collected and the number of male and hermaphrodite flowers was counted. Percentage of hermaphrodite flowers was calculated using the formula:

$$\text{Percentage of hermaphrodite flowers} = \frac{\text{Number of hermaphrodite flowers} \times 100}{\text{Total number of flowers}}$$

3.3.2.4. Inflorescence length and breadth

Ten inflorescences per replication were collected for recording the observations on these parameters. Length of the inflorescence from bottom to tip was measured using a meter scale and expressed in centimeters. Inflorescence breadth is length of the broadest part which was measured using the meter scale and expressed in centimeters.

3.3.3. Fruit set and drop

Ten unopened inflorescences per replication were selected and tagged in all four directions. One week after the full bloom stage, the initial number of fruits per tagged inflorescence was counted and the average was recorded as the basis for fruit set.

Further, the number of fruits retained was recorded at fortnightly intervals up to 60 days after initial fruit set and the intensity of fruit drop was calculated and expressed in percentage. Increment in fruit drop at different stages after fruit set was noted.

3.3.4. Number of days for flowering and fruit maturity

Number of days from chemical application to flowering as well as from flowering to fruit maturity was recorded for each treatment.

3.3.5. Fruit yield

Yield per tree in terms of weight and number of fruits were recorded at the time of each harvest and the total yield was calculated for each treatment.

3.3.6. Physical parameters of fruits

From each treatment, ten fully mature fruits per replication were collected for recording the following fruit characters.

3.3.6.1. Fruit weight

Individual fruit weight was measured using a weighing balance and expressed in grams.

3.3.6.2. Fruit length, breadth and girth

Length, breadth and girth of the fruits were measured using a thread and scale and expressed in centimeters.

3.3.6.3. Peel and pulp weight

Weight of peel and pulp of the fruit were recorded separately using a weighing balance and expressed in grams.

3.3.7. Stone characters

Parameters such as weight, length and breadth of individual stones of fruits were measured and recorded for each treatment.

3.3.8. Percentage contribution of fruit parts to whole fruit weight

From the values recorded on weights of whole fruit, pulp, peel and stone, percentage contribution of each component in the total fruit weight was calculated. Pulp/stone ratio was calculated by dividing the value of pulp weight by stone weight.

3.3.9. Quality attributes of fruits

Chemical parameters of fruits estimated include total soluble solids, acidity, reducing, non reducing and total sugars.

3.3.9.1. Total Soluble Solids

TSS of fruits were recorded after extracting the juice out of the pulp and measured using a hand refractometer and expressed in degree Brix.

3.3.9.2. Reducing sugars

Reducing sugars were determined by adopting the method given by Lane and Eynon (Ranganna, 1986). The fruit sample was ground in a blender and filtered through No.4 Whatman paper. An aliquot of 25 ml of filtered juice was transferred to a 250ml volumetric flask, mixed with distilled water and neutralized with NaOH. Solution was clarified with neutral lead acetate. Excess lead acetate was removed by adding potassium oxalate and volume was made up to 250 ml.

The solution was filtered and aliquot of the filtrate was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator and the reducing sugar was expressed as percentage.

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

3.3.9.3. Total sugars

For the estimation of total sugars, 50 ml of clarified solution (filterate of reducing sugars) was boiled gently after adding citric acid and water. It was neutralized using NaOH and volume made up to 250 ml. The made up solution was titrated against a mixture of Fehling's solution A and B and total sugar content was expressed as percentage (Ranganna, 1986).

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

Percentage of non-reducing sugars was calculated by subtracting the percentage of reducing sugars from total sugars.

3.3.9.4. Titrable acidity

Acidity was estimated as per AOAC (1984) method. Ten grams of the macerated sample was digested with distilled water and made up to 250 ml. An aliquot of 25 ml of the filtrate was titrated against N/10 sodium hydroxide (NaOH), using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid.

$$\text{Acidity (\%)} = \frac{\text{Titre value x } 0.1 \text{ x Volume made up x } 0.064 \text{ x } 100}{\text{Wt of the sample taken x Volume of the sample}}$$

3.3.9.5. Sugar/acid ratio

Sugar / acid ratio was worked out by dividing the value of total sugars by the value of titrable acidity.

3.3.10. Keeping quality of fruits

From each treatment, ten fruits were kept in room temperature and number of days taken by fruits from the day of harvest to ripening as well as from ripening to senescence was noted.

3.3.11. Carbohydrate and nitrogen analysis

Leaf samples were collected as per the sampling technique given by Bhargava and Chadha (1993). Four to seven month old leaves (Twenty to thirty in No.), including petiole, from the middle of tertiary shoot were collected from all sides of the tree. First sampling was done before the application of chemicals. Further, three more samples were collected at monthly intervals up to the flowering stage. Collected samples were dried to constant weight in an electric hot air oven at 80 ± 5^{0}C. The dried leaves were then ground into fine powder using a grinder and used for analysis.

Total carbohydrate in the samples was estimated using anthrone reagent method as per Sadasivam and Manickam (1991) and expressed in percentage.

$$\text{Carbohydrate (\%)} = \frac{\text{Optical Density (sample) x Standard concentration x Total volume}}{\text{Optical Density (standard) x Volume taken x Sample weight}}$$

Organic nitrogen content in the samples was determined using microkjeldhal method (Sadasivam and Manickam, 1991) and expressed in percentage.

$$\text{Nitrogen content (\%)} = \frac{\text{Normality} \times \text{Titer value} \times 0.014 \times 100}{\text{Sample weight}}$$

Carbohydrate/nitrogen (CHO/N) ratio was calculated by dividing the value of carbohydrate by total nitrogen of each sample.

3.3.12. Meteorological observations

The weekly record of maximum and minimum temperature, relative humidity, sunshine hours, rainfall and evaporation for the time period September 2008 to June 2010 was collected from the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara.

Singh et al. (2011) reported that heat unit per day can be calculated by subtracting the base temperature of 17.9^{0}C from the mean of daily maximum and minimum temperature. In treatments, total heat units accumulated during the period from chemical application to flowering as well as from peak flowering to fruit maturity were calculated and expressed as degree days.

$$\text{Heat unit} = \frac{\text{Max. temp.} + \text{Min. temp.}}{2} - 17.9 \text{ (base temp.)}$$

3.3.13. Statistical analysis

The data were subjected for pooled analysis of variance following the method of Panse and Sukhatme (1978). M STAT C and MS-Excel softwares were used for computation and analysis.

Results

4. RESULTS

An experiment was conducted at Department of Pomology and Floriculture, College of Horticulture, Vellanikkara to regulate flowering and fruiting in mango by application of growth regulators and chemicals during 2008-09 and 2009-10. Varieties used for conducting the experiment were Prior and Alphonso. Results of the experiment are furnished in this chapter.

4.1. Biometric parameters

Biometric observations of the experimental trees of Prior and Alphonso varieties recorded before and after the experiments are presented in Tables 1 and 2 respectively.

4.1.1. Tree height

Before treatment imposition, height of trees in Prior varied from 6.70 to 9.66m. After the experiment, treatments did not show significant impact on this parameter (Table 1a) and the values ranged from 7.15 m in T_1 to 9.95 m in T_8. Increment in height varied from 0.08m in T_6 to 1.15m in T_4.

In Alphonso, height of trees before treatment imposition varied from 9.0 to 11.70m. Treatments did not influence this parameter significantly as seen in Table 2a. Increment in height varied from 0.15m in T_6 to 0.63m in T_2.

4.1.2. Tree girth

In Prior, tree girth before treatment imposition ranged from 0.81 to 1.03m and treatments did not significantly made any impact on this parameter. Increment in girth varied from 0.03m in T_2 to 0.23m in T_3, which was also non significant.

Before treatment imposition, tree girth in Alphonso ranged from 1.03 to 1.30m. Post experiment data showed non significant effects on this parameter and values ranged from 1.11m in T_7 to 1.42m in T_2. Increment in tree girth varied from 0.06m in T_7 to 0.12m in both T_2 and T_4, which was also statistically non significant.

4.1.3. Tree spread

In Prior, tree spread before treatment imposition was in the range of 6.51 to 9.05m. Post treatment observation showed that treatments did not influence this parameter and the values ranged from 7.74m in T_1 to 9.67m in T_8. Influence on increment in tree spread was also non significant (Table 1a).

Before treatment application, tree spread of Alphonso ranged from 7.55 to 8.70m. Treatment effects were insignificant and values ranged from 8.01m in T_5 to 9.37m in T_2. Increment in tree spread ranged from 0.34m in T_6 to 1.13m in T_3 and was not influenced significantly by treatments (Table 2a).

4.1.4. Shoot length

In Prior, shoot length before treatment application ranged from 7.79 to 13.92cm and post treatment values showed that treatments had significantly influenced this parameter and paclobutrazol treatments recorded lower values. Highest shoot length was recorded by T_8 (Table 1b).

Before treatment imposition, shoot length in Alphonso ranged from 9.04 to 11.60cm. Treatments had significant impact on this parameter and minimum shoot length was produced by paclobutrazol treatments (T_5, T_6 and T_7). T_8 recorded the highest value (Table 2b).

Table 1a. Biometric parameters in Prior before and after the experiment

Treatments	Before the experiment			After the experiment					
	Tree height (m)	Girth (m)	Spread (m)	Tree height (m)	Increment in height (m)	Girth (m)	Increment in girth (m)	Spread (m)	Increment in spread (m)
T_1	6.70[a]	0.81[a]	6.51[a]	7.15[a]	0.48[a]	0.93[a]	0.11[a]	7.74[a]	1.22[a]
T_2	9.0[a]	1.0[a]	8.60[a]	9.20[a]	0.20[a]	1.03[a]	0.03[a]	9.25[a]	0.65[a]
T_3	7.66[a]	0.98[a]	8.76[a]	8.41[a]	0.75[a]	1.22[a]	0.23[a]	9.55[a]	0.79[a]
T_4	7.33[a]	0.93[a]	7.71[a]	8.48[a]	1.15[a]	1.06[a]	0.13[a]	8.68[a]	0.96[a]
T_5	7.0[a]	0.85[a]	7.73[a]	7.50[a]	0.50[a]	0.89[a]	0.04[a]	8.09[a]	0.36[a]
T_6	8.33[a]	0.96[a]	8.26[a]	8.41[a]	0.08[a]	1.01[a]	0.04[a]	8.58[a]	0.32[a]
T_7	8.33[a]	0.95[a]	8.13[a]	8.63[a]	0.30[a]	1.03[a]	0.08[a]	8.41[a]	0.28[a]
T_8	9.66[a]	1.03[a]	9.05[a]	9.95[a]	0.28[a]	1.12[a]	0.09[a]	9.67[a]	0.62[a]
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2a. Biometric parameters in Alphonso before and after the experiment

Treatments	Before the experiment			After the experiment					
	Tree height (m)	Girth (m)	Spread (m)	Tree height (m)	Increment in height (m)	Girth (m)	Increment in girth (m)	Spread (m)	Increment in spread (m)
T_1	9.7[a]	1.10[a]	8.15[a]	10.02[a]	0.35[a]	1.20[a]	0.10[a]	8.80[a]	0.65[a]
T_2	10.7[a]	1.30[a]	8.70[a]	11.30[a]	0.63[a]	1.42[a]	0.12[a]	9.37[a]	0.67[a]
T_3	9.7[a]	1.21[a]	7.55[a]	10.27[a]	0.60[a]	1.31[a]	0.09[a]	8.68[a]	1.13[a]
T_4	10.0[a]	1.26[a]	8.16[a]	10.37[a]	0.37[a]	1.38[a]	0.12[a]	9.01[a]	0.84[a]
T_5	9.3[a]	1.07[a]	7.60[a]	9.79[a]	0.46[a]	1.15[a]	0.08[a]	8.01[a]	0.41[a]
T_6	11.7[a]	1.18[a]	8.30[a]	11.81[a]	0.15[a]	1.25[a]	0.07[a]	8.64[a]	0.34[a]
T_7	9.0[a]	1.05[a]	7.65[a]	9.51[a]	0.51[a]	1.11[a]	0.06[a]	8.04[a]	0.39[a]
T_8	9.3[a]	1.03[a]	7.56[a]	9.65[a]	0.31[a]	1.14[a]	0.11[a]	8.46[a]	0.90[a]
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment means having similar alphabets in superscript, do not differ significantly.

4.1.5. Number of leaves per shoot

Number of leaves per shoot in Prior before treatment imposition ranged from 5.41 to 7.83. Post treatment values indicated significant influence on this parameter and trees which received paclobutrazol treatments (T_5, T_6 and T_7) recorded significantly lower values. T_8 recorded the maximum number of leaves per shoot.

Before treatment application, number of leaves per shoot in Alphonso ranged from 6.50 to 8.83. Treatments had significant impact and T_7 was statistically significant with the lowest value for this parameter. Other paclobutrazol treatments (T_5 and T_6) were also statistically different from the rest of treatments recording lower values.

4.1.6. Inter nodal length

Before treatment imposition, inter nodal length in Prior ranged from 1.10 to 2.40cm. Treatments had significantly influenced this parameter and paclobutrazol treatments recorded statistically significant lower values in the order of T_7, T_6 and T_5. T_8 recorded the highest value (Table 1b).

Before treatment application, inter nodal length in Alphonso ranged from 1.20 to 2.10 cm. Post treatment observation indicated that treatments had significant impact on this parameter and paclobutrazol treatments (T_5, T_6 and T_7) recorded lower values. T_8 produced the maximum inter nodal length (Table 2b).

4.2. Flowering characters

Flowering characters of Prior and Alphonso varieties are presented in Tables 3 and 4 respectively. Plates 4 and 5 indicate the influence of selected treatments on flowering of trees.

Table 1b. Biometric parameters in Prior before and after the experiment

Treatments	Before the experiment			After the experiment		
	Shoot length (cm)	No. of leaves/shoot	Inter nodal length (cm)	New shoot length (cm)	No. of leaves/shoot	Inter nodal length (cm)
T_1	9.16[a]	5.41[a]	1.73[a]	10.88[c]	6.23[c]	1.74[c]
T_2	13.92[a]	6.16[a]	2.40[a]	10.71[c]	6.19[c]	1.72[c]
T_3	9.52[a]	6.41[a]	1.43[a]	11.51[b]	6.45[b]	1.78[c]
T_4	10.59[a]	5.83[a]	1.83[a]	11.80[b]	6.33[bc]	1.86[b]
T_5	11.07[a]	7.58[a]	1.40[a]	8.65[d]	5.66[d]	1.52[d]
T_6	7.79[a]	7.33[a]	1.10[a]	8.24[e]	5.80[d]	1.42[e]
T_7	11.53[a]	6.58[a]	1.83[a]	7.72[f]	5.78[d]	1.33[f]
T_8	13.45[a]	7.83[a]	1.73[a]	13.62[a]	6.90[a]	1.97[a]
CD (0.05)	NS	NS	NS	0.34	0.16	0.07

Table 2b. Biometric parameters in Alphonso before and after the experiment

Treatments	Before the experiment			After the experiment		
	Shoot length (cm)	No. of leaves/shoot	Inter nodal length (cm)	New shoot length (cm)	No. of leaves/shoot	Inter nodal length (cm)
T_1	10.04[a]	8.33[a]	1.20[a]	9.80[d]	6.37[b]	1.53[c]
T_2	10.22[a]	7.41[a]	1.40[a]	10.82[c]	6.41[b]	1.68[bc]
T_3	11.60[a]	6.50[a]	2.10[a]	11.75[bc]	6.58[b]	1.78[b]
T_4	10.41[a]	7.08[a]	1.50[a]	11.90[b]	6.63[b]	1.79[b]
T_5	9.28[a]	7.25[a]	1.43[a]	7.30[e]	6.01[c]	1.21[d]
T_6	10.34[a]	7.91[a]	1.40[a]	7.82[e]	6.05[c]	1.29[d]
T_7	9.04[a]	7.41[a]	1.23[a]	6.30[f]	5.58[d]	1.13[d]
T_8	11.17[a]	8.83[a]	1.26[a]	13.86[a]	7.03[a]	1.97[a]
CD (0.05)	NS	NS	NS	0.95	0.30	0.17

4.2.1. Floral intensity

During first year, treatments did not show significant difference on this parameter in Prior and the values ranged from 5.60 in T_4 to 8.60 in T_1. Treatments had significant influence during second year and T_3 (Potassium nitrate 3%) and paclobutrazol treatments (T_5, T_6 and T_7) recorded higher values, which were statistically superior to other treatments. Trees under T_2 (Ethrel 200ppm + NAA 30ppm) did not flower during second year.

Results of pooled analysis exhibited the significant influence of paclobutrazol treatments (T_5, T_6 and T_7) and T_3 on this parameter (Fig. 2). Other treatments were inferior to these and were on par with one another.

In Alphonso, treatments did not differ significantly with respect to the floral intensity during first year and values ranged from 0.50 in T_1 to 3.20 in T_5. During second year, paclobutrazol treatments recorded higher values and were statistically superior to other treatments. T_3 (Potassium nitrate 3%) did not show any sign of flowering during second year.

Pooled analysis indicated the superior influence of paclobutrazol treatments (T_5, T_6 and T_7) on this parameter (Fig. 3). Among other treatments, there existed statistical differences and T_1 recorded the lowest value.

4.2.2. Percentage of hermaphrodite flowers

In Prior, treatments did not significantly influence this parameter during first year and the values ranged from 10.97% in T_3 to 15.80% in T_2. During second year, treatments except T_3 recorded higher values. Pooled analysis revealed no significant influence of treatments on this parameter and the values ranged from 8.98% in T_3 to 16.06% in T_8.

Even though treatments had significant influence on percentage of hermaphrodite flowers in Alphonso during both years, the pattern was not specific. Pooled analysis also indicated the same however T_2 (Ethrel 200ppm + NAA 30ppm) and paclobutrazol treatments (T_5, T_6 and T_7) recorded higher values (Table 4).

4.2.3. Inflorescence length

During first year, treatments did not show significant impact on this parameter in Prior and the values ranged from 19.86cm in T_8 to 27.10cm in T_1. During second year, treatments had significant impact and trees of T_1, T_3 and T_4 recorded higher values. Pooled analysis also pointed out the same trend of second year.

In Alphonso, effect of treatments on this parameter was non significant during first year and the values ranged from 19.33cm in T_2 to 25.53cm in T_7. Treatments had significant influence during second year and T_5 recorded the highest value of 31.0cm and was statistically superior to other treatments. In pooled analysis, T_4 (KNO_3 3% + NAA 30ppm) and paclobutrazol treatments (T_5, T_6 and T_7) recorded statistically superior values.

4.2.4. Inflorescence breadth

In Prior, treatments effects were found to be non significant during first year and the values ranged from 20.73cm in T_8 to 28.33cm in T_1. Even though treatments showed significant influence during second year, the pattern was not specific however T_1, potassium nitrate treatments (T_3 and T_4) and T_6 recorded higher values. Pooled analysis also indicated the similar pattern of second year.

Treatments failed to influence this parameter in Alphonso during first year. However, they exhibited significant influence during second year and T_5 recorded highest inflorescence breadth of 32.70cm, which was statistically superior to other treatments.

Table 3. Effect of treatments on flowering characters in Prior

Treatments	Intensity of flowering (No. of inflorescence/m^2)			% of hermaphrodite flowers			Inflorescence length (cm)			Inflorescence breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	8.60^{a}	3.10^{b}	5.85^{b}	14.53^{a}	13.20^{ab}	13.86^{a}	27.10^{a}	29.20^{a}	28.15^{a}	28.33^{a}	25.40^{ab}	26.86^{a}
T_2	7.10^{a}	0	-	15.80^{a}	0	-	22.90^{a}	0	-	24.33^{a}	0	-
T_3	6.10^{a}	14.0^{a}	10.04^{a}	10.97^{a}	7.0^{bc}	8.98^{a}	23.60^{a}	24.50^{ab}	24.05^{ab}	24.93^{a}	27.50^{a}	26.21^{ab}
T_4	5.60^{a}	5.80^{b}	5.70^{b}	12.81^{a}	12.60^{ab}	12.70^{a}	24.0^{a}	25.30^{ab}	24.65^{ab}	24.70^{a}	22.30^{abc}	23.50^{abc}
T_5	7.10^{a}	13.90^{a}	10.50^{a}	12.70^{a}	17.50^{a}	15.10^{a}	21.73^{a}	19.70^{b}	20.76^{b}	22.70^{a}	16.50^{c}	19.63^{cd}
T_6	6.70^{a}	16.0^{a}	11.33^{a}	12.49^{a}	13.10^{ab}	12.79^{a}	25.13^{a}	20.70^{b}	22.91^{b}	25.80^{a}	22.10^{abc}	23.93^{ab}
T_7	6.30^{a}	17.80^{a}	12.06^{a}	13.04^{a}	18.20^{a}	15.62^{a}	25.30^{a}	20.30^{b}	22.80^{b}	25.63^{a}	19.50^{bc}	22.56^{bcd}
T_8	6.90^{a}	2.40^{b}	4.65^{b}	14.82^{a}	17.30^{a}	16.06^{a}	19.86^{a}	19.50^{b}	19.68^{b}	20.73^{a}	17.0^{c}	18.86^{d}
CD (0.05)	NS	6.92	3.87	NS	9.52	NS	NS	6.68	4.61	NS	6.46	3.85

Table 4. Effect of treatments on flowering characters in Alphonso

Treatments	Intensity of flowering (No. of inflorescence/m^2)			% of hermaphrodite flowers			Inflorescence length (cm)			Inflorescence breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	0.50^{a}	1.50^{bc}	1.0^{c}	10.96^{d}	8.80^{b}	9.88^{d}	20.43^{a}	17.50^{c}	18.96^{b}	23.13^{a}	21.50^{bc}	22.31^{bc}
T_2	1.20^{a}	2.80^{bc}	1.98^{bc}	13.10^{abc}	13.90^{a}	13.50^{a}	19.33^{a}	21.50^{bc}	20.41^{b}	20.97^{a}	23.90^{b}	22.43^{bc}
T_3	1.80^{a}	0	-	13.93^{a}	0	-	21.57^{a}	0	-	23.27^{a}	0	-
T_4	2.80^{a}	3.50^{b}	3.12^{b}	10.80^{d}	9.50^{b}	10.15^{cd}	22.53^{a}	22.40^{bc}	22.46^{a}	24.03^{a}	22.80^{bc}	23.41^{bc}
T_5	3.20^{a}	15.80^{a}	9.45^{a}	13.70^{ab}	11.0^{ab}	12.35^{abc}	22.83^{a}	31.0^{a}	26.91^{a}	23.60^{a}	32.70^{a}	28.15^{a}
T_6	2.90^{a}	14.30^{a}	8.60^{a}	11.95^{bcd}	13.80^{a}	12.87^{ab}	21.33^{a}	24.60^{b}	22.96^{a}	21.30^{a}	17.0^{c}	19.15^{c}
T_7	3.0^{a}	13.40^{a}	8.20^{a}	12.26^{abcd}	11.30^{ab}	11.78^{abcd}	25.53^{a}	25.0^{b}	25.26^{a}	24.57^{a}	24.30^{b}	24.43^{ab}
T_8	1.40^{a}	3.0^{bc}	2.20^{bc}	11.23^{cd}	10.80^{ab}	11.01^{bcd}	20.33^{a}	17.20^{c}	18.76^{b}	19.97^{a}	19.60^{bc}	19.78^{c}
CD (0.05)	NS	3.13	1.76	1.92	4.14	2.33	NS	5.88	4.73	NS	6.0	4.58

^{0} not flowered

Fig. 2. Effect of treatments on flowering in Prior

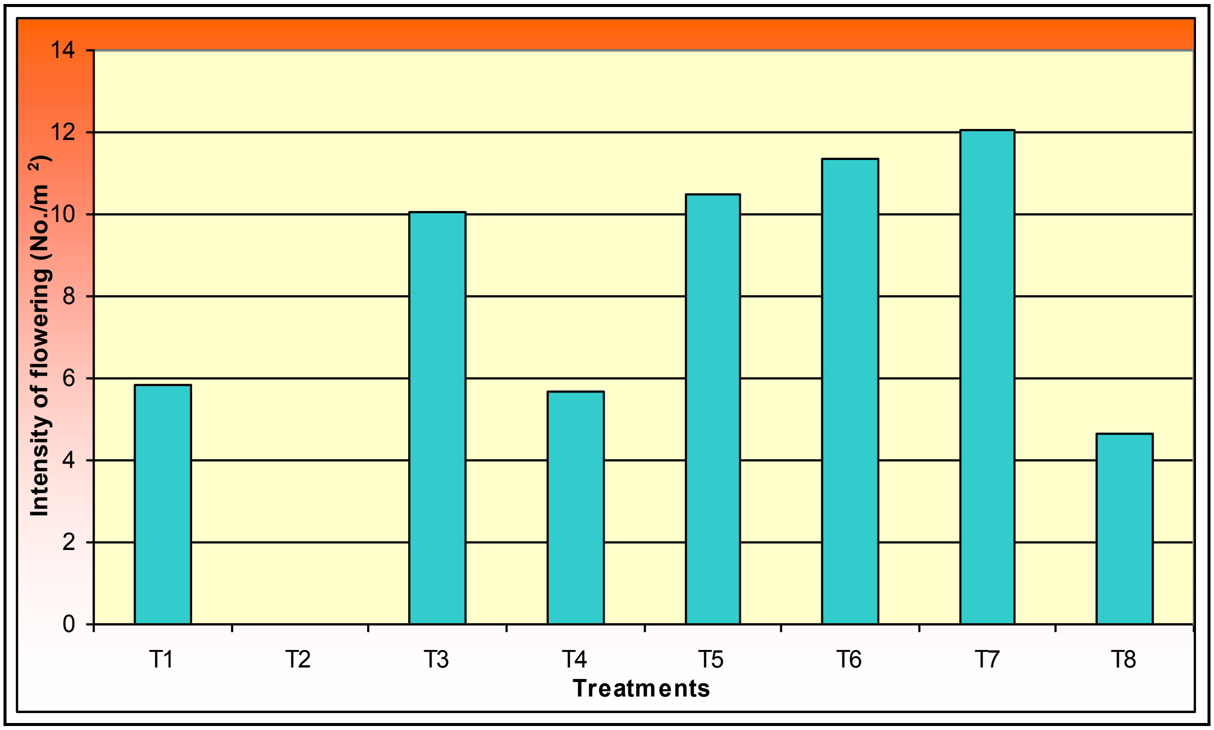


Fig. 3. Effect of treatments on flowering in Alphonso

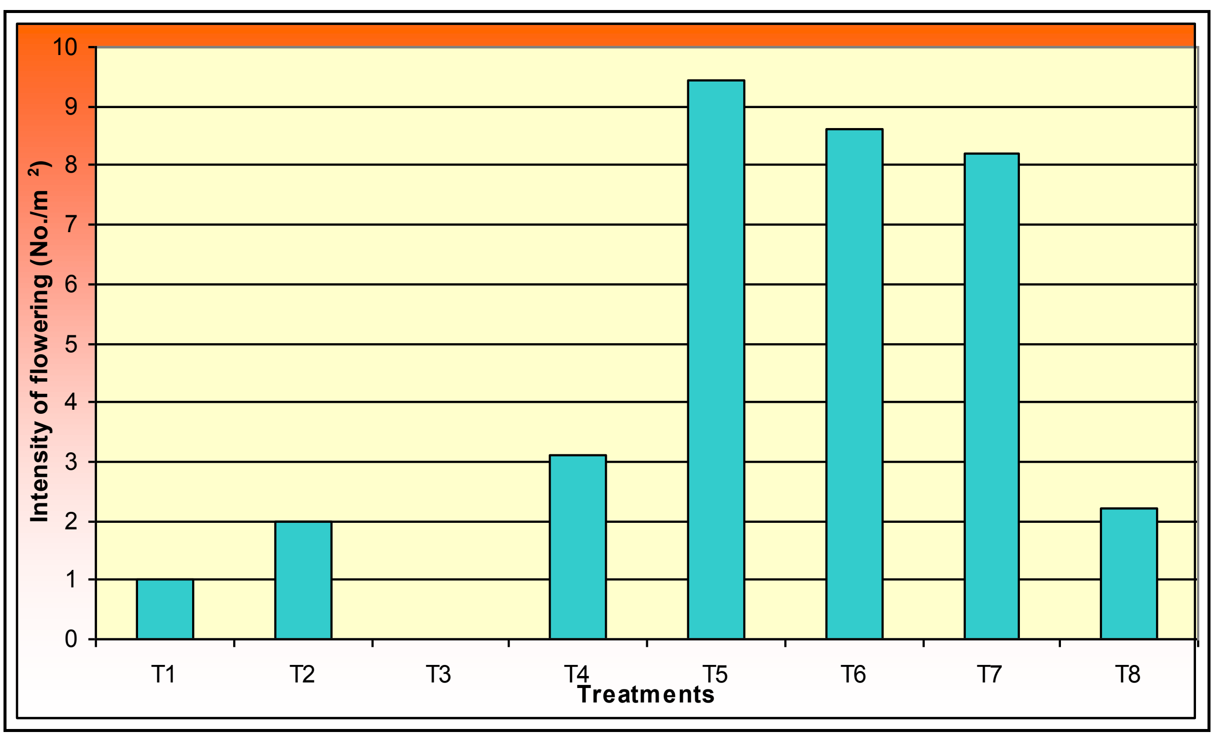


Plate 4. Effect of treatments on flowering in Prior

T_7- Paclobutrazol (5 g /tree) + KNO_3 (3%)

T_6- Paclobutrazol (5 g /tree) + NAA (30 ppm)

T_5- Paclobutrazol (5 g /tree)

T_8- Control

Plate 5. Effect of treatments on flowering in Alphonso

T_5- Paclobutrazol (5 g /tree)

T_6- Paclobutrazol (5 g /tree) +NAA (30 ppm)

T_7- Paclobutrazol (5 g /tree) + KNO_3 (3%)

T_8- Control

Pooled analysis indicated the significant influence of paclobutrazol treatments (T_5 and T_7) with respect to this parameter in Alphonso.

4.3. Fruit set and drop

Data on fruit set and drop are furnished from Tables 5 to 14 for both varieties and Figures 4 and 5 shows graphical representation of the data.

4.3.1. Initial fruit set

Treatments differed significantly with respect to this parameter in Prior during both years and paclobutrazol treatments recorded higher values during first year. T_1 and T_4 recorded statistically inferior values. During second year, paclobutrazol treatments (T_5, T_6 and T_7) and T_3 recorded higher values (Table 5).

Pooled analysis indicated the significant superior influence of T_3 (KNO_3 3%) and paclobutrazol treatments (T_5, T_6 and T_7) on this parameter.

Treatments had significant influence on initial set in Alphonso during both years. Paclobutrazol treatments recorded higher values and were significantly superior to other treatments during first year. Whereas the significant pattern was not specific during second year however, T_6 recorded highest value and T_1 recorded the lowest (Table 6).

Pooled analysis exhibited that paclobutrazol treatments (T_5, T_6 and T_7) and T_4 (Potassium nitrate 3% + NAA 30ppm) resulted in significantly higher initial set.

4.3.2. Fruit drop at 15 days after set

In Prior, treatments did not influence this parameter during first year (Table 7). During second year, influence of treatments was significant and T_3, T_6 and T_7 recorded

Table 5. Effect of treatments on initial fruit set in Prior

Treatments	**Initial fruit set (No.)**		
	I Year	II Year	Pooled
T_1	30.58^{d}	25.0^{c}	27.79^{c}
T_2	38.0^{c}	0	-
T_3	39.50^{bc}	36.70^{a}	38.10^{a}
T_4	32.91^{d}	27.20^{bc}	30.05^{bc}
T_5	41.75^{ab}	31.70^{abc}	36.72^{a}
T_6	44.16^{a}	34.28^{ab}	39.22^{a}
T_7	42.33^{a}	36.85^{a}	39.59^{a}
T_8	39.08^{bc}	24.75^{c}	31.91^{b}
CD at 5%	2.82	7.99	3.95

Table 6. Effect of treatments on initial fruit set in Alphonso

Treatments	**Initial fruit set (No.)**		
	I Year	II Year	Pooled
T_1	26.90^{c}	27.50^{b}	27.18^{b}
T_2	27.30^{c}	32.0^{ab}	29.65^{b}
T_3	26.0^{c}	0	-
T_4	36.80^{b}	33.70^{ab}	35.21^{a}
T_5	39.30^{a}	33.40^{ab}	36.32^{a}
T_6	40.40^{a}	36.0^{a}	38.18^{a}
T_7	39.80^{a}	32.80^{ab}	36.27^{a}
T_8	27.0^{c}	31.70^{ab}	29.35^{b}
CD at 5%	1.88	7.64	3.71

lower values, which were statistically superior to other treatments. T_1 and T_8 resulted in maximum fruit drop.

Pooled analysis revealed the significant influence of paclobutrazol treatments (T_6 and T_7) which recorded statistically minimum values (62.31% and 63.18% respectively) for this parameter. T_1 recorded the highest drop of 74.30%.

Influence of treatments on fruit drop at 15 days after set was insignificant in Alphonso during first year. During second year, though treatments influenced this parameter significantly, the pattern was not specific however T_7 recorded lowest drop and T_1 recorded the highest value (Table 8). In pooled analysis, treatments failed to influence this parameter and the values ranged from 69.30% in T_7 to 76.52% in T_1.

4.3.3. Fruit drop at 30 days after set

During first year, effect of treatments were non significant in Prior. However, treatments exhibited significant influence during second year and T_6 and T_7 recorded lower values (74.92% and 74.58% respectively), which were statistically superior to other treatments. In pooled analysis also, significant influence of paclobutrazol treatments (T_6 and T_7) was clear showing the minimum drop at this stage.

During first year, treatments failed to show significant impact on fruit drop in Alphonso at 30 days after set. However, treatments significantly influenced this parameter during second year and T_7 was found to be superior one by recording the lowest value of 78.16%. T_1 and T_8 recorded statistically higher values of 89.65% and 88.38% respectively.

Pooled analysis exhibited the significant influence of paclobutrazol treatments (T_6 and T_7) as they recorded minimum drop at this stage. T_1 recorded the highest drop.

Table 7. Effect of treatments on fruit drop at 15 and 30 days after set in Prior

Treatments	Fruit drop (%) at 15 DAS			Fruit drop (%) at 30 DAS		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	73.33(8.58)[a]	75.27(8.70)[a]	74.30(8.64)[a]	87.68 (9.37)[a]	88.17(9.41)[a]	87.93(9.39)[a]
T_2	70.96(8.44)[a]	0	-	81.51(9.05)[a]	0	-
T_3	72.36(8.53)[a]	62.51(7.93)[c]	67.44(8.23)[cd]	80.97(9.01)[a]	81.47(9.05)[b]	81.22(9.03)[bcd]
T_4	73.84(8.62)[a]	69.97(8.39)[b]	71.90(8.50)[abc]	84.55(9.22)[a]	88.02(9.40)[a]	86.28(9.31)[ab]
T_5	69.58(8.37)[a]	69.33(8.25)[b]	69.45(8.31)[bc]	77.88(8.85)[a]	82.0(9.08)[b]	79.94(8.96)[cd]
T_6	62.44(7.93)[a]	62.19(7.91)[c]	62.31(7.92)[e]	72.53(8.54)[a]	74.92(8.68)[c]	73.72(8.61)[e]
T_7	66.29(8.16)[a]	60.06(7.78)[c]	63.18(7.97)[de]	76.02(8.74)[a]	74.58(8.66)[c]	75.30(8.70)[de]
T_8	69.61(8.36)[a]	78.19(8.87)[a]	73.90(8.61)[ab]	82.66(9.11)[a]	89.14(9.46)[a]	85.90(9.28)[abc]
CD at 5%	NS	4.60(0.25)	4.71(0.28)	NS	5.10(0.31)	6.09(0.33)

Table 8. Effect of treatments on fruit drop at 15 and 30 days after set in Alphonso

Treatments	Fruit drop (%) at 15 DAS			Fruit drop (%) at 30 DAS		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	78.32 (8.87)[a]	74.73(8.67)[a]	76.52(8.77)[a]	89.68(9.49)[a]	89.65(9.49)[a]	89.66(9.49)[a]
T_2	79.0(8.91)[a]	70.83(8.43)[ab]	74.91(8.67)[a]	87.04(9.35)[a]	84.41(9.21)[bc]	85.73(9.28)[abc]
T_3	79.20(8.92)[a]	0	-	87.46(9.37)[a]	0	-
T_4	72.46(8.54)[a]	68.31(8.28)[ab]	70.38(8.41)[a]	81.63(9.06)[a]	82.98(9.13) [c]	82.30(9.09)[bcd]
T_5	69.33(8.33)[a]	69.30(8.35)[ab]	69.32(8.34)[a]	78.42(8.88)[a]	83.92(9.18)[c]	81.17(9.03)[cd]
T_6	71.76(8.48)[a]	72.17(8.52)[ab]	71.97(8.50)[a]	76.95(8.77)[a]	83.37(9.15)[c]	80.16(8.96)[d]
T_7	73.60(8.60)[a]	65.0(8.09)[b]	69.30(8.34)[a]	79.03(8.91)[a]	78.16(8.86)[d]	78.59(8.89)[d]
T_8	75.0(8.67)[a]	73.44(8.59)[a]	74.22(8.63)[a]	85.66(9.27)[a]	88.38(9.42)[ab]	87.02(9.35)[ab]
CD at 5%	NS	8.09 (0.49)	NS	NS	4.33 (0.24)	5.40 (0.32)

DAS - Days after set
Figures in the parentheses indicate square root transformed values

4.3.4. Increment in drop between 15 and 30 days after set

Treatments did not significantly influence this parameter in Prior during both years. Pooled analysis also indicated the same pattern (Table 9).

Influence of treatments on increment in drop between 15-30 days after set was insignificant in Alphonso during both years as well as in pooled analysis (Table 10).

4.3.5. Fruit drop at 45 days after set

Influence of treatments on this parameter was insignificant in Prior during first year. During second year, paclobutrazol treatments (T_6 and T_7) recorded statistically minimum values. Pooled analysis pointed out the significant influence of paclobutrazol treatments (T_5, T_6 and T_7) on this parameter (Table 11).

In Alphonso, even though treatments had significant influence on fruit drop at 45 days after set during first year, the pattern was not specific however T_5, T_6 and T_7 recorded minimum values (Table 12). T_7 was statistically superior to other treatments during second year and recorded the lowest drop of 82.95%. T_1 and T_8 recorded higher values of 94.36% and 93.71% respectively. Pooled analysis indicated the statistical significance of paclobutrazol treatments (T_5, T_6 and T_7) on this parameter.

4.3.6. Increment in drop between 30 and 45 days after set

Treatments did not significantly influence this parameter in Prior during first year. T_3 recorded the highest drop and was statistically inferior to other treatments during second year (Table 11). However, pooled analysis revealed no significant influence by treatments on this parameter.

Table 9. Effect of treatments on increment in fruit drop between 15 and 30 days after set in Prior

Treatments	% increment in drop (15-30 DAS)		
	I Year	II Year	Pooled
T_1	14.35 (3.59)[a]	12.90(3.63)[a]	13.62(3.61)[a]
T_2	10.54(3.31)[a]	0	-
T_3	8.61(2.92)[a]	18.95(4.40)[a]	13.78(3.66)[a]
T_4	10.71(3.34)[a]	18.05(4.30)[a]	14.38(3.82)[a]
T_5	8.30(2.96)[a]	12.67(3.60)[a]	10.48(3.28)[a]
T_6	10.09(3.11)[a]	12.73(3.55)[a]	11.41(3.33)[a]
T_7	9.72(3.19)[a]	14.52(3.87)[a]	12.12(3.53)[a]
T_8	13.05(3.66)[a]	10.95(3.42)[a]	12.0(3.54)[a]
CD at 5%	NS	8.01(1.25)	NS

Table 10. Effect of treatments on increment in fruit drop between 15 and 30 days after set in Alphonso

Treatments	% Increment in drop (15-30 DAS)		
	I Year	II Year	Pooled
T_1	11.36(3.40)[a]	14.92(3.80)[a]	13.14(3.60)[a]
T_2	8.04(2.73)[a]	13.58(3.56)[a]	10.81(3.15)[a]
T_3	8.26(2.95)[a]	0	-
T_4	9.16(3.10)[a]	14.67(3.87)[a]	11.91(3.49)[a]
T_5	9.09(2.70)[a]	14.62(3.88)[a]	11.85(3.29)[a]
T_6	5.19(2.33)[a]	11.19(3.41)[a]	8.19(2.87)[a]
T_7	5.43(2.42)[a]	13.16(3.66)[a]	9.29(3.04)[a]
T_8	10.66(3.30)[a]	14.94(3.82)[a]	12.79(3.56)[a]
CD at 5%	NS	NS	NS

Table 11. Effect of treatments on fruit drop at 45 days after set and increment between 30 and 45 days after set in Prior

Treatments	Fruit drop (%) at 45 DAS			% Increment in drop (30-45 DAS)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	91.43(9.57)^{a}	92.63(9.65)^{a}	92.03(9.61)^{a}	3.75(1.87)^{a}	4.46(2.21)^{b}	4.10(2.04)^{a}
T_2	87.03(9.35)^{a}	0	-	5.52(2.39)^{a}	0	-
T_3	85.73(9.28)^{a}	89.96(9.51)^{ab}	87.84(9.39)^{ab}	4.75(2.15)^{a}	8.49(2.99)^{a}	6.62(2.57)^{a}
T_4	88.34(9.41)^{a}	92.41(9.63)^{a}	90.37(9.52)^{a}	3.78(2.58)^{a}	4.39(2.21)^{b}	4.09(2.36)^{a}
T_5	81.20(9.03)^{a}	86.34(9.31)^{b}	83.77(9.17)^{bc}	3.31(1.94)^{a}	4.33(2.19)^{b}	3.82(2.07)^{a}
T_6	78.91(8.90)^{a}	79.95(8.96)^{c}	79.43(8.93)^{c}	6.38(2.60)^{a}	5.03(2.34)^{b}	5.70(2.47)^{a}
T_7	80.90(9.02)^{a}	78.91(8.91)^{c}	79.90(8.96)^{c}	4.88(2.22)^{a}	4.32(2.16)^{b}	4.60(2.19)^{a}
T_8	87.38(9.37)^{a}	93.10(9.67)^{a}	90.24(9.52)^{a}	4.71(2.12)^{a}	3.95(2.06)^{b}	4.33(2.09)^{a}
CD at 5%	NS	3.86(0.23)	5.34(0.28)	NS	2.13(0.50)	NS

Table 12. Effect of treatments on fruit drop at 45 days after set and increment between 30 and 45 days after set in Alphonso

Treatments	Fruit drop (%) at 45 DAS			% Increment in drop (30-45 DAS)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	95.99(9.82)^{a}	94.36(9.73)^{a}	95.18(9.78)^{a}	6.31(2.60)^{a}	4.71(2.28)^{a}	5.51 (2.44)^{a}
T_2	93.79(9.70)^{ab}	88.70(9.44)^{b}	91.24(9.57)^{b}	6.74(2.64)^{a}	4.29(2.18)^{a}	5.51 (2.41)^{a}
T_3	94.88(9.76)^{a}	0	-	7.42(2.80)^{a}	0	-
T_4	88.40(9.42)^{bc}	87.42(9.37)^{b}	87.91(9.40)^{c}	6.76(2.69)^{a}	4.44(2.08)^{a}	5.60 (2.38)^{a}
T_5	84.95(9.24)^{cd}	87.69(9.39)^{b}	86.32(9.31)^{cd}	6.53(2.64)^{a}	3.76(2.06)^{a}	5.14 (2.35)^{a}
T_6	81.0(9.01)^{d}	86.81(9.34)^{b}	83.90(9.18)^{de}	4.04(1.74)^{a}	3.44(1.98)^{a}	3.74 (1.86)^{a}
T_7	82.47(9.10)^{cd}	82.95(9.13)^{c}	82.71 (9.12)^{e}	3.43(1.75)^{a}	4.79(2.29)^{a}	4.11 (2.02)^{a}
T_8	92.78(9.65)^{ab}	93.71(9.70)^{a}	93.25(9.68)^{ab}	7.12(2.70)^{a}	5.33(2.29)^{a}	6.23 (2.50)^{a}
CD at 5%	6.31 (0.38)	2.71 (0.14)	3.28 (0.17)	NS	3.23 (0.70)	NS

In Alphonso, effect of treatments on this parameter was non significant during both years as well as in pooled analysis (Table 12).

4.3.7. Fruit drop at 60 days after set

In Prior, treatments did not influence this parameter during first year. However, treatments had significant influence during second year and paclobutrazol treatments (T_6 and T_7) recorded statistically minimum values (82.47% and 81.27% respectively). T_5 was also statistically different from rest of treatments recording the lower value of 89.22%.

Pooled analysis displayed the significant influence of paclobutrazol treatments (T_5, T_6 and T_7) which recorded minimum values for this parameter. T_1, T_4 and T_8 resulted in more drop, the values being 95.13%, 93.06% and 92.52% respectively.

In Alphonso, significant influence of treatments on fruit drop was evident during both years. During first year, T_5, T_6 and T_7 resulted in lower values, which were statistically different from rest of treatments. During second year, T_7 recorded the lowest drop (84.31%) and was statistically superior to other treatments. Among other treatments, T_1 and T_8 resulted in statistically maximum values.

Pooled analysis also exhibited a similar pattern of influence as in first year, showing significant influence of paclobutrazol treatments (T_5, T_6 and T_7) in giving minimum fruit drop, when statistically compared with other treatments (Table 14).

4.3.8. Increment in drop between 45 and 60 days after set

Treatments did not show significant influence on this parameter in Prior during both years and also the same trend was shown in pooled analysis (Table 13).

Table 13. Effect of treatments on fruit drop at 60 days after set and increment between 45 and 60 days after set in Prior

Treatments	Fruit drop (%) at 60 DAS			% Increment in drop (45-60 DAS)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	94.33(9.73)[a]	95.93(9.86)[a]	95.13(9.79)[a]	2.90(1.48)[a]	3.30(1.93)[a]	3.10(1.70)[a]
T_2	88.86(9.45)[a]	0	-	1.82(1.52)[a]	0	-
T_3	87.61(9.37)[a]	93.02(9.67)[b]	90.32(9.52)[bc]	1.88(1.54)[a]	3.06(1.88)[a]	2.47(1.71)[a]
T_4	90.74(9.54)[a]	95.39(9.79)[a]	93.06(9.66)[ab]	2.40(1.58)[a]	2.97(1.69)[a]	2.68(1.63)[a]
T_5	83.21(9.14)[a]	89.22(9.47)[c]	86.21(9.30)[cd]	2.01(1.56)[a]	2.88(1.83)[a]	2.44(1.69)[a]
T_6	81.02(9.02)[a]	82.47(9.10)[d]	81.74 (9.06)[d]	2.11(1.54)[a]	2.51(1.73)[a]	2.31(1.64)[a]
T_7	82.41(9.10)[a]	81.27(9.04)[d]	81.84 (9.07)[d]	1.51(1.41)[a]	2.36(1.68)[a]	1.93(1.54)[a]
T_8	89.04(9.46)[a]	96.0(9.82)[a]	92.52(9.64)[ab]	1.66(1.46)[a]	2.89(1.84)[a]	2.28(1.65)[a]
CD at 5%	NS	2.04 (0.10)	4.75 (0.25)	NS	NS	NS

Table 14. Effect of treatments on fruit drop at 60 days after set and increment between 45 and 60 days after set in Alphonso

Treatments	Fruit drop (%) at 60 DAS			% Increment in drop (45-60 DAS)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	96.55(9.85)[a]	97.0(9.87)[a]	96.77(9.86)[a]	0.55(1.02)[a]	2.64(1.77)[a]	1.59(1.39)[a]
T_2	96.36(9.84)[a]	90.84(9.55)[b]	93.60(9.69)[b]	2.57(1.66)[a]	2.14(1.60)[ab]	2.35(1.63)[a]
T_3	95.78(9.81)[a]	0	-	0.89(1.18)[a]	0	-
T_4	89.20(9.47)[b]	89.82(9.50)[bc]	89.51(9.48)[c]	0.80(1.14)[a]	2.40(1.70)[a]	1.60(1.42)[a]
T_5	85.97(9.29)[c]	89.22(9.47)[bc]	87.59(9.38)[d]	1.01(0.98)[a]	1.53(1.41)[bc]	1.27(1.20)[a]
T_6	82.55(9.11)[d]	87.99(9.40)[c]	85.27(9.25)[e]	1.55(1.42)[a]	1.18(1.29)[c]	1.36(1.35)[a]
T_7	84.30(9.20)[cd]	84.31(9.20)[d]	84.31(9.20)[e]	1.83(1.42)[a]	1.36(1.36)[c]	1.59(1.39)[a]
T_8	96.37(9.84)[a]	96.22(9.83)[a]	96.29(9.83)[a]	3.59(2.02)[a]	2.50(1.73)[a]	3.04(1.87)[a]
CD at 5%	2.72 (0.16)	2.72 (0.14)	1.84(0.09)	NS	0.72 (0.20)	NS

Fig. 4. Effect of treatments on fruit drop (%) in Prior

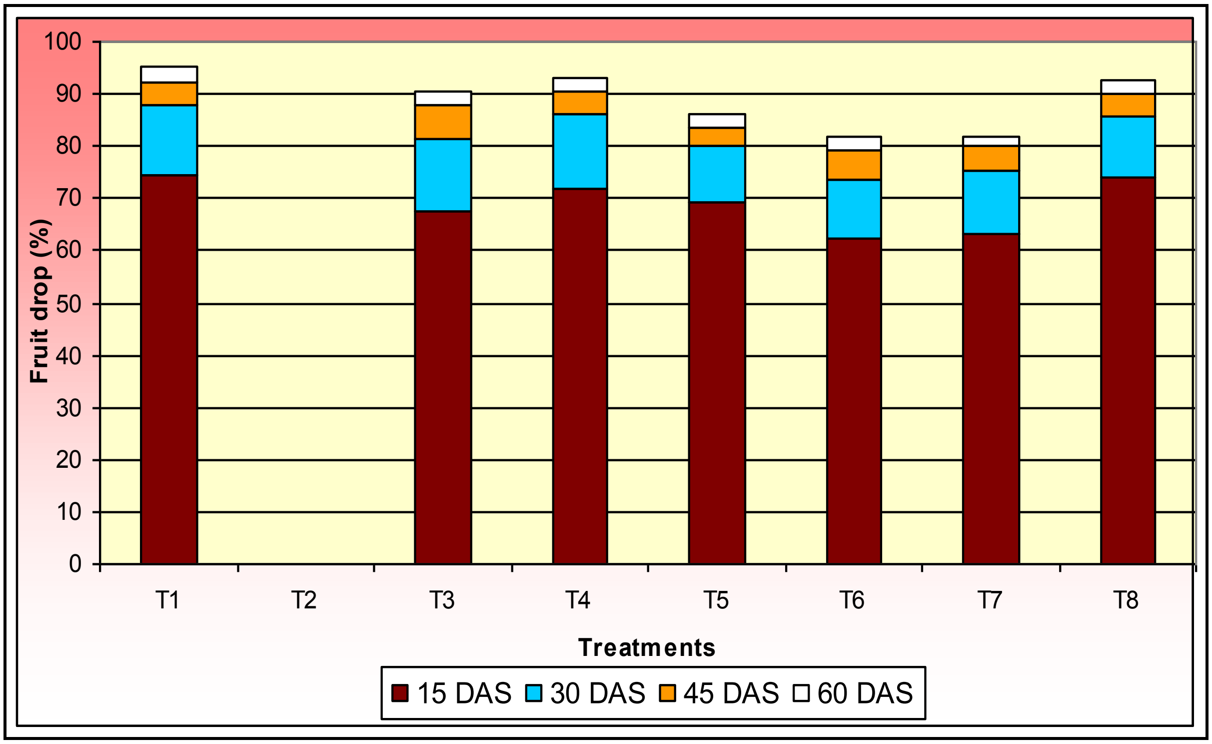
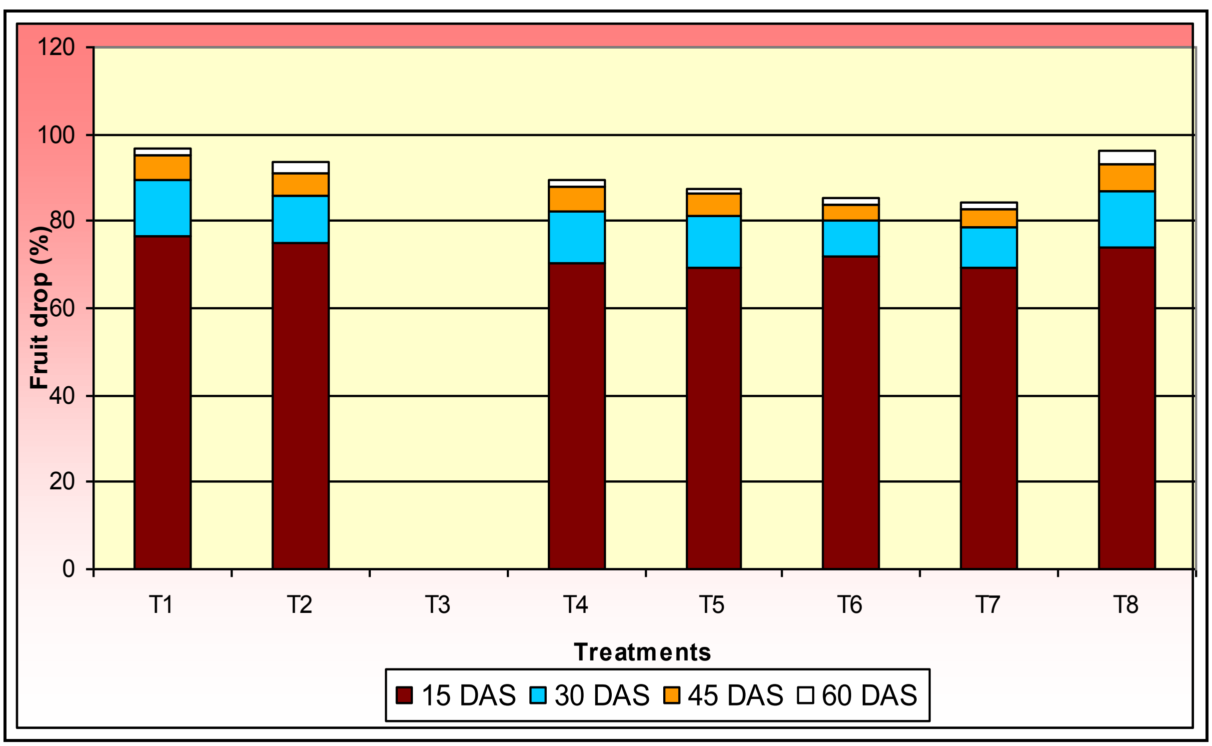


Fig. 5. Effect of treatments on fruit drop (%) in Alphonso



In Alphonso, treatments did not significantly influence the increment in drop during 45-60 days after set during first year. Paclobutrazol treatments (T_5, T_6 and T_7) recorded minimum increment in drop at this stage during second year (Table 14). Pooled analysis revealed no significant influence of treatments on this parameter and the values ranged from 1.27% in T_6 to 3.04% in T_8.

4.4. Number of days from flowering to fruit maturity

Number of days from chemical application to flowering and fruit maturity are depicted in Tables 15 and 16 for Prior and Alphonso varieties.

4.4.1. Season of flowering

During first year, peak flowering in Prior extended from December 4th week in T_5 to February 1st week in T_1 and during second year from December 3rd week in T_3 to February 1st week in T_8.

In Alphonso, peak flowering during first year was from December 4th week in T_5 to February 1st week in T_1 and during second year from December 3rd week in T_4 to January 4th week in T_1.

4.4.2. Time of first harvest

During first year, time of harvest in Prior extended from March 4th week in T_5 to May 2nd week in T_2 and during second year from March 3rd week in T_3 to May 2nd week in T_8.

In Alphonso, time of harvest during first year was from April 1st week in T_5 to May 3rd week in T_1 and during second year from March 3rd week in T_4 to May 2nd week in T_1.

Table 15a. Effect of treatments on duration of flowering and fruiting in Prior

Treatments	Season of flowering		First harvest	
	I Year	II Year	I Year	II Year
T_1	Feb 1st week	Jan 2nd week	May 1st week	April 3rd week
T_2	Feb 1st week	0	May 2nd week	0
T_3	Jan 2nd week	Dec 3rd week	April 2nd week	March 3rd week
T_4	Jan 2nd week	Dec 3rd week	April 2nd week	March 3rd week
T_5	Dec 4th week	Dec 3rd week	March 4th week	March 4th week
T_6	Jan 2nd week	Dec 4th week	April 2nd week	April 1st week
T_7	Dec 4th week	Dec 3rd week	April 1st week	March 4th week
T_8	Jan 2nd week	Feb 1st week	April 4th week	May 2nd week

Table 16a. Effect of treatments on duration of flowering and fruiting in Alphonso

Treatments	Season of flowering		First harvest	
	I Year	II Year	I Year	II Year
T_1	Feb 1st week	Jan 4th week	May 3rd week	May 2nd week
T_2	Feb 1st week	Jan 2nd week	May 3rd week	April 4th week
T_3	Jan 2nd week	0	May 1st week	0
T_4	Jan 2nd week	Dec 3rd week	April 4th week	March 3rd week
T_5	Dec 4th week	Dec 4th week	April 1st week	April 1st week
T_6	Jan 2nd week	Dec 4th week	April 4th week	March 4th week
T_7	Jan 2nd week	Dec 4th week	April 3rd week	April 1st week
T_8	Jan 3rd week	Jan 3rd week	May 1st week	May 1st week

4.4.3. Time taken from chemical application to flowering

Treatments had significant influence on flowering in Prior as evident from potassium nitrate (T_3 and T_4) and paclobutrazol treatments (T_5 and T_7) which took minimum duration for flowering during first year (Table 15b). Influence of treatments was not specific during second year, however trees of T_3 and T_4 flowered in minimum time after chemical application. Pooled analysis exhibited the similar trend of second year.

Effect of treatments on flowering was significant during both years in Alphonso. During first year, T_3, T_4 and T_5 took minimum duration for flowering and were statistically superior to other treatments. Other treatments did not show variation among themselves with respect to this parameter. T_4 recorded statistically minimum and superior value (76 days) during second year. Pooled analysis pointed out the similar trend of second year (Table 16b).

4.4.4. Time taken from flowering to fruit maturity

In Prior, influence of treatments on this parameter was insignificant during first year. Though, treatments showed significant influence during second year, the pattern was not specific however, T_3 recorded minimum value (91.0 days) when compared to other treatments. Pooled analysis pointed out the non significant effect of treatments on this parameter.

Effect of treatments on days from flowering to fruit maturity was non significant in Alphonso during first year. However, during second year, treatments exhibited significant influence and T_4 and T_6 were the superior ones, which took minimum duration for fruit maturity. Pooled analysis indicated the significance of T_4 and paclobutrazol treatments (T_5, T_6 and T_7) on this parameter.

4.4.5. Time taken from chemical application to fruit maturity

In Prior, significance pattern between treatments was not specific during both years, however potassium nitrate treatments (T_3 and T_4) recorded minimum values for this parameter. Pooled analysis also indicated the same.

Even though treatments had significant influence on this parameter during both years, the pattern was not specific during first year. T_4 recorded statistically minimum value during second year (166 days) however T_1 and T_8 took maximum duration for fruit maturity (213.33 and 215 days respectively). Pooled analysis showed the similar pattern as that of second year (Table 16b).

4.5. Fruit yield

Yield per tree in terms of weight of fruits and number of fruits are presented in Tables 17 and 18, respectively, for Prior and Alphonso varieties. Plates 6 and 7 indicate the influence of selected treatments on yield of trees.

4.5.1. Weight of fruits per tree

Treatments exhibited significant influence on this parameter in Prior during both years. During first year, Treatments except T_1 and T_4 recorded higher values and were statistically superior to these treatments. Paclobutrazol treatment (T_7) recorded the highest yield and was statistically superior during second year. Other paclobutrazol treatments (T_5 and T_6) were statistically different from rest of the treatments recording higher values.

Pooled analysis indicated that paclobutrazol treatments (T_5, T_6 and T_7) recorded higher values and T_3 was also statistically on par with these treatments. Lowest yield was recorded by T_1 (Fig. 6).

Table 15b. Effect of treatments on duration of flowering and fruiting in Prior

Treatments	No. of days from chemical application to flowering			No. of days from flowering to fruit maturity			No. of days from chemical application to fruit maturity		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	109.33^{a}	95.0^{b}	102.16^{b}	98.66^{a}	102.0^{a}	100.33^{a}	208.0^{a}	197.0^{b}	202.50^{b}
T_2	110.0^{a}	0	-	99.33^{a}	0	-	209.33^{a}	0	-
T_3	93.33^{b}	76.0^{c}	84.66^{d}	91.66^{a}	91.0^{b}	91.33^{a}	185.0^{b}	167.0^{d}	176.0^{d}
T_4	93.33^{b}	76.0^{c}	84.66^{d}	91.66^{a}	96.0^{ab}	93.83^{a}	185.0^{b}	172.0^{d}	178.50^{d}
T_5	94.0^{b}	84.0^{bc}	89.0^{cd}	91.66^{a}	96.0^{ab}	93.83^{a}	185.66^{b}	180.0^{cd}	182.83^{cd}
T_6	107.0^{a}	90.0^{bc}	98.50^{bc}	93.0^{a}	99.0^{a}	96.0^{a}	200.0^{ab}	189.0^{bc}	194.50^{bc}
T_7	94.0^{b}	83.0^{bc}	88.50^{cd}	95.0^{a}	96.0^{ab}	95.50^{a}	189.0^{b}	179.0^{cd}	184.0^{cd}
T_8	111.0^{a}	123.0^{a}	117.0^{a}	99.0^{a}	102.0^{a}	100.50^{a}	210.0^{a}	225.0^{a}	217.50^{a}
CD (0.05)	6.92	17.17	10.80	NS	6.13	NS	16.17	16.16	12.40

Table 16b. Effect of treatments on duration of flowering and fruiting in Alphonso

Treatments	No. of days from chemical application to flowering			No. of days from flowering to fruit maturity			No. of days from chemical application to fruit maturity		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	109.0^{a}	108.33^{a}	108.66^{a}	109.66^{a}	105.0^{ab}	107.33^{a}	218.66^{ab}	213.33^{a}	216.0^{ab}
T_2	109.66^{a}	100.0^{ab}	104.83^{ab}	105.0^{a}	102.0^{b}	103.50^{ab}	214.66^{ab}	202.0^{b}	208.33^{b}
T_3	94.33^{b}	0	-	104.0^{a}	0	-	198.33^{cd}	0	-
T_4	94.0^{b}	76.0^{c}	85.0^{d}	101.0^{a}	90.0^{d}	95.50^{c}	195.0^{d}	166.0^{d}	180.50^{d}
T_5	94.0^{b}	92.33^{b}	93.16^{c}	100.66^{a}	97.0^{c}	98.83^{bc}	194.66^{d}	189.33^{c}	192.0^{c}
T_6	107.0^{a}	90.0^{b}	98.50^{bc}	103.0^{a}	90.0^{d}	96.50^{c}	210.0^{abc}	180.0^{c}	195.0^{c}
T_7	108.0^{a}	92.33^{b}	100.16^{bc}	99.33^{a}	96.0^{c}	97.66^{c}	207.33^{bcd}	188.33^{c}	197.83^{c}
T_8	112.33^{a}	109.0^{a}	110.66^{a}	110.0^{a}	106.0^{a}	108.0^{a}	222.33^{a}	215.0^{a}	218.66^{a}
CD (0.05)	8.87	11.05	7.98	NS	3.93	5.40	13.27	10.51	10.12

Significant influence of treatments was observed on fruit yield in Alphonso and paclobutrazol treatments (T_5, T_6 and T_7) recorded higher yields during both years however T_4 was statistically on par with these treatments during first year (Table 18). Pooled analysis exhibited the similar pattern of first year (Fig. 7).

4.5.2. Number of fruits per tree

Treatments exhibited significant influence on this parameter in Prior during both years. During first year, treatments except T_1, T_2 and T_4 recorded maximum number of fruits per tree. T_7 showed the superiority during second year. Pooled analysis indicated the significant influence of various treatments on this parameter.

In Alphonso, influence of treatments on number of fruits per tree followed almost the similar pattern as in weight of fruits per tree.

4.6. Physical parameters of fruits

Physical characteristics of the fruits are presented in Tables 19 and 20 for Prior and Alphonso varieties.

4.6.1. Fruit weight

Influence of treatments on average fruit weight was insignificant in Prior during first year. Even though treatments had significant influence during second year, the pattern was not specific however potassium nitrate (T_3 and T_4) and paclobutrazol treatments (T_6 and T_7) recorded higher values. Analysis of pooled data indicated the non existence of significance between treatments with respect to this parameter in Prior (Table 19a).

Effect of treatments on fruit weight differed significantly in Alphonso during both years. In first year, T_3, T_4 and T_6 recorded higher values and T_1 recorded the minimum

Table 17. Effect of treatments on fruit yield in Prior

Treatments	Weight of fruits (kg/tree)			No. of fruits/tree		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	21.30^{b}	13.0^{e}	17.15^{d}	72.70^{d}	48.33^{e}	60.52^{c}
T_2	53.70^{a}	0	-	180.0^{bc}	0	-
T_3	62.90^{a}	28.53^{c}	45.72^{ab}	226.0^{ab}	109.67^{c}	167.83^{a}
T_4	35.10^{b}	16.23^{d}	25.67^{cd}	121.90^{cd}	61.0^{d}	91.45^{bc}
T_5	61.0^{a}	28.03^{c}	44.52^{ab}	222.90^{ab}	106.0^{c}	164.45^{a}
T_6	65.17^{a}	36.17^{b}	50.67^{a}	244.20^{a}	138.33^{b}	191.27^{a}
T_7	63.0^{a}	39.40^{a}	51.20^{a}	220.0^{ab}	148.67^{a}	184.33^{a}
T_8	59.63^{a}	12.50^{e}	36.07^{bc}	238.0^{ab}	43.67^{e}	140.83^{ab}
CD (0.05)	15.18	2.27	14.03	63.61	9.19	61.17

Table 18. Effect of treatments on fruit yield in Alphonso

Treatments	Weight of fruits (kg/tree)			No. of fruits/tree		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	13.80^{c}	8.47^{d}	11.13^{b}	57.50^{bc}	31.67^{c}	44.58^{c}
T_2	13.60^{c}	10.57^{cd}	12.08^{b}	53.30^{c}	37.67^{c}	45.48^{c}
T_3	14.80^{bc}	0	-	53.80^{c}	0	-
T_4	25.60^{abc}	17.53^{b}	21.57^{a}	84.50^{abc}	65.0^{b}	74.75^{ab}
T_5	28.40^{ab}	22.17^{a}	25.28^{a}	105.0^{abc}	81.33^{a}	93.17^{a}
T_6	35.60^{a}	21.37^{a}	28.48^{a}	119.83^{a}	81.0^{a}	100.41^{a}
T_7	28.90^{a}	21.03^{a}	24.97^{a}	108.40^{ab}	80.67^{a}	94.53^{a}
T_8	14.30^{c}	11.67^{c}	12.98^{b}	57.80^{bc}	42.0^{c}	49.90^{bc}
CD (0.05)	13.94	2.94	6.94	54.39	11.48	25.80

Fig. 6. Effect of treatments on fruit yield in Prior

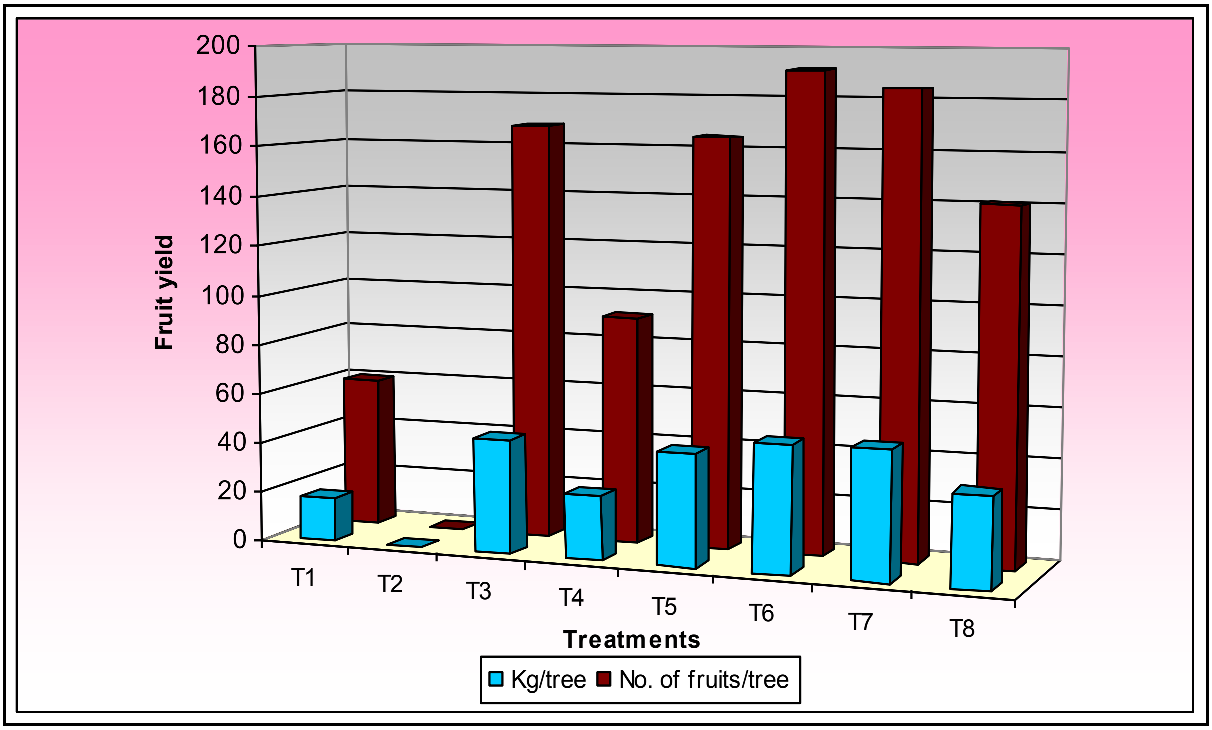


Fig. 7. Effect of treatments on fruit yield in Alphonso

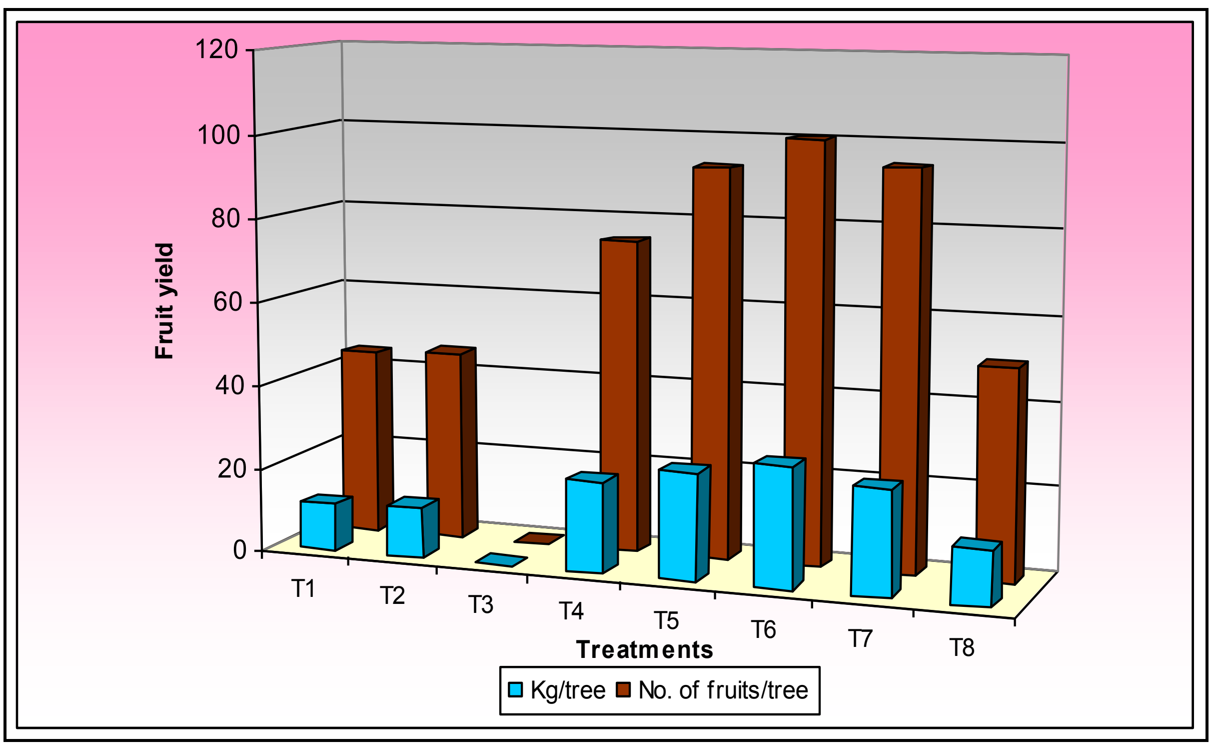


Plate 6. Effect of treatments on fruit yield in Prior

T_7- Paclobutrazol (5 g /tree) + KNO_3 (3%)

T_6 – Paclobutrazol (5 g /tree) + NAA (30 ppm)

T_5– Paclobutrazol (5 g /tree)

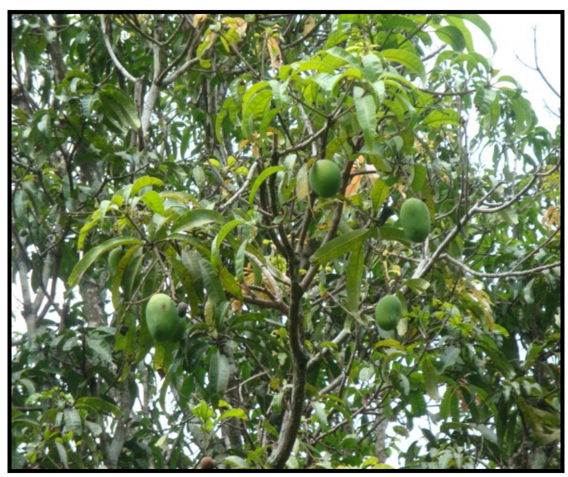
T_8- Control

Plate 7. Effect of treatments on fruit yield in Alphonso

T_6 – Paclobutrazol (5 g /tree) + NAA (30 ppm)

T_5– Paclobutrazol (5 g /tree)

T_7- Paclobutrazol (5 g /tree) + KNO_3 (3%)



T_8- Control

(Table 20a). During second year, T_4 produced the maximum fruit weight (266.13 g) and was statistically superior to other treatments. Pooled analysis pointed out the statistically superior influence of T_4 and T_6 on this parameter.

4.6.2. Fruit length

In Prior, treatments did not significantly influence this parameter during first year. During second year, the influence of treatments was same as in fruit weight (Table 19a). Pooled analysis exhibited that trees under T_4, T_6 and T_7 recorded higher values and T_8 recorded the minimum fruit length.

Influence of treatments on fruit length was insignificant in Alphonso during first year. Treatments had significant influence during second year and T_4 and T_6 recorded higher values. T_8 was statistically inferior to other treatments. Pooled analysis exhibited the significant influence of T_2, T_4 and paclobutrazol treatments (T_6 and T_7) which resulted in larger fruits.

4.6.3. Fruit breadth

In Prior, treatments influenced this parameter significantly during both years, but the pattern was not specific (Table 19a). Pooled analysis indicated the same, however, application of potassium nitrate (T_3 and T_4) and paclobutrazol treatments (T_6 and T_7) resulted in higher values.

In Alphonso, treatments did not show significant influence on fruit breadth during first year. Significance pattern of treatments was not specific during second year however T_4 recorded highest value and T_8 recorded statistically the minimum value (Table 20a). Pooled analysis exhibited the significant influence of T_2, T_4 and paclobutrazol treatments (T_6 and T_7) on this parameter (Table 20a).

Table 19a. Effect of treatments on physical parameters of Prior fruits

Treatments	Fruit weight (g)			Fruit length (cm)			Fruit breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	292.93^{a}	267.33^{bcd}	280.13^{a}	11.83^{a}	13.0^{b}	12.41^{cde}	9.46^{bc}	11.60^{ab}	10.53^{bc}
T_2	299.50^{a}	0	-	12.40^{a}	0	-	10.56^{a}	0	-
T_3	278.10^{a}	270.13^{abcd}	274.11^{a}	12.03^{a}	13.50^{ab}	12.76^{bcd}	10.10^{ab}	11.75^{ab}	10.92^{ab}
T_4	287.93^{a}	280.26^{a}	284.09^{a}	13.03^{a}	14.02^{a}	13.52^{a}	10.90^{a}	11.86^{ab}	11.38^{a}
T_5	273.67^{a}	264.03^{cd}	268.85^{a}	11.40^{a}	12.90^{b}	12.15^{de}	8.50^{cd}	11.50^{b}	10.0^{cd}
T_6	267.07^{a}	277.46^{ab}	272.26^{a}	12.40^{a}	14.19^{a}	13.29^{ab}	10.90^{a}	12.20^{a}	11.55^{a}
T_7	286.60^{a}	272.60^{abc}	279.60^{a}	12.13^{a}	13.60^{ab}	12.86^{abc}	10.10^{ab}	11.80^{ab}	10.95^{ab}
T_8	250.43^{a}	260.80^{d}	255.61^{a}	11.46^{a}	12.70^{b}	12.08^{e}	8.16^{d}	11.40^{b}	9.78^{d}
CD (0.05)	NS	11.66	NS	NS	0.98	0.67	1.09	0.60	0.73

Table 20a. Effect of treatments on physical parameters of Alphonso fruits

Treatments	Fruit weight (g)			Fruit length (cm)			Fruit breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	240.16^{d}	244.63^{bc}	242.39^{b}	11.10^{a}	12.36^{cd}	11.73^{bc}	9.10^{a}	11.01^{ab}	10.05^{bc}
T_2	255.23^{bcd}	246.23^{bc}	250.73^{b}	11.96^{a}	12.60^{bc}	12.28^{ab}	10.03^{a}	11.33^{a}	10.68^{ab}
T_3	275.0^{ab}	0	-	11.76^{a}	0	-	9.66^{a}	0	-
T_4	297.50^{a}	266.13^{a}	281.81^{a}	11.90^{a}	13.30^{a}	12.60^{a}	10.66^{a}	11.50^{a}	11.08^{a}
T_5	269.40^{bc}	241.36^{bc}	255.38^{b}	11.20^{a}	12.0^{d}	11.60^{bc}	8.80^{a}	10.60^{b}	9.70^{cd}
T_6	297.40^{a}	249.56^{b}	273.48^{a}	12.06^{a}	13.0^{ab}	12.53^{a}	10.70^{a}	11.30^{ab}	11.0^{a}
T_7	266.50^{bc}	244.96^{bc}	255.73^{b}	11.70^{a}	12.46^{cd}	12.08^{ab}	9.86^{a}	11.10^{ab}	10.48^{abc}
T_8	247.50^{cd}	240.16^{c}	243.83^{b}	11.06^{a}	11.10^{e}	11.08^{c}	8.50^{a}	9.80^{c}	9.15^{d}
CD (0.05)	22.71	8.97	15.89	NS	0.47	0.70	NS	0.71	0.78

4.6.4. Fruit girth

Values of fruit girth were significantly influenced by treatments in Prior and T_4 and T_6 recorded higher values during both years. However T_2, T_3 and T_7 were statistically on par with these treatments during first year. Pooled analysis indicated the similar trend of second year.

In Alphonso, treatments had significant influence on fruit girth and T_2, T_4 and T_6 recorded higher values during both years. Pooled analysis also exhibited the same trend.

4.6.5. Peel weight

In Prior, influence of treatments was insignificant during first year. Even though treatments influenced this parameter during second year, the pattern was not specific however T_4 recorded highest value and T_8 recorded the minimum (Table 19b). Pooled analysis indicated the non specific influence of treatments as that of second year.

Treatments had significantly influenced the peel weight in Alphonso during both years. T_4 and T_6 recorded higher values during first year and T_1 recorded the lowest (Table 20b). During second year, T_4 recorded the highest value and other treatments recorded lower values which were statistically on par with one another. Pooled analysis indicated that ethrel treatments (T_1 and T_2) and T_8 recorded lower values for peel weight.

4.6.6. Pulp weight

In Prior, treatments did not show significant influence during first year. Influence of treatments on this parameter was significant during second year however the pattern was not specific. Pooled analysis indicated the non significant influence of treatments on this parameter (Table 19b).

Table 19b. Effect of treatments on physical parameters of Prior fruits

Treatments	Fruit girth (cm)			Peel weight (g)			Pulp weight (g)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	21.60^{bc}	23.40^{c}	22.50^{de}	59.34^{a}	52.69^{bc}	56.01^{ab}	179.23^{a}	153.86^{bc}	166.55^{a}
T_2	22.76^{a}	0	-	62.26^{a}	0	-	186.78^{a}	0	-
T_3	22.46^{ab}	23.80^{bc}	23.13^{cd}	52.89^{a}	54.93^{abc}	53.91^{ab}	165.19^{a}	160.37^{abc}	162.78^{a}
T_4	22.76^{a}	25.70^{a}	24.23^{ab}	57.45^{a}	59.94^{a}	58.69^{a}	175.46^{a}	176.21^{a}	175.83^{a}
T_5	21.10^{c}	23.30^{c}	22.20^{ef}	51.50^{a}	51.29^{c}	51.40^{bc}	161.85^{a}	149.89^{bc}	155.87^{a}
T_6	23.46^{a}	25.66^{a}	24.56^{a}	48.87^{a}	58.25^{ab}	53.56^{abc}	157.60^{a}	171.04^{a}	164.32^{a}
T_7	22.76^{a}	24.45^{b}	23.60^{bc}	56.24^{a}	56.43^{abc}	56.33^{ab}	174.61^{a}	163.52^{ab}	169.06^{a}
T_8	21.0^{c}	21.99^{d}	21.49^{f}	43.79^{a}	50.28^{c}	47.03^{c}	146.22^{a}	144.64^{c}	145.43^{a}
CD (0.05)	1.09	1.03	0.78	NS	6.43	6.87	NS	16.02	NS

Table 20b. Effect of treatments on physical parameters of Alphonso fruits

Treatments	Fruit girth (cm)			Peel weight (g)			Pulp weight (g)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	21.66^{cd}	21.20^{bc}	21.43^{c}	40.92^{f}	47.02^{b}	43.97^{c}	146.13^{d}	144.74^{b}	145.44^{c}
T_2	22.70^{abc}	22.10^{ab}	22.40^{ab}	44.82^{def}	47.54^{b}	46.18^{c}	158.21^{cd}	147.29^{b}	152.75^{c}
T_3	22.0^{bc}	0	-	52.49^{bc}	0	-	171.59^{abc}	0	-
T_4	23.23^{a}	23.10^{a}	23.16^{a}	61.60^{a}	55.93^{a}	58.76^{a}	187.16^{a}	165.57^{a}	176.36^{a}
T_5	20.86^{d}	21.10^{bc}	20.98^{cd}	49.74^{cd}	46.07^{b}	47.90^{bc}	167.79^{abc}	142.30^{b}	155.04^{bc}
T_6	22.96^{ab}	22.90^{a}	22.93^{a}	57.57^{ab}	48.24^{b}	52.90^{b}	186.08^{ab}	149.98^{ab}	168.03^{ab}
T_7	22.10^{bc}	21.30^{bc}	21.70^{bc}	48.65^{cde}	47.27^{b}	47.96^{bc}	166.29^{bcd}	145.58^{b}	155.93^{bc}
T_8	20.70^{d}	20.0^{c}	20.35^{d}	42.45^{ef}	45.25^{b}	43.85^{c}	152.36^{cd}	140.94^{b}	146.65^{c}
CD (0.05)	1.12	1.48	0.85	6.59	5.36	5.16	20.21	18.03	14.41

Effect of treatments on pulp weight was significant in Alphonso and T_4 and T_6 recorded higher values during individual years. However T_3 and T_5 were statistically on par with these treatments during first year. Pooled analysis indicated the same trend of second year (Table 20b).

4.7. Stone characters

Stone characters, such as, weight, length and breadth are furnished for Prior and Alphonso varieties in Tables 21 and 22, respectively.

4.7.1. Stone weight

In Prior, effect of treatments on this parameter was non significant during first year. Even though treatments had significant influence during second year, the pattern was not specific however T_4 recorded highest value and T_8 recorded the lowest (Table 21). Pooled analysis indicated the non specific influence of treatments on this parameter.

Influence of treatments on stone weight in Alphonso was not specific during individual years. But in pooled analysis, T_4 (62.09 g) turned out to be the one resulting in larger stones.

4.7.2. Stone length

In Prior, treatments significantly influenced this parameter and T_4 and T_6 recorded higher values during both years however T_2 and T_7 were statistically on par with these treatments during first and second year respectively. Pooled analysis indicated the superior influence of T_4 and T_6 on this parameter.

Treatments had shown significant influence during both years, but the pattern was not specific during first year. During second year, T_4 and T_6 recorded higher values and the same result was obtained in pooled analysis.

4.7.3. Stone breadth

Even though treatments had significant influence, the pattern was not specific however T_4 recorded the highest value during both years. Pooled analysis pointed out the same.

During first year, treatments failed to influence the stone breadth in Alphonso. Treatments showed significant influence during second year, but the pattern was not specific however T_6 recorded the highest value. Pooled analysis exhibited the significant influence of T_2, T_4 and paclobutrazol treatments (T_6 and T_7) on this parameter.

4.8. Percentage contribution of fruit parts to total fruit weight

Percentage contribution of different fruit parts to total fruit weight is given in Table 23 for Prior. The data indicated that influence of treatments on this aspect was not specific and statistically significant.

In Alphonso also, the percentage contribution of different parts to total fruit weight was not much influenced by treatments as clear from Table 24. However, in this variety T_4 exhibited significant influence on peel % resulting in maximum value during the pooled analysis.

4.9. Quality attributes of fruits

Data on qualitative analysis of fruits are tabulated in Tables 25 and 26 for Prior and Alphonso varieties respectively.

Table 21. Effect of treatments on stone characters in Prior

Treatments	Stone weight (g)			Stone length (cm)			Stone breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	65.65^{a}	56.05^{bcd}	60.85^{a}	7.90^{cd}	7.90^{cd}	7.90^{cd}	4.96^{bc}	4.90^{bc}	4.93^{c}
T_2	67.98^{a}	0	-	8.53^{ab}	0	-	5.30^{bc}	0	-
T_3	61.21^{a}	57.56^{abc}	59.38^{a}	8.10^{bcd}	8.16^{bc}	8.13^{bc}	5.20^{bc}	5.0^{abc}	5.10^{bc}
T_4	63.63^{a}	63.0^{a}	63.31^{a}	8.93^{a}	8.60^{a}	8.76^{a}	6.0^{a}	5.32^{a}	5.66^{a}
T_5	59.25^{a}	54.68^{cd}	56.96^{ab}	7.76^{cd}	7.76^{de}	7.76^{de}	4.90^{c}	4.80^{c}	4.85^{c}
T_6	56.18^{a}	61.19^{ab}	58.68^{a}	8.80^{a}	8.47^{ab}	8.63^{a}	5.50^{ab}	5.20^{ab}	5.35^{ab}
T_7	63.31^{a}	59.22^{abc}	61.26^{a}	8.20^{bc}	8.40^{ab}	8.30^{b}	5.26^{bc}	4.91^{bc}	5.08^{bc}
T_8	52.0^{a}	52.02^{d}	52.01^{b}	7.60^{d}	7.40^{e}	7.50^{e}	4.86^{c}	4.70^{c}	4.78^{c}
CD (0.05)	NS	5.50	6.37	0.50	0.37	0.28	0.55	0.34	0.32

Table 22. Effect of treatments on stone characters in Alphonso

Treatments	Stone weight (g)			Stone length (cm)			Stone breadth (cm)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	45.44^{c}	50.99^{b}	48.22^{c}	6.60^{bc}	6.70^{c}	6.65^{cd}	4.40^{a}	4.0^{bc}	4.20^{b}
T_2	50.97^{bc}	52.51^{ab}	51.74^{c}	6.90^{ab}	6.89^{bc}	6.89^{bc}	4.50^{a}	4.13^{abc}	4.31^{ab}
T_3	58.55^{ab}	0	-	6.80^{ab}	0	-	4.50^{a}	0	-
T_4	66.21^{a}	57.97^{a}	62.09^{a}	7.0^{a}	7.40^{a}	7.20^{a}	4.60^{a}	4.36^{ab}	4.48^{a}
T_5	57.03^{abc}	49.48^{b}	53.25^{bc}	6.60^{bc}	6.30^{d}	6.45^{de}	4.40^{a}	3.90^{cd}	4.15^{b}
T_6	66.17^{a}	53.51^{ab}	59.84^{ab}	6.90^{ab}	7.20^{ab}	7.05^{ab}	4.60^{a}	4.46^{a}	4.53^{a}
T_7	56.10^{abc}	51.80^{b}	53.95^{bc}	6.80^{ab}	6.80^{c}	6.80^{bc}	4.50^{a}	4.10^{abc}	4.30^{ab}
T_8	48.25^{bc}	48.75^{b}	48.50^{c}	6.40^{c}	6.10^{d}	6.25^{e}	4.20^{a}	3.50^{d}	3.85^{c}
CD (0.05)	11.74	5.90	7.23	0.31	0.31	0.26	NS	0.45	0.28

Table 23. Percentage contribution of fruit parts to total fruit weight in Prior as influenced by treatments

Treatments	Peel (%)			Pulp (%)			Stone (%)			Pulp/stone ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	20.30[a]	19.71[a]	20.0[a]	61.20[a]	57.60[ab]	59.40[a]	22.40[a]	20.98[ab]	21.69[a]	2.73[a]	2.74[a]	2.73[a]
T_2	20.73[a]	0	-	62.36[a]	0	-	22.76[a]	0	-	2.75[a]	0	-
T_3	19.10[a]	20.30[a]	19.70[a]	59.46[a]	59.38[ab]	59.42[a]	22.03[a]	21.31[ab]	21.67[a]	2.69[a]	2.79[a]	2.74[a]
T_4	19.96[a]	21.40[a]	20.68[a]	60.93[a]	62.93[a]	61.93[a]	22.12[a]	22.48[a]	22.30[a]	2.75[a]	2.79[a]	2.77[a]
T_5	18.76[a]	19.42[a]	19.09[a]	59.36[a]	56.77[ab]	58.06[a]	21.60[a]	20.70[ab]	21.15[a]	2.76[a]	2.74[a]	2.75[a]
T_6	18.30[a]	20.99[a]	19.64[a]	58.66[a]	61.68[ab]	60.17[a]	21.0[a]	22.05[a]	21.52[a]	2.78[a]	2.79[a]	2.79[a]
T_7	19.66[a]	20.69[a]	20.18[a]	60.93[a]	60.0[ab]	60.46[a]	22.06[a]	21.73[ab]	21.89[a]	2.77[a]	2.76[a]	2.76[a]
T_8	17.50[a]	19.27[a]	18.38[a]	58.35[a]	55.46[b]	56.90[a]	20.76[a]	19.95[b]	20.36[a]	2.81[a]	2.78[a]	2.79[a]
CD (0.05)	NS	2.12	NS	NS	6.34	NS	NS	1.99	NS	NS	0.25	NS

Table 24. Percentage contribution of fruit parts to total fruit weight in Alphonso as influenced by treatments

Treatments	Peel (%)			Pulp (%)			Stone (%)			Pulp/stone ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	17.06[a]	19.21[b]	18.14[b]	60.83[a]	59.20[a]	60.01[a]	19.0[a]	20.87[a]	19.93[a]	3.22[a]	2.84[a]	3.03[a]
T_2	17.70[a]	19.31[ab]	18.50[b]	61.83[a]	59.79[a]	60.81[a]	19.86[a]	21.36[a]	20.61[a]	3.12[a]	2.85[a]	2.98[a]
T_3	19.10[a]	0	-	62.40[a]	0	-	21.30[a]	0	-	2.93[a]	0	-
T_4	20.70[a]	21.0[a]	20.85[a]	62.93[a]	62.24[a]	62.58[a]	22.23[a]	21.77[a]	22.0[a]	2.86[a]	2.86[a]	2.86[a]
T_5	18.46[a]	19.09[b]	18.77[b]	62.26[a]	58.94[a]	60.60[a]	21.16[a]	20.50[a]	20.83[a]	2.94[a]	2.89[a]	2.91[a]
T_6	19.33[a]	19.32[ab]	19.33[b]	62.56[a]	60.11[a]	61.34[a]	22.23[a]	21.41[a]	21.82[a]	2.82[a]	2.80[a]	2.81[a]
T_7	18.23[a]	19.29[ab]	18.76[b]	62.33[a]	59.40[a]	60.86[a]	21.0[a]	21.14[a]	21.07[a]	2.98[a]	2.81[a]	2.90[a]
T_8	17.16[a]	18.84[b]	18.0[b]	61.56[a]	58.68[a]	60.12[a]	19.50[a]	20.30[a]	19.90[a]	3.15[a]	2.91[a]	3.03[a]
CD (0.05)	NS	1.78	1.45	NS	6.99	NS	NS	2.50	NS	NS	0.42	NS

4.9.1. Total Soluble Solids

In Prior, treatments exhibited significant influence, but the pattern was not specific during first year. T_4, T_6 and T_7 recorded higher values in the second year. Pooled analysis revealed the significant influence of T_4 and T_6 on this parameter (Table 25a).

Treatments had significantly influenced the total soluble solids in Alphonso during both years. During first year, T_4 and T_5 recorded higher values and T_2 recorded the minimum (Table 26a). Influence of treatments was not specific during second year however T_4 recorded the highest value. Pooled analysis indicated the non specific influence of treatments on this parameter.

4.9.2. Reducing sugars

In Prior, treatments exhibited significant influence on this parameter and T_4 and T_6 recorded higher values during both years. However, T_2 was statistically on par with these treatments during first year. Results of pooled analysis followed the same pattern as that of second year.

In Alphonso, treatments had significant influence on reducing sugars during both years but the pattern was not specific during first year. T_4 recorded statistically superior value in the second year. Pooled analysis displayed significant influence of treatments with T_4 and T_6 recording the maximum values.

4.9.3. Non reducing sugars

Effect of treatments on this parameter was significant during both years and in the first year, influence of treatments was not specific however T_4 recorded highest value. During second year and in pooled analysis, similar patterns were noticed where T_4, T_6 and T_7 being the superior treatments.

Table 25a. Effect of treatments on quality attributes of Prior fruits

Treatments	**Total Soluble Solids (^{0}Brix)**			**Reducing sugars (%)**			**Non-reducing sugars (%)**		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	13.65^{ab}	12.75^{c}	13.20^{c}	2.63^{b}	2.48^{cd}	2.55^{cd}	7.60^{ab}	7.42^{cd}	7.51^{cd}
T_2	14.10^{ab}	0	-	2.83^{ab}	0	-	8.09^{ab}	0	-
T_3	12.60^{bc}	13.0^{bc}	12.80^{cd}	2.69^{b}	2.64^{bcd}	2.66^{bcd}	7.56^{ab}	7.78^{bc}	7.67^{bcd}
T_4	15.10^{a}	13.57^{a}	14.33^{a}	3.27^{a}	3.72^{a}	3.49^{a}	8.43^{a}	8.58^{a}	8.50^{a}
T_5	13.10^{bc}	12.30^{d}	12.70^{cd}	2.51^{b}	2.21^{d}	2.36^{d}	7.24^{bc}	7.28^{cd}	7.26^{de}
T_6	14.77^{a}	13.40^{a}	14.08^{ab}	3.01^{ab}	3.13^{ab}	3.07^{ab}	8.10^{ab}	8.33^{a}	8.21^{ab}
T_7	13.50^{abc}	13.30^{ab}	13.40^{bc}	2.71^{b}	3.0^{bc}	2.85^{bc}	7.72^{ab}	8.22^{ab}	7.97^{abc}
T_8	12.03^{c}	12.10^{d}	12.06^{d}	1.40^{c}	2.03^{d}	1.71^{e}	6.20^{c}	7.21^{d}	6.70^{e}
CD (0.05)	1.60	0.37	0.81	0.52	0.64	0.43	1.12	0.52	0.55

Table 26a. Effect of treatments on quality attributes of Alphonso fruits

Treatments	**Total Soluble Solids (^{0}Brix)**			**Reducing sugars (%)**			**Non-reducing sugars (%)**		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	16.50^{def}	16.84^{b}	16.67^{bc}	2.60^{b}	3.01^{b}	2.80^{cd}	8.30^{cde}	8.63^{c}	8.46^{cd}
T_2	15.60^{f}	17.50^{ab}	16.55^{c}	2.77^{ab}	3.16^{b}	2.96^{bc}	8.80^{b}	9.28^{bc}	9.04^{c}
T_3	17.50^{bcd}	0	-	2.70^{ab}	0	-	8.50^{bcd}	0	-
T_4	18.50^{ab}	18.70^{a}	18.60^{a}	2.90^{a}	3.52^{a}	3.21^{a}	10.20^{a}	11.58^{a}	10.89^{a}
T_5	19.20^{a}	16.49^{b}	17.84^{ab}	2.60^{b}	2.62^{c}	2.61^{d}	8.19^{de}	7.55^{d}	7.87^{de}
T_6	17.30^{cde}	17.73^{ab}	17.51^{abc}	2.90^{a}	3.19^{b}	3.04^{ab}	9.90^{a}	9.82^{b}	9.86^{b}
T_7	18.0^{bc}	17.0^{b}	17.50^{abc}	2.70^{ab}	3.16^{b}	2.93^{bc}	8.70^{bc}	8.98^{bc}	8.84^{c}
T_8	16.30^{ef}	16.46^{b}	16.38^{c}	2.20^{c}	2.27^{d}	2.23^{e}	8.0^{e}	7.22^{d}	7.61^{e}
CD (0.05)	1.00	1.38	1.18	0.29	0.31	0.23	0.40	0.97	0.66

In Alphonso, treatments significantly influenced the non reducing sugars and T_4 recorded highest and statistically superior value during both years. However T_6 was statistically on par with this treatment during first year. Pooled analysis exhibited the statistically superior influence of treatment T_4.

4.9.4. Total sugars

In Prior, influence of treatments on this parameter followed the similar pattern as that of reducing sugars (Table 25b).

Treatments had significantly influenced total sugars and indicated the similar trend of non reducing sugars in Alphonso (Table 26b).

4.9.5. Acidity

Treatments failed to influence this parameter in Prior during both years. In pooled analysis, treatments showed significant influence but the pattern was not specific however, T_8 recorded the maximum value.

Treatments significantly influenced the acidity of Alphonso fruits and T_5 and T_8 recorded statistically superior values during first year. Even though treatments had significant influence during second year, the pattern was not specific however T_8 recorded highest value and T_4 recorded the lowest (Table 26b). In pooled analysis, T_8 recorded the maximum value.

4.9.6. Sugar/acid ratio

During first year, influence of treatments was not specific however T_4 recorded the highest value. Potassium nitrate (T_3 and T_4) and paclobutrazol treatments (T_6 and T_7)

Table 25b. Effect of treatments on quality attributes of Prior fruits

Treatments	Total sugars (%)			Acidity (%)			Sugar/acid ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	10.23^{bc}	9.90^{de}	10.07^{d}	0.29^{a}	0.31^{a}	0.30^{abc}	35.61^{bc}	31.68^{bc}	33.64^{cde}
T_2	10.92^{ab}	0	-	0.26^{a}	0	-	41.65^{abc}	0	-
T_3	10.25^{bc}	10.42^{cd}	10.34^{cd}	0.27^{a}	0.27^{a}	0.27^{abc}	37.97^{bc}	38.62^{ab}	38.29^{bcd}
T_4	11.70^{a}	12.30^{a}	12.0^{a}	0.21^{a}	0.26^{a}	0.23^{d}	56.50^{a}	47.21^{a}	51.85^{a}
T_5	9.75^{c}	9.49^{e}	9.62^{d}	0.31^{a}	0.34^{a}	0.33^{ab}	31.28^{c}	28.82^{c}	30.05^{de}
T_6	11.11^{ab}	11.46^{ab}	11.28^{ab}	0.23^{a}	0.26^{a}	0.25^{cd}	47.04^{ab}	44.15^{a}	45.60^{ab}
T_7	10.43^{bc}	11.22^{bc}	10.83^{bc}	0.26^{a}	0.26^{a}	0.26^{bcd}	40.68^{bc}	42.57^{a}	41.62^{bc}
T_8	7.60^{d}	9.24^{e}	8.42^{e}	0.32^{a}	0.34^{a}	0.33^{a}	28.84^{c}	27.80^{c}	28.32^{e}
CD (0.05)	1.12	0.86	0.73	NS	0.08	0.06	14.95	9.57	8.32

Table 26b. Effect of treatments on quality attributes of Alphonso fruits

Treatments	Total sugars (%)			Acidity (%)			Sugar/acid ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	10.90^{c}	11.64^{c}	11.27^{c}	0.42^{b}	0.41^{abc}	0.41^{bc}	26.10^{de}	28.82^{bc}	27.46^{d}
T_2	11.57^{b}	12.44^{bc}	12.0^{c}	0.30^{d}	0.37^{bc}	0.33^{d}	38.81^{b}	34.11^{b}	36.46^{bc}
T_3	11.20^{bc}	0	-	0.38^{bc}	0	-	30.46^{cd}	0	-
T_4	13.10^{a}	15.10^{a}	14.10^{a}	0.26^{d}	0.34^{c}	0.30^{d}	50.48^{a}	43.93^{a}	47.21^{a}
T_5	10.79^{c}	10.17^{d}	10.48^{d}	0.50^{a}	0.44^{ab}	0.47^{ab}	21.62^{e}	22.67^{cd}	22.15^{e}
T_6	12.80^{a}	13.01^{b}	12.90^{b}	0.30^{d}	0.37^{bc}	0.33^{d}	42.86^{b}	35.60^{b}	39.23^{b}
T_7	11.40^{b}	12.14^{bc}	11.77^{c}	0.32^{cd}	0.39^{bc}	0.35^{cd}	36.24^{bc}	31.19^{b}	33.71^{c}
T_8	10.20^{d}	9.49^{d}	9.84^{d}	0.52^{a}	0.47^{a}	0.50^{a}	19.37^{e}	19.85^{d}	19.61^{e}
CD (0.05)	0.45	0.87	0.74	0.07	0.08	0.05	7.53	7.62	5.05

recorded higher values during second year. Pooled analysis indicated the significant influence of T_4 and T_6 on this parameter.

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In Alphonso, T_4 recorded statistically superior values during both years as well as in pooled analysis.

4.10. Keeping quality of fruits

Shelf life properties of both Prior and Alphonso varieties are presented in Tables 27 and 28 respectively.

4.10.1. Number of days from harvest to ripening of fruits

Treatments did not exhibit any significant influence on this parameter in Prior during both years and also in pooled analysis.

Influence of treatments on number of days from harvest to ripening of fruits was insignificant in Alphonso during first year. Even though treatments showed significant influence during second year, the pattern was not specific however, T_2 recorded highest value and T_6 the lowest (Table 28). Pooled analysis did not indicate any significant effect of treatments on this parameter.

4.10.2. Number of days from ripening to senescence of fruits

In Prior, treatments failed to influence this parameter during both years and in pooled analysis also (Table 27).

During both years, influence of treatments on number of days from ripening to senescence of fruits was insignificant in Alphonso (Table 28). Results of pooled analysis followed the same trend.

Table 27. Effect of treatments on keeping quality of Prior fruits

Treatments	Duration from harvest to ripening (days)			Duration from ripening to senescence (days)			Duration from harvest to senescence (days)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	5.10^a	5.0^a	5.05^a	6.80^a	6.50^a	6.65^a	11.90^a	11.50^a	11.70^a
T_2	5.0^a	0	-	6.50^a	0	-	11.60^a	0	-
T_3	5.07^a	5.20^a	5.13^a	6.67^a	6.40^a	6.53^a	11.73^a	11.60^a	11.67^a
T_4	5.20^a	5.0^a	5.10^a	7.0^a	6.67^a	6.83^a	12.20^a	11.67^a	11.93^a
T_5	5.20^a	5.20^a	5.20^a	6.80^a	6.50^a	6.65^a	12.0^a	11.70^a	11.85^a
T_6	5.07^a	5.10^a	5.08^a	6.40^a	6.70^a	6.55^a	11.47^a	11.80^a	11.63^a
T_7	5.27^a	5.10^a	5.18^a	6.80^a	6.70^a	6.75^a	12.07^a	11.80^a	11.93^a
T_8	5.53^a	5.0^a	5.27^a	6.67^a	6.50^a	6.58^a	12.20^a	11.50^a	11.85^a
CD(0.05)	NS	0.30	NS	NS	0.70	NS	NS	0.69	NS

Table 28. Effect of treatments on keeping quality of Alphonso fruits

Treatments	Duration from harvest to ripening (days)			Duration from ripening to senescence (days)			Duration from harvest to senescence (days)		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	4.87^a	5.10^{ab}	4.98^a	6.77^a	7.0^a	6.88^a	11.63^a	12.10^a	11.87^a
T_2	5.27^a	5.30^a	5.28^a	7.07^a	6.60^a	6.83^a	12.33^a	11.90^a	12.12^a
T_3	5.20^a	0	-	6.60^a	0	-	11.80^a	0	-
T_4	5.20^a	5.0^{ab}	5.10^a	6.73^a	6.50^a	6.62^a	11.93^a	11.50^a	11.72^a
T_5	5.07^a	5.0^{ab}	5.03^a	6.93^a	7.0^a	6.97^a	12.0^a	12.0^a	12.0^a
T_6	5.27^a	4.70^b	4.98^a	6.40^a	6.70^a	6.55^a	11.67^a	11.40^a	11.53^a
T_7	5.13^a	4.90^{ab}	5.02^a	6.67^a	6.60^a	6.63^a	11.80^a	11.50^a	11.65^a
T_8	4.93^a	5.0^{ab}	4.97^a	6.67^a	6.50^a	6.58^a	11.60^a	11.50^a	11.55^a
CD (0.05)	NS	0.42	NS	NS	0.59	NS	NS	0.74	NS

4.10.3. Number of days from harvest to senescence of fruits

Treatments did not significantly influence this parameter in Prior and Alphonso during both years and also in pooled analysis.

4.11. Carbohydrate/nitrogen ratio

Carbohydrate and nitrogen content in the leaves and their ratio at different growth stages are furnished from Tables 29 to 36 for both Prior and Alphonso varieties.

4.11.1. Carbohydrate content before the experiment

Carbohydrate contents before treatment in both varieties were significantly the same during first and second years and also in pooled analysis. The level ranged from 13.01 to 13.97% in Prior and 12.95 to 13.51% in Alphonso during the pooled analysis.

4.11.2. Nitrogen content before the experiment

In both varieties, this parameter was not significantly influenced by treatments during individual years as well as in pooled analysis (Tables 29 and 30).

4.11.3. Carbohydrate/nitrogen ratio before the experiment

Carbohydrate/nitrogen ratio in Prior ranged from 8.82 to 9.87 and from 9.67 to 11.63 in first and second year respectively. In pooled analysis, it ranged from 9.40 to 10.67.

Carbohydrate/nitrogen ratio in Alphonso ranged from 9.31 to 10.97 and from 9.76 to 11.0 during two years of the experiment. In pooled analysis, these values in Alphonso ranged from 9.87 to 10.78.

Table 29. CHO/N ratio in Prior before the experiment

Treatments	Before the experiment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	12.65[a]	13.71[a]	13.18[a]	1.44[a]	1.38[a]	1.41[a]	8.82[a]	10.02[a]	9.42[a]
T_2	12.75[a]	13.27[a]	13.01[a]	1.39[a]	1.32[a]	1.35[a]	9.15[a]	10.20[a]	9.68[a]
T_3	12.57[a]	14.38[a]	13.47[a]	1.34[a]	1.44[a]	1.39[a]	9.46[a]	10.01[a]	9.73[a]
T_4	13.05[a]	14.30[a]	13.67[a]	1.38[a]	1.31[a]	1.34[a]	9.73[a]	10.93[a]	10.33[a]
T_5	12.72[a]	14.21[a]	13.46[a]	1.44[a]	1.35[a]	1.39[a]	8.87[a]	10.61[a]	9.74[a]
T_6	13.41[a]	14.54[a]	13.97[a]	1.38[a]	1.27[a]	1.32[a]	9.72[a]	11.63[a]	10.67[a]
T_7	12.89[a]	14.55[a]	13.72[a]	1.31[a]	1.32[a]	1.31[a]	9.87[a]	10.97[a]	10.42[a]
T_8	12.65[a]	13.88[a]	13.26[a]	1.39[a]	1.44[a]	1.41[a]	9.12[a]	9.67[a]	9.40[a]
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 30. CHO/N ratio in Alphonso before the experiment

Treatments	Before the experiment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	12.97[a]	12.94[a]	12.95[a]	1.40[a]	1.24[a]	1.32[a]	9.32[a]	10.51[a]	9.92[a]
T_2	13.0[a]	13.50[a]	13.25[a]	1.26[a]	1.26[a]	1.26[a]	10.73[a]	10.82[a]	10.78[a]
T_3	13.08[a]	13.80[a]	13.44[a]	1.28[a]	1.36[a]	1.32[a]	10.24[a]	10.40[a]	10.32[a]
T_4	13.26[a]	13.53[a]	13.39[a]	1.37[a]	1.28[a]	1.32[a]	9.77[a]	10.79[a]	10.28[a]
T_5	13.21[a]	13.74[a]	13.47[a]	1.32[a]	1.28[a]	1.30[a]	10.05[a]	11.0[a]	10.53[a]
T_6	13.24[a]	13.78[a]	13.51[a]	1.24[a]	1.31[a]	1.27[a]	10.97[a]	10.68[a]	10.74[a]
T_7	13.21[a]	13.40[a]	13.30[a]	1.42[a]	1.27[a]	1.34[a]	9.31[a]	10.51[a]	9.91[a]
T_8	13.03[a]	13.35[a]	13.19[a]	1.31[a]	1.38[a]	1.34[a]	9.99[a]	9.76[a]	9.87[a]
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.11.4. Carbohydrate level at one month after treatment

In Prior, treatment effects were significant on this parameter and T_6 recorded highest as well as superior values during both years. However, T_7 was statistically on par with this treatment during second year. In pooled analysis, paclobutrazol treatments (T_5, T_6 and T_7) recorded higher values and were statistically superior to other treatments (Table 31). T_2 recorded the lowest content.

In Alphonso, treatments had significant influence on carbohydrate content and T_5, T_6 and T_7 recorded statistically higher values compared to other treatments during both years and also in pooled analysis (Table 32).

4.11.5. Nitrogen level at one month after treatment

Treatments significantly influenced this parameter in Prior and potassium nitrate treatments (T_3 and T_4) recorded higher values during both years. Pooled analysis pointed out the same effect.

Effect of treatments on nitrogen content was significant in Alphonso and T_3 and T_4 recorded statistically higher values during both years. However, T_6 was statistically on par with these treatments during second year. Pooled analysis also indicated the superiority of these treatments on this parameter.

4.11.6. Carbohydrate/nitrogen ratio at one month after treatment

Influence of treatments on this parameter was significant in Prior and treatments except T_3 and T_4 recorded statistically higher values during both years (Table 31). Results of pooled analysis also displayed the same pattern.

Table 31. Effect of treatments on CHO/N ratio in Prior at one month after treatment

Treatments	One month after treatment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	12.77^{ef}	13.83^{e}	13.30^{de}	1.13^{d}	1.09^{cd}	1.11^{c}	11.30^{ab}	12.69^{a}	11.99^{a}
T_2	12.85^{e}	13.39^{f}	13.12^{e}	1.15^{d}	1.05^{d}	1.10^{c}	11.18^{b}	12.75^{a}	11.96^{a}
T_3	12.69^{f}	14.50^{c}	13.59^{bc}	1.29^{b}	1.38^{a}	1.33^{a}	9.83^{c}	10.55^{c}	10.19^{c}
T_4	13.17^{d}	14.42^{c}	13.79^{b}	1.33^{a}	1.25^{b}	1.29^{a}	9.90^{c}	11.53^{b}	10.72^{b}
T_5	13.93^{b}	15.02^{b}	14.47^{a}	1.22^{c}	1.17^{bc}	1.19^{b}	11.42^{ab}	12.84^{a}	12.13^{a}
T_6	14.11^{a}	15.25^{a}	14.68^{a}	1.23^{c}	1.15^{cd}	1.19^{b}	11.47^{a}	13.26^{a}	12.37^{a}
T_7	13.79^{c}	15.26^{a}	14.52^{a}	1.20^{c}	1.17^{bc}	1.18^{b}	11.49^{a}	13.04^{a}	12.27^{a}
T_8	12.77^{ef}	14.0^{d}	13.38^{cd}	1.12^{d}	1.10^{cd}	1.11^{c}	11.33^{ab}	12.73^{a}	12.03^{a}
CD (0.05)	0.11	0.15	0.24	0.03	0.10	0.06	0.26	0.93	0.46

Table 32. Effect of treatments on CHO/N ratio in Alphonso at one month after treatment

Treatments	One month after treatment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	13.11^{d}	13.06^{e}	13.08^{f}	1.08^{c}	0.99^{c}	1.03^{b}	12.13^{a}	13.20^{ab}	12.67^{a}
T_2	13.09^{d}	13.62^{d}	13.35^{de}	1.05^{c}	1.03^{bc}	1.04^{b}	12.48^{a}	13.24^{ab}	12.86^{a}
T_3	13.20^{d}	13.92^{c}	13.56^{c}	1.23^{ab}	1.30^{a}	1.26^{a}	10.80^{b}	10.95^{c}	10.87^{b}
T_4	13.38^{c}	13.65^{d}	13.51^{cd}	1.33^{a}	1.22^{ab}	1.27^{a}	10.11^{b}	11.48^{bc}	10.79^{b}
T_5	14.21^{a}	14.64^{a}	14.42^{a}	1.12^{bc}	1.07^{bc}	1.10^{b}	12.61^{a}	13.64^{a}	13.12^{a}
T_6	14.04^{b}	14.57^{a}	14.31^{ab}	1.11^{c}	1.10^{abc}	1.10^{b}	12.58^{a}	13.25^{ab}	12.91^{a}
T_7	14.14^{ab}	14.31^{b}	14.23^{b}	1.13^{bc}	1.07^{bc}	1.10^{b}	12.52^{a}	13.38^{a}	12.95^{a}
T_8	13.13^{d}	13.47^{d}	13.30^{e}	1.07^{c}	1.04^{bc}	1.05^{b}	12.20^{a}	12.96^{ab}	12.58^{a}
CD (0.05)	0.14	0.22	0.19	0.10	0.21	0.10	0.95	1.88	0.92

In Alphonso, treatments had significant effect during both years and treatments except T_3 and T_4 recorded statistically higher values during first year. Even though treatments influenced this parameter during second year, the pattern was not specific however T_3 recorded the lowest value. Pooled analysis indicated the same trend of first year.

4.11.7. Carbohydrate level at two months after treatment

Treatment effects were significant with respect to this parameter in Prior and T_6 recorded statistically the highest value during both years however T_7 was statistically on par with this treatment during second year. Pooled analysis also indicated significant difference among treatments on this aspect and paclobutrazol treatments (T_5, T_6 and T_7) recorded statistically superior values. Ethrel treatments (T_1 and T_2) recorded minimum values (Table 33).

Treatments had significant influence on carbohydrate level in Alphonso and Paclobutrazol treatments (T_5 and T_6) recorded higher and statistically superior values during both years. However, T_7 was statistically on par with these treatments during first year. Pooled analysis indicated the superior influence of paclobutrazol treatments (T_5, T_6 and T_7) and T_1 recorded statistically the lowest value (Table 34).

4.11.8. Nitrogen level at two months after treatment

In Prior, potassium nitrate treatments (T_3 and T_4) formed the superior treatments during both years with respect to this parameter and in pooled analysis also. In Alphonso also, the same pattern was observed as in Prior (Table 34).

4.11.9. Carbohydrate/nitrogen ratio at two months after treatment

In Prior, influence of treatments was significant on this parameter and paclobutrazol treatments (T_5, T_6 and T_7) recorded statistically higher values during both years as well as in pooled analysis.

Treatments had shown significant effect on carbohydrate/nitrogen ratio in Alphonso and paclobutrazol treatments (T_5, T_6 and T_7) recorded statistically superior values during first year. Treatments except T_3 and T_4 recorded statistically higher values during second year. Pooled analysis indicated the same trend of first year.

4.11.10. Carbohydrate level at flowering stage

At flowering stage, influence of treatments was significant on this parameter and T_6 recorded higher as well as superior values during both years in Prior. However, T_7 was statistically par with this treatment during second year. Pooled analysis exhibited the statistical superior influence of paclobutrazol treatments (T_5, T_6 and T_7) on this parameter (Table 35).

In Alphonso, paclobutrazol treatments (T_5, T_6 and T_7) recorded statistically superior values compared to other treatments during individual years as well as in pooled analysis (Table 36).

4.11.11. Nitrogen level at flowering stage

In Prior, results during individual years and in pooled analysis indicated that potassium nitrate treatments (T_3 and T_4) were superior to other treatments recording higher values.

Table 33. Effect of treatments on CHO/N ratio in Prior at two months after treatment

Treatments	Two months after treatment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	13.09^{ef}	14.15^{d}	13.62^{d}	1.06^{bc}	1.02^{b}	1.04^{b}	12.35^{b}	13.87^{c}	13.11^{b}
T_2	13.20^{e}	13.71^{e}	13.45^{d}	1.08^{bc}	0.98^{b}	1.03^{b}	12.22^{b}	13.95^{c}	13.08^{b}
T_3	13.02^{f}	14.82^{c}	13.92^{bc}	1.23^{a}	1.32^{a}	1.27^{a}	10.59^{c}	11.28^{d}	10.93^{c}
T_4	13.49^{d}	14.74^{c}	14.12^{b}	1.27^{a}	1.21^{a}	1.24^{a}	10.62^{c}	12.19^{d}	11.40^{c}
T_5	15.19^{b}	16.18^{b}	15.68^{a}	1.09^{bc}	1.05^{b}	1.07^{b}	13.93^{a}	15.42^{ab}	14.67^{a}
T_6	15.37^{a}	16.41^{ab}	15.89^{a}	1.10^{b}	1.02^{b}	1.06^{b}	13.98^{a}	16.09^{a}	15.03^{a}
T_7	15.05^{c}	16.52^{a}	15.78^{a}	1.08^{bc}	1.04^{b}	1.06^{b}	13.93^{a}	15.90^{a}	14.92^{a}
T_8	13.07^{ef}	14.32^{d}	13.69^{cd}	1.05^{c}	1.01^{b}	1.03^{b}	12.39^{b}	14.20^{bc}	13.29^{b}
CD (0.05)	0.13	0.31	0.28	0.04	0.10	0.06	0.47	1.29	0.64

Table 34. Effect of treatments on CHO/N ratio in Alphonso at two months after treatment

Treatments	Two months after treatment								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	13.41^{c}	13.39^{e}	13.40^{d}	0.99^{b}	0.92^{c}	0.95^{b}	13.55^{b}	14.56^{a}	14.06^{b}
T_2	13.44^{c}	13.93^{d}	13.68^{bc}	0.98^{b}	0.96^{bc}	0.97^{b}	13.71^{b}	14.51^{a}	14.11^{b}
T_3	13.52^{bc}	14.24^{c}	13.88^{b}	1.18^{a}	1.23^{a}	1.20^{a}	11.54^{c}	11.89^{b}	11.72^{c}
T_4	13.70^{b}	13.97^{d}	13.83^{b}	1.26^{a}	1.17^{ab}	1.21^{a}	10.94^{c}	12.30^{b}	11.62^{c}
T_5	15.17^{a}	15.69^{a}	15.43^{a}	1.01^{b}	0.96^{bc}	0.98^{b}	15.02^{a}	16.35^{a}	15.69^{a}
T_6	15.30^{a}	15.73^{a}	15.52^{a}	1.01^{b}	0.97^{bc}	0.99^{b}	15.06^{a}	16.22^{a}	15.64^{a}
T_7	15.34^{a}	15.37^{b}	15.36^{a}	1.02^{b}	0.96^{bc}	0.99^{b}	15.05^{a}	15.91^{a}	15.48^{a}
T_8	13.42^{c}	13.79^{d}	13.61^{c}	1.0^{b}	0.94^{c}	0.97^{b}	13.33^{b}	14.69^{a}	14.01^{b}
CD (0.05)	0.19	0.20	0.19	0.09	0.21	0.10	0.91	2.12	1.0

During first year, T_3 and T_4 recorded statistically superior values in Alphonso. During second year, treatments showed significant influence however T_1 recorded statistically the lowest value. Pooled analysis indicated the strong influence of T_4 on this parameter.

4.11.12. Carbohydrate/nitrogen ratio at flowering stage

In Prior, treatments had significant positive influence on this parameter however, T_3 and T_4 recorded statistically lower values during both years. Pooled analysis pointed out the significance of paclobutrazol treatments (T_5, T_6 and T_7) on this parameter.

In Alphonso, treatments except T_3 and T_4 recorded statistically higher values during first year. Even though treatments showed significant influence during second year, the pattern was not specific however T_4 recorded the lowest value. Pooled analysis exhibited the positive influence of treatments on this parameter.

4.12. Heat units

Total heat units accumulated during the period from treatment application to flowering and peak flowering to fruit maturity are furnished in Tables 37 and 38 for Prior and Alphonso varieties respectively.

4.12.1. Heat units accumulated during chemical application to flowering

In Prior, Minimum heat units were recorded in T_5 and T_7 (863.20 DD each) and ethrel treatments (T_1 and T_2) recorded higher values during first year. During second year, potassium nitrate treatments (T_3 and T_4) recorded minimum values of 772.35 DD each and T_8 recorded the maximum value of 1221.20 DD. Pooled analysis indicated the significant positive influence of potassium nitrate (T_3 and T_4) and paclobutrazol treatments (T_5 and T_7) on this parameter.

Table 35. Effect of treatments on CHO/N ratio in Prior at flowering

Treatments	At flowering stage								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	12.05[de]	13.11[d]	12.58[d]	0.99[b]	0.95[c]	0.97[b]	12.09[a]	13.76[b]	12.92[c]
T_2	12.15[d]	*	-	1.01[b]	*	-	12.03[a]	*	-
T_3	11.99[e]	13.78[bc]	12.88[bc]	1.20[a]	1.29[a]	1.24[a]	9.99[b]	10.73[c]	10.36[d]
T_4	12.45[c]	13.70[c]	13.08[b]	1.24[a]	1.18[b]	1.21[a]	10.09[b]	11.62[c]	10.85[d]
T_5	13.04[b]	14.03[b]	13.53[a]	1.02[b]	0.98[c]	1.0[b]	12.82[a]	14.32[ab]	13.57[ab]
T_6	13.22[a]	14.36[a]	13.79[a]	1.03[b]	0.97[c]	1.0[b]	12.84[a]	14.81[a]	13.82[a]
T_7	12.90[b]	14.36[a]	13.63[a]	1.02[b]	0.97[c]	0.99[b]	12.65[a]	14.82[a]	13.73[ab]
T_8	12.02[de]	13.28[d]	12.65[cd]	0.98[b]	0.94[c]	0.96[b]	12.19[a]	14.13[ab]	13.16[bc]
CD (0.05)	0.14	0.27	0.26	0.08	0.09	0.06	0.81	1.03	0.62

Table 36. Effect of treatments on CHO/N ratio in Alphonso at flowering

Treatments	At flowering stage								
	Carbohydrate (%)			Nitrogen (%)			CHO/N ratio		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	12.30[d]	12.29[d]	12.30[d]	0.94[b]	0.88[b]	0.91[b]	13.09[a]	13.98[ab]	13.53[a]
T_2	12.34[d]	12.82[c]	12.58[c]	0.94[b]	0.91[a]	0.92[b]	13.13[a]	14.09[ab]	13.61[a]
T_3	12.42[d]	*	-	1.15[a]	*	-	10.88[b]	*	-
T_4	12.60[c]	12.93[c]	12.76[b]	1.23[a]	1.11[a]	1.17[a]	10.30[b]	12.03[b]	11.17[b]
T_5	13.02[b]	13.54[ab]	13.28[a]	0.94[b]	0.90[a]	0.92[b]	13.85[a]	15.09[a]	14.47[a]
T_6	13.15[ab]	13.58[a]	13.37[a]	0.93[b]	0.91[a]	0.92[b]	14.04[a]	14.93[a]	14.48[a]
T_7	13.18[a]	13.32[b]	13.25[a]	0.95[b]	0.89[a]	0.92[b]	13.90[a]	14.92[a]	14.41[a]
T_8	12.31[d]	12.75[c]	12.53[c]	0.93[b]	0.90[a]	0.92[b]	13.14[a]	14.13[ab]	13.64[a]
CD (0.05)	0.15	0.23	0.17	0.10	0.22	0.10	0.99	2.31	1.09

* Analysis not possible since trees did not flower

In Alphonso, T_4 recorded statistically minimum heat units during both years however, T_3 and T_5 were on par with this treatment during first year (Table 38). Pooled analysis pointed out the statistical significance of T_4 on this parameter.

4.12.2. Heat units accumulated during flowering to fruit maturity

During first year, minimum heat units were recorded in T_5 and higher values were recorded by T_1, T_2 and T_8. T_3 recorded statistically minimum value during second year and T_8 recorded the highest (Table 37). Pooled analysis indicated the non specific influence of treatments on this parameter however T_3 recorded the lowest value.

In Alphonso, T_5 recorded the minimum value during first year. T_4 and T_6 recorded minimum values during second year. Pooled analysis indicated the superior influence of T_4 and paclobutrazol treatments (T_5, T_6 and T_7) on this parameter.

Table 37. Heat unit requirement of Prior

Treatments	Days from chemical application to flowering Total heat units (DD)			Days from flowering to fruit maturity Total heat units (DD)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	1047.05[a]	957.70[b]	1002.37[b]	1139.60[a]	1197.05[b]	1168.32[a]
T_2	1056.75[a]	0	-	1154.20[a]	0	-
T_3	914.10[d]	772.35[e]	843.22[d]	1027.60[b]	970.85[f]	999.22[d]
T_4	914.10[d]	772.35[e]	843.22[d]	1027.60[b]	1032.60[e]	1030.10[bcd]
T_5	863.20[e]	841.35[d]	852.27[d]	966.30[c]	1054.35[d]	1010.32[cd]
T_6	970.85[c]	899.55[c]	935.20[c]	1034.25[b]	1094.50[c]	1064.37[b]
T_7	863.20[e]	830.65[d]	846.92[d]	1018.30[b]	1052.90[d]	1035.60[bcd]
T_8	1009.95[b]	1221.20[a]	1115.57[a]	1122.50[a]	1233.85[a]	1178.17[a]
CD (0.05)	35.43	39.93	33.99	48.15	11.64	37.23

Table 38. Heat unit requirement of Alphonso

Treatments	Days from chemical application to flowering Total heat units (DD)			Days from flowering to fruit maturity Total heat units (DD)		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	1047.05[a]	1084.50[a]	1065.77[a]	1263.80[a]	1262.95[a]	1263.37[a]
T_2	1047.05[a]	1007.75[b]	1027.40[a]	1220.60[a]	1206.40[b]	1213.50[b]
T_3	902.70[d]	0	-	1185.80[b]	0	-
T_4	902.70[d]	772.35[d]	837.52[d]	1149.15[bc]	958.20[d]	1053.67[c]
T_5	863.20[d]	909.25[c]	886.22[c]	1071.30[d]	1075.10[c]	1073.20[c]
T_6	970.85[c]	899.55[c]	935.20[b]	1152.65[b]	984.55[d]	1068.60[c]
T_7	980.90[bc]	909.25[c]	945.07[b]	1106.45[cd]	1062.85[c]	1084.65[c]
T_8	1019.45[ab]	1075.85[a]	1047.65[a]	1259.45[a]	1257.55[a]	1258.50[a]
CD (0.05)	41.25	47.79	38.55	43.59	26.46	32.01

Discussion

5. DISCUSSION

Inconsistent crop production is the major perennial handicap experienced by the mango growers through out the country. Hence crop manipulation strategies are of utmost importance in mango commercial orcharding. The present study on '**Chemical regulation of cropping in mango'** was taken up with the main objective of exploring the possibilities of tackling the flowering and fruiting problems using chemicals and bio-regulators. The results obtained are discussed in this chapter.

5.1. Regulation of flowering

Scientists consider flowering of mango trees as an unpredictable and complex phenomenon. However, everyone knows that flowering process is of vital importance in this crop as yield is directly dependent upon its success or failure. In the present experiment, influence of different chemicals and bioregulators on the various parameters of flowering in two important varieties, Prior and Alphonso was evaluated for two consecutive years. Profuse flowering as a result of paclobutrazol treatments was evident from the data generated in the study. Gibberellic acid is found to inhibit flowering in mango as higher gibberellic acid levels are antagonistic to the formation of flowering primodia. Lower levels of endogenous gibberellins and higher level of endogenous auxins favour flower bud initiation (Kachru et al., 1971). Kurian and Iyer (1992) have reported that stronger and persistent influence of paclobutrazol as anti gibberellins might be responsible for its effectiveness in promoting flowering.

In Prior, significant influence of potassium nitrate application along with paclobutrazol treatments was evidenced by profuse flowering in this treatment during second year. But no information is available to show that through what specific process KNO_3 induces flowering in mango. Many workers like Beevers and Hageman (1969) and Filner et al. (1969) showed the ability of KNO_3 and other nitrate sources to induce nitrate reductase activity in many species. According to Bondad et al. (1978), one effect of KNO_3 is to trigger formation of nitrate reductase, an adaptive enzyme that appears in plants when nitrate is present and leads to the synthesis of amino acids like methionine which forms the precursor for ethylene that may induce flowering in mango. In the current experiment, ethylene formed in such a way might have played the key role on the nitrate induced flowering in mango.

Though treatments did not exhibit significantly specific influence on percentage of hermaphrodite flowers in Prior variety, application of paclobutrazol resulted in improvement of the values for this parameter in Alphonso. Singh et al. (2004) found that by using inhibitors of GA synthesis, such as paclobutrazol, sex ratio can be modified. Paclobutrazol treatments might have produced more number of hermaphrodite flowers because of their influence on blocking the conversion of Kaurene to Kaurenoic acid, a precursor to gibberellin synthesis.

Improvement in inflorescence measurements was also noticed in Alphonso variety due to paclobutrazol treatments. There exist supportive (Protacio et al., 2009) as well as contradictory (Kulkarni, 1988a) reports to this effect. Favourable effect might have resulted due to the influence of paclobutrazol on assimilate partitioning in favour of the reproductive shoot instead of acting as a growth retardant at this stage.

5.2. Regulation of fruit set and drop

Excessive fruit drop is considered to be a serious problem in mango leading to low yields. Initial fruit set and subsequent fruit drops take place at various intensities in different varieties and are also influenced by a number of factors including hormonal level, climatic conditions, pests and disease incidences etc. Initial set considered as 100 % followed by continuous drop to the tune of 90-95 % in two weeks time have been reported by Anila (2002) in a study with six popular varieties under Kerala conditions.

In the present study impact of different treatments on the initial fruit set and fruit drop was evaluated, the results of which indicated the positive influence of paclobutrazol treatments and potassium nitrate application in both Prior and Alphonso varieties. Soil application of paclobutrazol @ 5 g/tree improved the fruit set and retention in different mango cultivars as per reports from various authors (Burondkar and Gunjate, 1993; Desai and Chundawat, 1994). Higher number of fruit set and retention were possible due to retardation of vegetative growth and accumulation of more carbohydrates in leaves as reported by Karuna et al. (2007) in an experiment with Langra variety. In the present experiment also carbohydrate levels in leaves were influenced by paclobutrazol treatments which can be considered as a reason for improvement in fruit set values when treated with this chemical.

Foliar nitrogen treatments were very effective in improving the number of male and hermaphrodite flowers thereby increasing potential fruit set in mango. According to Yeshitela (2004), the amount of fruit set on a panicle and the number of set fruit retained to harvest is more important than the number of panicle per tree. In his experiment, treatments with higher KNO_3 and urea concentrations produced a higher fruit set, fruit number and fruit weight per tree and the assumption was that nitrogen supplement from KNO_3 and urea spray might be the reason for increase in the quantitative parameters of yield. In the current experiment also KNO_3 sprays were found to improve fruit set which can be explained based on this theory mentioned by the above author.

Fruit drop at biweekly intervals showed that irrespective of treatments, maximum drop was seen during the initial 15 days after set in both varieties. The first two weeks after set were the most important from the point of view of fruit shedding in mango. The initial drop might be due to internal competition between large number of small fruitlets initially formed and the drop included some incompletely fertilized ovules also. During the course of development, there was a gradual reduction in the drop and it ceased by 45th day. Present results indicated significant influence of treatments on overall fruit drop and paclobutrazol treatments recorded minimum values in the case of both varieties. In general, shortage of hormones to prevent the formation of abscission zones in fruits is considered to be the reason for fruit drop. Exhaustion of the growth substances or cessation of their flow from other parts of the plant has been suggested as the immediate cause for subsequent fruit drop. There is a correlation between fruit drop and endogenous auxin level and existence of high level of internal auxin like substances prevent drop. Yet, it is logical to assume that exogenous application of growth regulators like paclobutrazol might have helped in building up endogenous level of hormone at optimal level favourable for reduction of fruit drop and increase in fruit retention (Karuna et al., 2007).

In paclobutrazol treated trees, NAA @ 30ppm was given at full bloom stage in one treatment (T_6) and their combined action might have significantly reduced the fruit drop in current experiment as the drop was minimum to the tune of 81.74 and 85.27 % in Prior and Alphonso varieties respectively. This result showing the efficacy of NAA treatment is in conformity with the findings reported by Baghel et al. (1987), Suma (1987) and Gupta and Brahmachari (2004) in different mango varieties. Application of NAA increased fruit retention by increasing internal auxin (IAA) content or antagonizing adverse effects of endogenous hormones like ethylene and ABA. There is correlation between abscission and endogenous auxin level and existence of high level of internal auxin prevents fruit drop (Wright, 1956).

In the present experiment, trees under T_7 were treated with paclobutrazol followed by KNO_3 spray after 90 days which coincided with flowering which also resulted in improved fruit set and reduced drop. Davenport (2007) and Protacio et al. (2009) have reported that KNO_3 application 3-4 months after paclobutrazol treatment, induced the bud break of quiescent pre-existing floral buds in mango which in turn increased flowering, fruit retention and yield and the present result can be explained in this direction.

5.3. Yield and yield parameters

Fruit yield in terms of weight and number of fruits per tree were appreciably increased by various treatments in the current experiment. Paclobutrazol and potassium nitrate treatments recorded higher values for fruit yield in both varieties. Positive effect of these treatments on yield could be due to their favourable influence on yield attributing characters such as profuse flowering, higher fruit set and more fruit retention which ultimately contributed to more yield. Paclobutrazol application increasing the yield in terms of number and weight of fruits per tree in different cultivars has been reported by various workers who have explained the result as cumulative effect of profuse flowering, increased fruit set and retention at early and late maturity stages (Burondkar and Gunjate, 1993; Desai and Chundawat, 1994; Yeshitela, 2004; Karuna et al., 2007; Tandel and Patel, 2011).

Quantitative yield parameters including the physical characters and stone characters of fruits were significantly influenced by treatments in both varieties. Treatments did not influence the average fruit weight in Prior. However, in Alphonso, treatments showed significant influence. In trees sprayed with potassium nitrate followed by NAA application during full bloom stage maximum fruit weight was recorded, which might be due to the combination effect of nitrate treatment and NAA. Experimental results of some scientists supported the nutritional effect of KNO_3 as observed in the present study. Burondkar (2005) reported that size of individual fruit was significantly increased with nutrients like KNO_3 and K_2SO_4 compared to other treatments. Hima (2007) reported that by applying nitrate treatments, individual fruit weight was improved in mango cv. Prior and Muvandan. On the other hand, Yeshitela (2004) reported that treatments involving KNO_3 alone or in combinations with additional nitrogen sources did not show significant influence on average fruit weight in Tommy Atkins mango. Increase in fruit weight by application of NAA was reported by Suma (1987), Sharma et al. (1990a) and Gupta and Brahmachari (2004) in different mango varieties. The synthesis and translocation of nutrients and photosynthates into fruits is controlled by auxins and hence exogenous application of auxins like NAA might result in increased fruit weight.

Fruit weight was improved due to paclobutrazol and NAA application which may be as a result of promotion of cell expansion by auxins. The minimum fruit weight recorded in other paclobutrazol treatments shows that these treatments do not have much influence on individual fruit weight in Alphonso. This can be explained on the account of greater competition for food reserves among the developing fruit lets. In trees treated with paclobutrazol and KNO_3, profuse flowering, higher fruit set and reduced fruit drop might have resulted in greater competition for nutrients among developing fruit lets, contributing to lower fruit weight observed in this treatment of Alphonso.

5.4. Qualitative yield parameters

Results pertaining to chemical composition of fruits revealed that there was considerable enhancement in the various qualitative parameters like TSS, reducing and non reducing sugars, total sugars, sugar/ acid ratio and reduced acidity due to treatments in Prior and Alphonso varieties. Quality of the fruits in terms of these parameters was benefited mainly by T_4 (KNO_3 3%+ NAA 30ppm) and T_6 (Paclobutrazol 5g/tree+ NAA 30ppm) in Prior variety. In trees sprayed with KNO_3 and NAA (T_4), their combination effect might have resulted in the improvement of TSS of the fruits. Singh (1980) suggested that growth regulators and KNO_3 proved beneficial for improving the fruit quality. These treatments were highly helpful in the process of photosynthesis leading to accumulation of carbohydrate and hence an increase in the sugar content. Significant effect of NAA on this parameter has been observed by Suma (1987), Sharma et al. (1990b), Gupta and Brahmachari (2004) in various cultivars of mango. The increase in TSS content of fruits might be accounted to the rapid hydrolysis of polysaccharides into soluble carbohydrates and also due to increased mobilization of carbohydrates from the source to sink under the influence of applied chemicals (Vijayalakshmi and Sreenivasan, 2000).

Increase in sugar content by chemical application was probably due to rapid translocation of sugars in larger amounts towards fruit and rapid conversion of starch into sugars, which also contributed to early maturity of fruits. Acidity of fruits under the influence of chemicals applied might have declined due to fast conversion into sugars and their derivatives or consumption in the process of respiration or both as explained by Sharma et al. (1990b). Higher sugar/acid ratio recorded in treatments could be due to increased sugar content and reduced acidity of the fruits.

5.5. Role of carbohydrate and nitrogen in mango flowering

The carbohydrate reserves, total nitrogen content and carbohydrate/nitrogen ratio of leaves from all treatments were analyzed. It was observed that in both varieties, carbohydrate content continued to increase up to flowering and maximum content of carbohydrate was recorded during two months after treatment then, decreased rapidly regardless of the treatments. Whereas nitrogen content was found to decrease at every stage and its content before flowering was much lowered compared to pre treatment estimation, irrespective of treatments and varieties. Carbohydrate/nitrogen ratio also followed similar trend as that of the carbohydrate content.

In the present experiment, maximum accumulation of carbohydrate content was noticed in those treatments which produced the maximum number of inflorescence i.e. paclobutrazol treatments (T_5, T_6 and T_7). Reports indicated decreasing total non structural carbohydrates in leaves within two weeks after paclobutrazol application coinciding with the period of rapid vegetative growth (Subhadrabandhu et al., 1997). As leaf is the organ for producing food in plants or the source for assimilates production, this food is sent to the growing parts of plant (sink) for their growth. In this case, sink is the newly formed terminal shoots which require high amounts of assimilates for good growth. Total carbohydrate content in leaves accumulated to the highest level at the time before first flowering in these treated trees. When flower buds develop to flowering and fruit setting, they become strong sinks and need high amounts of food reserves first from leaves and later from terminal shoots. At flowering time, the amount of total carbohydrate in leaves was lowered due to the competitive ability of flowers for food at the expense of leaves and shoots. The degree of flowering induced by paclobutrazol treatments can be related to the amount of carbohydrate in leaves and shoots as well as the C/N ratio of treated trees at the time before flowering. As the treated mango trees had higher total carbohydrate contents in leaves as well as high amounts of flowers, this would indicate the close relationship between food reserve accumulation in leaves and flowering of the mango.

Drastic depletion of stored starch during spring and summer corresponded to vegetative growth, flowering and fruit growth where fruits were the strong sink for starch and dominated other plant parts during their development (Stassen and Janse van Vuuren, 1997). The results obtained in the current experiment as depletion of carbohydrates at the time of flowering in both varieties, irrespective of the treatments was in conformity with the above report.

Protacio et al. (2009) reported that presence of gibberellic acid (GA) inhibits the expression of competence of mango to flower. One of the principle effects of GA is to mobilize carbohydrates by stimulating their degradation to glucose. According to them, a treatment for decreasing GA levels in the tree is available by applying paclobutrazol as a soil drench or as a spray. Paclobutazol blocks the biosynthesis of GA, thus prevents the vegetative growth and promotes reproductive shoots in mango.

In the present experiment, even though total nitrogen content in treatments showed a decreasing trend at successive stages prior to flowering, potassium nitrate treatments recorded significantly higher values in both varieties. Nitrogen supplement from KNO_3 might have increased the leaf nitrogen content and this result was well supported by the findings of Hima (2007) who has reported that application of nitrates and other sources of nitrogen improved the leaf nitrogen content. Urban et al. (2008) in their experiment, observed lower levels of leaf nitrogen close to developing inflorescences than in vegetative standard leaves. Such differences in nitrogen content have been attributed to the proximity of strong sinks such as developing inflorescences or fruits. They also suggested that demand for nitrogen increases with fruit set. In the present study also during flowering, total nitrogen content in leaves of both varieties was lowered irrespective of the treatments.

Carbohydrate/nitrogen ratio was increased at different stages because of the increasing levels of carbohydrate and decreasing levels of nitrogen noticed in the result of analysis. At flowering, CHO/N ratio was lowered due to the utilization of carbohydrate and nitrogen for flowering.

5.6. Biometric characters

Biometric parameters of trees such as height, girth, spread, shoot length, inter nodal length and number of leaves per shoot was recorded before and after the experiment. Results indicated no significant influence of any treatments on the parameters except shoot length, inter nodal length and number of leaves per shoot in varieties Prior and Alphonso. Paclobutrazol treatments resulted in significantly lower values for length of new shoots produced after the experiment in both varieties. Though length of new shoots produced under these treatments was significantly reduced in two years time, it made no impact on the tree height recorded. Kurian and Iyer (1992) and Davenport (2007) have already reported that shoot growth and tree size are not directly correlated in mango and the overall growth of the tree will be influenced by shoot growth only over a considerable period of years. Hence, we cannot expect any change in the tree height and spread in two years time though the treatments influenced the length of new shoots.

Reduction in shoot characters such as length, number of leaves per shoot and internodal length by paclobutrazol treatments was very clear from the present results which are in conformity with reports by earlier workers who showed that soil application of paclobutrazol reduces vegetative growth and stem elongation in mango (Kulkarni, 1988a; Burondkar and Gunjate, 1993). Paclobutrazol, being an important component of triazole group, commercially called as Cultar or Holdfast, reduces vegetative growth and stem elongation in mango by interrupting gibberellic acid synthesis at Kaurene biosynthesis stage (Singh, 2008). Paclobutrazol was effective in reducing length of new shoots, percentage of lateral shoots and number of leaves per shoot in mango and found to lower the levels of active forms of cytokinin in the treated trees (Kurian and Iyer, 1992) which could be a reason for reduced flushing and fewer nodes. Less gibberellin in the tissues resulting from the action of the growth retardants can account for the shorter internodes noticed.

In the present studies, potassium nitrate and ethrel treatments did not cause any effect on tree parameters and this result was supported by the report of Tandel and Patel (2011) who showed that spraying of ethrel and KNO_3 had no effect on the vegetative growth of the mango.

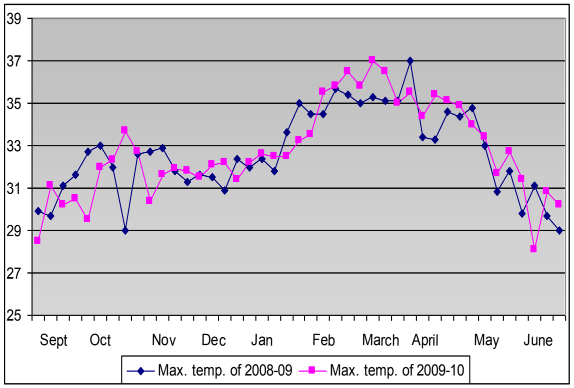
5.7. Weather parameters v/s flowering in mango

Mango season during second year of the experiment (2009-10) in Thrissur district and Kerala as a whole was typically characterized by erratic and delayed flowering resulting in poor crop. Compared to first year (2008-09), flowering was not only delayed but it was also poor and resulting in lower fruit set and yield. Weather data (Fig. 8) gives the clear indication that such variations noted in flowering pattern between the two seasons could be explained based on the deviations recorded in some of the major climatic variables especially rainfall.

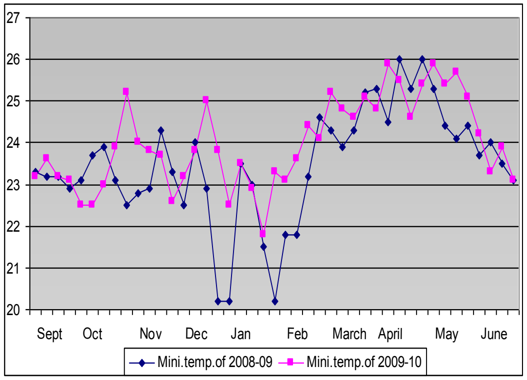
During second year, north east monsoon was very vigorous compared to previous season, setting heavy rainfall in November, which might have interfered with normal floral induction and differentiation process in mango, resulting in sparse/absence of flowering noticed in general. Ravishanker et al. (1979) reported that heavy rainfall and high humidity during flower bud differentiation period from November-December stimulated vegetative instead of reproductive growth under humid tropical climate of Kerala. Renisha (2011) reported that north east monsoon was very much active and vigorous in 2009-10 season during which a record rainfall was noted in central Kerala than the previous years. Unexpected rainfall during December, 2009 and January, 2010 was also recorded. It was assumed that the unexpected variations noticed in rainfall pattern of north east monsoon in the state has resulted in breaking the much needed moisture stress conditions for induction

Fig. 8. Meteorological data during the course of experiment

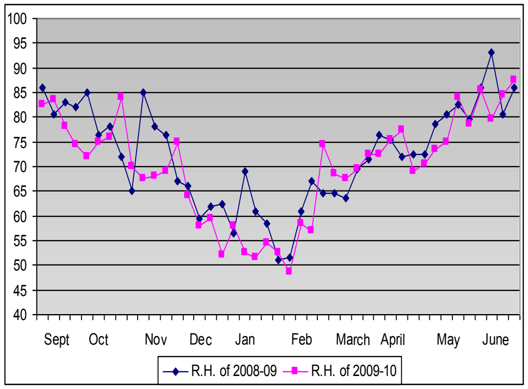
i. Maximum temperature



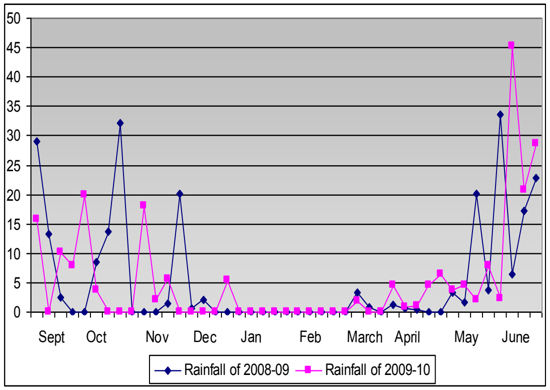
ii. Minimum temperature



iii. Relative humidity



iv. Rainfall



of flowering. It also interfered with the normal low temperature stress during December-January period, which resulted in delayed flowering.

Compared to first year, most of the trees during second year showed poor or no flowering including some trees under treatments such as T_2 (Ethrel 200pm+ NAA 30ppm) in Prior and T_3 (KNO_3 3%) in Alphonso. This might be due to heavy rainfall recorded during November, 2009 that might have interfered with the normal process of floral induction and differentiation in mango. This investigation was well supported by Hima (2007) who has reported that receding south west monsoon during the September, 2006 provided the optimal conditions for bud break and shoot growth and nitrate application during October, 2006 failed to induce flowering in mango as the shoots remained vegetative transiting the process of flushing and further growth.

The results clearly indicated good flowering of trees applied with paclobutrazol even during the second year (2009-10) when the weather conditions were not conducive for mango flowering as already discussed. This gives an indication that paclobutrazol application at proper time and concentration can be beneficial for induction of flowering in mango irrespective of the climatic conditions. This piece of information is of significance since under Kerala conditions interference of climatic conditions results in poor flowering followed by poor yields of mango in certain years, which can be overcome by the application of paclobutrazol at appropriate times.

5.8. Heat units

In mango, minimum heat units should be attained for flowering as well as for fruit maturity and this requirement varies between varieties (Burondkar et al., 2000; Anila, 2002; Singh et al., 2011). In the present experiment, heat units accumulated during the periods from chemical application to flowering and peak flowering to fruit maturity for trees under different treatments were calculated. Variation was noticed in the values between the treatments. It was noticed from the results that paclobutrazol and potassium nitrate treatments resulted in early flowering of trees though the heat unit values recorded were the minimum. This gives an indication that application of paclobutrazol and potassium nitrate might be acting as substitutes even for the heat unit requirement for the trees to enter into reproductive phase. In other words, by treating with these chemicals it may be possible to induce early flowering in mango trees though the weather conditions are not favourable for the attainment of the normally required heat unit accumulation.

5.9. Overall analysis

The overall perusal of the results obtained in the present experiment reveals the possibility of regulating flowering and fruiting in mango using chemicals and growth regulators. Among the treatments tried, T_5 (Paclobutrazol 5g/tree), T_6 (Paclobutrazol 5g/tree + NAA 30ppm) and T_7 (Paclobutrazol 5g/tree + KNO_3 3%) turned out to be the ones showing maximum beneficial effects in Prior and Alphonso varieties. Profuse flowering as shown by increased floral intensity, more initial fruit set, reduced fruit drop leading to increased yield in terms of weight and number of fruits harvested per tree were resulted due to these treatments. Since significant difference between these three treatments was not noticed in majority of the effects, we can presume that even application of paclobutrazol @ 5g/tree as soil drench alone will be enough to get beneficial effects, rather than going for subsequent sprays with NAA and KNO_3.

Among the other treatments, T_3 (KNO_3 3%) was found to be beneficial for increasing flowering and yield in Prior variety whereas T_4 (KNO_3 3% + NAA 30ppm) was good in Alphonso variety, indicating the response of Prior to KNO_3 sprays by profuse flowering. In Alphonso, T_4 resulted in medium flowering but due to higher set and lower drop as a result of NAA spray led to good fruit yield. However, the overall performance of both varieties was better with paclobutrazol treatments. The action and role of paclobutarzol in the phenomenon of mango flowering have been well reported from different sources in a number of varieties. The possibility of increasing flowering and fruiting in mango by this bio regulator applied as soil drench under Kerala conditions has been made clear from the present results. The climatic conditions during the second year (2009-10) of the experiment were not conducive for mango cropping which resulted in poor yields in general but the results showed that even under such conditions paclobutrazol treatments could give good flowering and yield in the two varieties used for the experiment. This is a good indication of the possibility for regulating the mango flowering and fruiting irrespective of variety or climatic conditions using this chemical. For taking the present results to a recommendation level under Kerala conditions, experiments should be conducted in more varieties for consecutive years to obtain conclusive results for tackling the problem of sparse and alternate flowering of mango as well as to study the economic feasibility of the practice.

Summary

6. SUMMARY

The experiment entitled '**Chemical regulation of cropping in mango'** was conducted in the Department of Pomology and Floriculture, College of Horticulture to study the effect of chemicals/growth regulators on flowering and fruiting in mango varieties Prior and Alphonso. The results obtained are summarized below.

1. Paclobutrazol treatments (T_5, T_6 and T_7) resulted in reduction in length of new shoots produced in both varieties after two years application.

2. Early and profuse flowering was noticed in trees of both Prior and Alphonso when treated with paclobutrazol.

3. The percentage of hermaphrodite flowers was not affected significantly by treatments in the case of Prior variety. Ethrel (T_2) and paclobutrazol treatments (T_5, T_6 and T_7) were found to be effective in promoting more number of hermaphrodite flowers in Alphonso.

4. Inflorescence characters such as length and breadth were significantly influenced by treatments. Ethrel (T_1) and potassium nitrate treatments (T_3 and T_4) resulted in maximum inflorescence size in Prior variety whereas, paclobutrazol treatments (T_5 and T_7) produced large inflorescences in Alphonso.

5. Increased fruit set and reduced fruit drop during the course of development were exhibited by trees under paclobutrazol treatments both in Alphonso and Prior varieties.

6. The fruit yield in terms of weight and number of fruits per tree were significantly increased by paclobutrazol treatments (T_5, T_6 and T_7) in both varieties, compared to control and other treatments.

7. Physical parameters of fruits were influenced by treatments in both varieties, but the pattern of significance was not specific. However, T_4 (KNO_3 3% + NAA 30ppm) and T_6 (Paclobutrazol 5g/tree + NAA 30 ppm) recorded higher values for various parameters like fruit length, breadth and girth in both the varieties. Application of ethrel 200 ppm + NAA 30 ppm was also beneficial for improving these fruit characters in Alphonso.

8. Though stone characters of fruits such as the weight, length and breadth were found to be influenced by different treatments in both varieties, the pattern of influence was not specific. Percentage contribution of different fruit parts to total fruit weight and pulp/stone ratio was unaffected by treatments in both varieties.

9. Qualitative parameters of fruits were significantly improved by various treatments compared to control but the influence was not specific. However, T_4 and T_6 recorded higher values for different parameters like TSS, reducing sugars, total sugars and sugar/acid ratio in Prior. The former treatment proved effective in improving these parameters in Alphonso.

10. Maximum content of carbohydrate in leaves was observed just before flowering in both varieties and the values reduced at the time of flowering in general. Paclobutrazol treatments (T_5, T_6 and T_7) significantly enhanced the carbohydrate content compared to control. Nitrogen content showed a decreasing trend up to the full bloom stage irrespective of treatments and varieties. However, potassium nitrate treatments (T_3 and T_4) exhibited higher nitrogen contents compared to control. A similar trend as that of carbohydrate was noticed for carbohydrate/nitrogen ratio.

11. Weather parameters strongly influenced the flowering during second year (2009-10) as most of the trees showed poor flowering and treatments T_2 and T_3 did not flower in Prior and Alphonso varieties respectively. The heavy rainfall coincided with floral differentiation period i.e. October-November during second year interfered

with the flowering process in both varieties. Even under unfavourable conditions, paclobutrazol treatments could result in fairly good flowering and fruiting during this particular year.

12. Overall perusal of the results clearly indicated the possibility of regulating flowering and fruiting in mango varieties Prior and Alphonso by growth regulator application, the best treatments being paclobutrazol (5g/tree), paclobutrazol (5g/tree) + NAA (30ppm) and paclobutrazol (5g/tree) + KNO_3 (3%).

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Appendices

Appendix I. Meteorological data from September 2008 to August 2009

Weekly observation	Max. temp. (^{0}C)	Min. temp. (^{0}C)	R.H. (%)	Sunshine (hrs)	Rainfall (mm)	Evaporation (mm)
03.9.08-09.9.08	29.9	23.3	82.5	3.9	28.98	2.7
10.9.08-16.9.08	29.7	23.2	83.5	2.8	13.28	2.5
17.9.08-23.9.08	31.1	23.2	78.0	6.7	2.47	3.6
24.9.08-30.9.08	31.6	22.9	74.5	7.6	0	3.6
01.10.08-07.10.08	32.7	23.1	72.0	9.2	0	4.4
08.10.08-14.10.08	33.0	23.7	75.0	6.0	8.6	3.7
15.10.08-21.10.08	32.0	23.9	76.0	4.8	13.6	3.1
22.10.08-28.10.08	29.0	23.1	84.0	1.5	32.2	1.8
29.10.08-04.11.08	32.6	22.5	70.0	8.9	0	3.6
05.11.08-11.11.08	32.7	22.8	67.5	8.4	0	3.8
12.11.08-18.11.08	32.9	22.9	68.0	6.8	0	3.7
19.11.08-25.11.08	31.8	24.3	69.0	4.3	1.5	3.9
26.11.08-02.12.08	31.3	23.3	75.0	3.9	20.2	2.7
03.12.08-09.12.08	31.6	22.5	64.0	7.0	0.6	5.2
10.12.08-16.12.08	31.5	24.0	57.95	6.6	2.0	5.2
17.12.08-23.12.08	30.9	22.9	59.5	6.8	0	6.3
24.12.08-31.12.08	32.4	20.2	52.0	9.6	0	6.1
01.1.09-07.1.09	32.0	20.2	58.0	9.6	0	5.3
08.1.09-14.1.09	32.4	23.5	52.5	9.9	0	7.8
15.1.09-21.1.09	31.8	23.0	51.45	9.9	0	8.0
22.1.09-28.1.09	33.6	21.5	54.5	8.6	0	6.3
29.1.09-04.2.09	35.0	20.2	52.5	9.6	0	5.9
05.2.09-11.2.09	34.5	21.8	48.5	9.9	0	6.9
12.2.09-18.2.09	34.5	21.8	58.5	9.5	0	5.7
19.2.09-25.2.09	35.7	23.2	57.0	10.0	0	7.1
26.2.09-03.3.09	35.4	24.6	74.5	7.9	0	5.2
05.3.09-11.3.09	35.0	24.3	68.5	7.9	0	6.3
12.3.09-18.3.09	35.3	23.9	67.5	8.3	3.3	5.6
19.3.09-25.3.09	35.1	24.3	69.5	7.7	0.8	5.4
26.3.09-01.4.09	35.1	25.2	72.5	7.9	0	5.0

Weekly observation	Max. temp. (^0C)	Min. temp. (^0C)	R.H. (%)	Sunshine (hrs)	Rainfall (mm)	Evaporation (mm)
02.4.09-08.4.09	37.0	25.3	72.5	7.4	1.2	5.7
09.4.09-15.4.09	33.4	24.5	75.5	3.2	0.7	3.6
16.4.09-22.4.09	33.3	26.0	77.5	4.5	0.4	4.4
23.4.09-29.4.09	34.6	25.3	69.0	7.9	0	5.5
30.4.09-06.5.09	34.4	26.0	70.5	6.8	0.1	5.2
07.5.09-13.5.09	34.8	25.3	73.5	7.3	3.3	4.9
14.5.09-20.5.09	33.0	24.4	75.0	4.9	1.6	4.4
21.5.09-27.5.09	30.8	24.1	84.0	3.3	20.1	3.1
28.5.09-03.6.09	31.8	24.4	78.5	6.7	3.7	3.7
04.6.09-10.6.09	29.8	23.7	85.5	3.8	33.6	3.0
11.6.09-17.6.09	31.1	24.0	79.5	6.2	6.5	3.8
18.6.09-24.6.09	29.7	23.5	84.5	2.2	17.3	2.8
25.6.09-01.7.09	29.0	23.1	87.5	1.5	22.9	2.9
02.7.09-08.7.09	27.1	22.5	92.5	0.2	31.6	2.7
09.7.09-15.7.09	28.8	23.2	87.5	1.0	26.4	3.4
16.7.09-22.7.09	27.6	22.7	90.0	0.4	51.0	2.6
23.7.09-29.7.09	30.7	23.0	81.5	5.5	5.8	3.7
30.7.09-05.8.09	29.7	23.2	85.5	2.8	19.0	2.8
06.8.09-12.8.09	30.9	23.5	84.5	4.1	4.4	3.1
13.8.09-19.8.09	30.3	23.5	82.5	4.1	15.4	3.1
20.8.09-26.8.09	30.3	22.7	88.5	4.5	27.1	4.4
27.8.09-02.9.09	29.1	22.9	86.5	2.9	15.3	3.0

Appendix II. Meteorological data from September 2009 to June 2010

Weekly observation	Max. temp. (^0C)	Min. temp. (^0C)	R.H. (%)	Sunshine (hrs)	Rainfall (mm)	Evaporation (mm)
03.9.09-09.9.09	28.5	23.2	86.0	1.7	15.8	2.5
10.9.09-16.9.09	31.1	23.6	80.5	6.7	0	3.6
17.9.09-23.9.09	30.2	23.2	83.0	3.5	10.1	3.2
24.9.09-30.9.09	30.5	23.1	82.0	4.2	7.8	3.4
01.10.09-07.10.09	29.5	22.5	85.0	5.0	19.9	3.4
08.10.09-14.10.09	32.0	22.5	76.5	7.9	3.8	3.8
15.10.09-21.10.09	32.3	23.0	78.0	6.8	0.1	3.1
22.10.09-28.10.09	33.7	23.9	72.0	7.1	0	3.5
29.10.09-04.11.09	32.7	25.2	65.0	7.0	0	5.1
05.11.09-11.11.09	30.4	24.0	85.0	2.0	18.0	3.1
12.11.09-18.11.09	31.6	23.8	78.0	5.0	2.0	2.6
19.11.09-25.11.09	31.9	23.7	76.5	6.5	5.7	3.5
26.11.09-02.12.09	31.8	22.6	67.0	9.4	0	4.3
03.12.09-09.12.09	31.5	23.2	66.0	8.0	0	4.6
10.12.09-16.12.09	32.1	23.8	59.5	9.3	0	5.9
17.12.09-23.12.09	32.2	25.0	62.0	8.4	0	6.1
24.12.09-31.12.09	31.4	23.8	62.5	5.6	5.3	5.8
01.1.10-07.1.10	32.2	22.5	56.5	9.2	0	5.0
08.1.10-14.1.10	32.6	23.5	69.0	7.4	0	4.1
15.1.10-21.1.10	32.5	22.9	61.0	9.1	0	5.4
22.1.10-28.1.10	32.5	21.8	58.5	9.6	0	5.3
29.1.10-04.2.10	33.2	23.3	51.0	9.7	0	6.9
05.2.10-11.2.10	33.5	23.1	51.5	10.0	0	7.1
12.2.10-18.2.10	35.5	23.6	61.0	8.4	0	5.3
19.2.10-25.2.10	35.8	24.4	67.0	8.9	0	4.8
26.2.10-04.3.10	36.5	24.1	64.5	9.0	0	5.6
05.3.10-11.3.10	35.8	25.2	64.5	8.2	0	5.5
12.3.10-18.3.10	37.0	24.8	63.5	8.3	1.8	6.2
19.3.10-25.3.10	36.5	24.6	69.5	9.0	0	5.3
26.3.10-01.4.10	35.0	25.1	71.5	7.6	0	4.5

Weekly observation	**Max. temp. (^0C)**	**Min. temp. (^0C)**	**R.H. (%)**	**Sunshine (hrs)**	**Rainfall (mm)**	**Evaporation (mm)**
02.4.10-08.4.10	35.5	24.8	76.5	7.4	4.6	4.9
09.4.10-15.4.10	34.4	25.9	75.5	6.5	0.9	4.1
16.4.10-22.4.10	35.4	25.5	72.0	8.0	1.0	5.2
23.4.10-29.4.10	35.1	24.6	72.5	7.2	4.5	4.4
30.4.10-06.5.10	34.9	25.4	72.5	8.9	6.5	5.2
07.5.10-13.5.10	34..0	25.9	78.5	4.6	3.7	3.9
14.5.10-20.5.10	33.4	25.4	80.5	5.3	4.6	3.9
21.5.10-27.5.10	31.7	25.7	82.5	3.0	2.1	2.7
28.5.10-03.6.10	32.7	25.1	79.5	7.1	7.8	3.9
04.6.10-10.6.10	31.4	24.2	86.0	3.5	2.3	2.9
11.6.10-17.6.10	28.1	23.3	93.0	0.6	45.3	2.3
18.6.10-24.6.10	30.8	23.9	80.5	3.6	20.7	3.5
25.6.10-30.6.10	30.2	23.1	86.0	2.7	28.6	3.7

CHEMICAL REGULATION OF CROPPING IN MANGO

By

RANDEEP. K. R.

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the
requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

Department of Pomology and Floriculture

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR-680 656
KERALA, INDIA
2012

ABSTRACT

The experiment on '**Chemical regulation of cropping in mango'** was taken up at Department of Pomology and Floriculture, college of Horticulture, Vellanikkara during September 2008 to June 2010.

The objective of the experiment was to regulate flowering and fruiting in mango varieties Prior and Alphonso using growth regulators and chemicals for sustained crop production and to ensure market supply. Alphonso and Prior varieties were selected for the study since they have alternate/irregular bearing habit but at the same time are superior and popular varieties in Kerala.

The treatments involved ethrel application alone and in combination with NAA, potassium nitrate alone and in combination with NAA, paclobutrazol alone and in combination with NAA as well as with KNO_3. Paclobutrazol was applied as soil drench and all the other chemicals in the form of foliar sprays. Ethrel, potassium nitrate and paclobutrazol were applied once during September. NAA application at full bloom stage was included as treatments to tackle the premature fruit drop.

In both varieties, paclobutrazol treatments induced early and profuse flowering compared to control. The percentage of hermaphrodite flowers produced in an inflorescence was not affected by treatments in Prior. Paclobutrazol treatments significantly influenced the number of hermaphrodite flowers produced in the inflorescence of Alphonso. Inflorescence size was significantly influenced by different treatments in both varieties however, ethrel and potassium nitrate treatments were found effective in Prior and paclobutrazol treatments were the best in Alphonso.

Paclobutrazol treatments improved the initial fruit set in both varieties and were also highly effective in controlling fruit drop at different stages after fruit set. Fruit drop at 60 days after set ranged from 81.74 to 95.13% in variety Prior and 84.31 to 96.77% in variety Alphonso, the minimum values being recorded by paclobutrazol treatments.

During the second year of experiment (2009-10), rainfall during October-November resulted in poor flowering of mango in the state. The results of the present experiment showed that in trees under paclobutrazol treatments, flowering was good in both the varieties even under adverse climatic conditions which gives an indication that though weather conditions go unfavourable for flowering, the trees can be induced to get substantially good flowering by this chemical.

In the present study, quantitative (fruit weight, length, breadth and stone weight) and qualitative parameters (TSS, total sugars and acidity) of the fruits were not influenced by the different treatments in a specific pattern in both the varieties.

Irrespective of treatments and varieties, Carbohydrate/nitrogen ratio increased at monthly intervals after treatment and recorded maximum value just before flowering and finally reduced at the time of flowering. Paclobutrazol treatments recorded significantly higher values for this parameter in both varieties.

Overall perusal of the results clearly indicates the potential of paclobutrazol application @ 5g/tree to regulate flowering and fruiting in mango varieties Prior and Alphonso. The beneficial effects of the chemical noticed were early and profuse flowering, increased fruit set and reduced fruit drop in turn resulting in higher yield in both the varieties. Further trials involving other varieties of mangoes of different age groups at same location as well as in different locations are suggested as the future line of work in this aspect.