STUDIES ON THE INFLUENCE OF PACLOBUTRAZOL (PP 333) ON FLOWERING AND FRUITING IN ALPHONSO MANGO (*Mangifera indica* L.)

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Dedicated to

My Grand Father

Late Sri Dodda Lingaiah

UNIVERSITY OF AGRICULTURAL SCIENCES
DIVISION OF HORTICULTURE
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE INFLUENCE OF PACLOBUTRAZOL (PP333) ON FLOWERING AND FRUITING IN ALPHONSO MANGO (*Mangifera indica* L.)"** submitted by **Mr. MAHESH KUMAR**, in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **POMOLOGY** to the University of Agricultural Sciences, Bangalore is a bonafide record of research work carried out by him during the period of his study in this University under my guidance and supervision and that no part of this thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

I. INTRODUCTION

Mango (*Mangifera indica* L.) which belongs to the family Anacardiaceae, is one of the most popular fruit crops in the tropical and sub-tropical regions of the world. It has been under cultivation in the Indian sub-continent since the past 4000 years (De Candolle, 1904). It is considered as the national fruit of India and is said to have originated in the Indo-Burma region (Mukherjee, 1958). It is termed as the "King of fruits" owing to its delicious taste, captivating flavour and attractive aroma, besides being an excellent source of vitamins A and C. The ripe fruit is not only eaten fresh, but is also utilized for processing into various products like canned mango slices in syrup, pulp, jam, squash, juice, nectar, cereal flakes, mango custard powder, mango toffee, mango leather and mango juice powder. Unripe mango fruits are also used for preparing various products like mango pickle, chutney, brined mango slices, dried green mango slices and powder, mango wine and other delicacies.

Although mango is commercially grown in more than 87 countries of the world, India ranks first with respect to both area (10.63 million hectares) and production (10 million tonnes). The export of fresh mangoes from India in 1990-91 amounted to 19,380 metric tonnes valued at Rs 312 million and the export of mango pulp was 62 per cent of the total exports of processed fruits and vegetables, valued at Rs. 220 million (Anon, 1992). India contributes to more than 70 per cent of the total world mango production, and the fruit is largely grown in the states of Uttar Pradesh, Bihar, Andhra Pradesh and Karnataka. In Karnataka, mango is the leading fruit crop, occupying an area of 68,100 ha with a total production of 6.46 lakh tonnes of fruit (Chadha and Pareek, 1993).

In India, nearly one thousand varieties of mango are under cultivation, but only about twenty of them are grown on a commercial scale. The most important North Indian varieties are Dashehari, Langra, Chausa, Bombay Green, Fazli and Amrapali, while the important South Indian varieties are Alphonso, Baneshan, Neelum, Bangalora, Mulgoa and Mallika. Among all these varieties, Alphonso occupies the premier position, and is one of the choicest varieties of mango for fresh trade, processing and export because of its fiberless capucine yellow pulp that has a delightful flavor and an excellent sugar-acid blend. Inspite of the economic importance and demand both in Indian and international markets, the cultivation of Alphonso mango is limited by certain problems like alternate bearing, susceptibility to spongy tissue disorder, limited adaptability, susceptibility to pests (mango hopper) and diseases (powdery mildew) and mango malformation (Pandey, 1989). Among these, alternate bearing is the major problem, where trees carry a heavy load of crop in one year ('on' year) and show a tendency towards reduced yield in the following year ('off' year). The extent of alternate bearing is influenced by several factors including cultural practices and crop load. It has been suggested that this problem can be corrected by following deblossoming and thinning of fruits, pruning, improved cultural practices and use of plant growth regulators (Chadha and Pareek, 1993).

In recent years, however, certain plant growth regulators like Ethephon, Alar, Cycocel, Paclobutrazol and other chemicals have been shown to induce flowering in mango during the 'off' year. Of these chemicals, the growth retardant "paclobutrazol" has been reported to exert profound effects on vegetative and flowering behaviour of mango and a number of other plant species (Kulkarni, 1988 ; Burondkar and Gunjate, 1991 ; Byun and Chang, 1986).

Paclobutrazol (PP333) is a member of the triazole group, which are the most highly active class of growth retardants. In relatively small quantities this compound has been reported to be very effective in inducing flowering and fruiting in a wide range of plant species (Voon et al., 1989). It can be effectively applied as foliar sprays or as soil drenches. Paclobutrazol being xylem mobile moves upwards with the transpiration stream. It inhibits the biosynthesis of gibberellins in plants by blocking the conversion of kaurene to kaurenoic acid in the gibberellin biosynthesis pathway. Hence paclobutrazol, which acts as a gibberellin biosynthesis inhibitor, has been demonstrated to induce flowering in a number of commercially important mango cultivars (Voon et al., 1989).

Paclobutrazol (PBZ) has been reported to be effective in reducing plant growth and inducing more flowering and fruiting in several temperate tree and vine species including apple (Byun and Chang, 1986; Kim et al., 1986), blueberry (Spiers, 1988), cherry (Looney and McKellar, 1987; Thomson and Thompson, 1989), peach (Tonutti et al., 1986; Marini, 1987; Mavrodiev et al., 1987) and plum (Webster and Andrews, 1985). Results have been reported on sub-tropical evergreen species like citrus

(Delgado *et al.*, 1986; He *et al.*, 1988), avocado (Adato, 1990), cashew (Misra and RoomSingh 1991) and mango (Davenport, 1986; Kulkarni, 1988; Tongumpai *et al.*, 1989; Charnivichit and Tongumpai, 1991; Hillier, 1991; Winston, 1992).

There is very limited published literature available regarding the use of paclobutrazol in Alphonso mango under South Indian conditions although this variety is grown on a rather large scale in this part of the country. Hence, the present study was carried out in Alphonso mango with the following broad objectives;

1. To study the influence of paclobutrazol on 'off' year flowering.
2. To study the effect of paclobutrazol on fruit set, yield and quality of fruits.
3. To study the effect of paclobutrazol on ripening and post-harvest behaviour of fruits.
4. To determine the effect of paclobutrazol on spongy tissue disorder and stem end rot disease.
5. To compare soil application v/s foliar spray of paclobutrazol with respect to the above mentioned attributes.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

In this chapter an attempt is made to present the literature on the effects of paclobutrazol (PBZ) application to mango trees on flowering, fruit set, fruit yield and fruit quality. The information available on the effect of PBZ on other perennial fruit crops is also included. The review is presented under the following headings:

1. Effect of paclobutrazol on flowering
2. Effect of paclobutrazol on fruit set and yield
3. Effect of paclobutrazol on fruit quality

2.1 Effect of paclobutrazol on flowering

Flowering in mango has been associated with reduced vegetative growth usually during the period of moisture stress. Reduced vegetative growth is related to reduced gibberellin levels. Kachru *et al*. (1971) reported that exogenous application of gibberellin inhibits flowering in mango.

The effect of paclobutrazol on growth retardation is primarily due to the inhibition of gibberellin synthesis in plants which could in turn trigger off flower initiation. Paclobutrazol treatments can induce flowering and show varied response with cultivars in terms of length of time taken to achieve flowering, intensity and consistency of flowering (Voon et al., 1989). Tongumpai et al. (1989) revealed that Cultar applied as a collar drench at the rate of 1 g a.i./m canopy diameter induced flowering 3 to 5 months after treatment in easy-to-flower cultivars.

Feungchan et al. (1989) found out that application of fertilizer at intervals of 7 and 15 days resulted in the highest rate of flower bud differentiation in mango cv. Khiewsawoey. Trees treated with paclobutrazol produced more flower buds promoted by frequent fertilizer application.

Application of paclobutrazol at 2500 and 5000 ppm delayed panicle development and flowering in mango, particularly when applied at 1-2cm panicles (Khader et al. (1989). Charnivichit and Tongumpai (1991) revealed that paclobutrazol applied at the rate of $1.5 g/m^2$ to mango trees flowered more profusely and considerably earlier than the controls.

Burondkar and Gunjate (1991) observed that paclobutrazol significantly supressed the vegetative growth, retarded the extension of shoots and induced profuse and early flowering in two subsequent cropping years. As compared to foliar applications, results obtained with soil application were more significant over control.

Tongumpai et al.(1991) reported that combination of soil application of paclobutrazol (6g/tree) and foliar spray of potassium nitrate eight weeks after paclobutrazol treatment induced very early flowering.

Vuillaume (1991), while working with Kiet, Brooks and Lippens mango varieties observed an advancement of flowering by one to two months with 15g paclobutrazol per tree.

Winston (1992) reported that soil applied paclobutrazol treatments had more effect on flowering and cropping than foliar treatments of mango cv. Kensington Pride.

Kulkarni (1988) concluded that soil application of the growth retardant paclobutrazol caused precocious flowering in young mango trees and promoted flowering in bearing trees. Axillary flowering and cauliflory were observed in treated trees, and the flowering was advanced. Soil treated trees given 10g a.i. per tree flowered six to eight weeks earlier than control.

Kurian and Iyer (1993a) reported that early and profuse flowering was a striking response to paclobutrazol treatments in nine year old mango trees when assessed for two successive years. Treatments resulted in condensed panicles, an enhanced proportion of hermoprodite flowers, and reduced pollen fertility.

Buban (1986) reported that young apple trees treated with paclobutrazol at 0.1 or 0.15 per cent had reduced shoot growth but higher number of spurs. Byun and Chang (1986) found that when Fuji apple trees were treated with paclobutrazol, the number of shoots on two year old branches increased at low application rates (2g/tree), but decreased at high rates (6g/tree).

Kwon and Lee (1986) revealed that flowering was delayed by two to three days when paclobutrazol applied as a soil drench to five year old Fuji apple trees. Shearing et al. (1986) concluded that paclobutrazol applied to cherry trees at 1.6g per tree in 1981 and at 0.8g per tree in 1982 reduced shoot growth and increased flower number.

2.2 Effect of paclobutrazol on fruit set and yield

Kulkarni (1988) reported that there was a significant increase in yield per tree when paclobutrazol was applied to mango trees although fruit size was not affected by this treatment. Similar results of higher and early yield was also reported by Feungchan *et al*.(1989) in mango when trees were treated with paclobutrazol.

Burondkar and Gunjate (1991) observed maximum fruit set in 10g (soil) treatment followed by 2000 ppm (foliar) of paclobutrazol in mango; these were significantly superior to the other treatments. Soil application of 5-10g or a foliar application of 1000 ppm of paclobutrazol were found to be significantly more effective for consistent and high yields.

Fruit set was promoted by 2.5g paclobutrazol per tree, but the highest concentration of paclobutrazol (10g per tree) had a detrimental influence both on fruit set and retention. Fruit yield was enhanced at 2.5 or 5.0g per tree but at 10.0g per tree it reduced yield (Kurian and Iyer, 1993b).

Byun and Chang (1986) reported that when apple trees were treated with paclobutrazol in March 1985, all rates of application reduced shoot growth, but none affected fruit set. Although fruit length increased and individual fruit weight decreased at the higher rates, the number of fruits and fruit weight per tree increased. Fruit stalk length decreased with increasing application rates (6g a.i. per tree).

Apple trees treated with paclobutrazol in two years (1983 and 1984) had reduced shoot growth but higher number of spurs and fruit buds. In the following year, due to heavier fruit set, the yield was upto 21 per cent more on treated than on untreated trees (Buban, 1986).

Costa and Biasi (1986) observed that application of paclobutrazol as soil drench at 1,2 and 4 kg/ha to apple cv. HiEarly on MM 106 showed increased fruit set, but fruit growth rates and average weights were little affected.

Miller and Swietlik (1986) reported that fruitset was significantly increased in four year old Golden Delicious apple trees on M 7A rootstocks treated with paclobutrazol at 5, 10 or 20g per tree. The degree to which trees responded and the time required after treatment varied with method of application and tree age. Kim *et al*. (1986) observed that there was no effect on fruit yield in 1983 or 1984, but in 1985, all paclobutrazol treated apple trees showed a significant increase in yield over untreated trees.

Paclobutrazol delayed bloom and reduced fruit bud number and yield in Yellow Spur on M26 rootstocks (Sansavini and Bonomo, 1986).

Volz and Knight (1986) while working on the use of paclobutrazol in Bramley Discovery and Cox's Orange Pippin cultivars of apple grown on M9 and MM106 rootstocks concluded that spraying of paclobutrazol at 500 ppm reduced the fruit yield in Cox Orange Pippin and reduced fruit set in Bramley. When young apple trees cv. Gloster were sprayed 2-4 times per season with 0.05 to 0.2 per cent Cultar (paclobutrazol) with or without oil additive, retardation of shoot extension growth, decreased apical dominance and production of greater number of spurs were observed (Buban et al., 1987). Fruit set was enhanced and yields were increased markedly in both small scale and commercial trials. Similarly Jones et al.(1988) observed that paclobutrazol (4 x 250 ppm) increased fruit number per unit trunk area and the number of flower clusters per unit limb area in 'Red Delicious' apple trees.

Jaumien et al. (1986) reported that the total yield of pear trees sprayed with paclobutrazol either singly or in combination with CEPA was 100 per cent higher than that of control trees. Knight and Browning (1986) reported that when paclobutrazol was applied at 1g/litre during 30 per cent full bloom + 300 mg/litre 7 days later together with GA_3 (2 or 20 mg/litre) during flowering, reduced initial fruit set but improved fruit size and fruit bud formation in pear trees.

Ogata et al. (1986) concluded that foliar application of paclobutrazol (1000 ppm) to peach trees increased the percentage of fancy fruits harvested from the basal part of the tree compared with untreated trees. Tonutti et al. (1986) reported that paclobutrazol increased the total and marketable yields in all treatments except at 2000 ppm applied to Spring Crest cultivar of peach.

Soil application of paclobutrazol at 6g per tree reduced fruit length and average fruit weight in 'Clapp's Favorite' variety of pear, but the yield was not affected (Embree et al., 1987). When paclobutrazol applied at 2 and 4 kg per hectare to Early Crest, May Crest and Spring Crest cultivars of peach, they observed increased fruit set in all the cultivars but increased fruit yield only in Spring Crest cultivar (Forlani and Tanca, 1987).

The effect of paclobutrazol on growth and cropping of five year old 'Red haven' peach trees was studied in detail by Marini (1987), and he observed that shoot growth was suppressed progressively by increasing concentrations of paclobutrazol over two years. However, yield per tree, number of fruits per tree and fruit size were not influenced by the treatments. Mavrodeiv et al. (1987) studied the effect of paclobutrazol on growth and fruiting of peach. Paclobutrazol applied to the soil in the irrigation water at 1.2g a.i. per tree increased the fruit yield by 46.9 per cent and 39.4 per cent at 2.4g a.i. per tree. Yoshikawa et al. (1987) concluded that soil application of paclobutrazol (0.5-2.0kg/ha) improved yield as well as fruit size without increasing split pits in peach. Highest yields were obtained with the application of paclobutrazol at 0.75 kg per hectare. They also observed earlier fruit maturity which eliminated the need for summer pruning but it increased the time taken to thin the fruit by hand.

Li et al. (1988) reported on the effect of paclobutrazol on growth and cropping in peach in relation to application method and concentrations used. The rapidity and persistence of its effects on fruit yield and fruit size were observed following paclobutrazol application. The effects were more persistent at 1000 ppm than at 500 ppm. Further more, it is suggested that paclobutrazol may decrease fruit cell division during the first stage of fruit growth and improve fruit cell enlargement during the following stages. The latter effect may result from an indirect stimulation by a reduction of shoot competition.

Sprays of 1000 or 2000 mg of paclobutrazol per litre thinned out the fruitlets and increased the fruit size on 2 sites when applied to mature plum trees at full bloom (Webster and Andrews, 1985). In trials with cherries, paclobutrazol applied to the soil at 1.6g per tree in 1981 and at 0.8g per tree in 1982 (applied over $4m^2$) reduced shoot growth and increased flower number and yields (Shearing et al., 1986). Paclobutrazol applied to Bramley apple trees in 3 successive years (1981, 82 and 83) at 2000, 1500 and 1000 ppm respectively increased the accumulated 3 year yield by over 10 per cent compared with the control. In trial with peaches soil application of paclobutrazol at 1.12 kg/ha increased fruit weight and circumference by 13.6 and 4.8 per cent respectively. Thomson and Thompson (1989) reported that paclobutrazol at rates between 25 and 100g a.i./ha applied to the cherry cultivars Moss Early and Lewis increased fruit set (fruit numbers as a percentage of flower clusters) and fruit numbers/branch in Moss Early trees (but not on Lewis trees) in the second year.

Antognozzi and Cataland (1985) reported that paclobutrazol at the rate of 1000 and 2000 ppm were sprayed at petal fall affecting fruit set which was increased from 1.0 to 1.5 per cent in case of twelve year old olive tree cv. Ascolana. Promalin treatment increased fruit weight and pulp : stone ratio when applied at petal fall. He et al. (1988) studied on the effect of paclobutrazol on shoot growth and fruit setting of orange. Satsuma mandarin trees were treated with PP333 (paclobutrazol) by application to the soil at 2, 4 or 6g/tree or by foliar spray at 1000 1,500 or 2000 ppm. Total nitrogen contents in the leaves of trees treated by soil application were 13.9. 9.3 and 13.3 per cent higher than control, but they were not significantly different from controls in fruit set treated by foliar spray except in the 2000 ppm. Delgado et al. (1986) studied soil application of paclobutrazol at 2.5, 5 or 10g/tree on bloom, fruit set and fruit growth in oranges. In spite of a low fruit set, yield was significantly increased due to greater blooming at the highest paclobutrazol rates.

2.3 Effect of paclobutrazol on fruit quality

Khader (1990) reported that application of paclobutrazol to mango trees of cv. Dashehari as a foliar spray at 250, 500, 1000, 2000 or 3000 mg/ litre at fruit bud differentiation resulted in the production of fruits of better quality as judged from the increased TSS, titratable acidity, ascorbic acid content, amylase and peroxidase activity from harvest upto 12 days of storage at ambient conditions.

According to Kurian and Iyer (1993b) use of paclobutrazol at high dosage adversely affected TSS, sugar/acid ratio and delayed fruit maturity and ripening in Alphonso mango.

Looney and McKeller (1987) reported that there was reduction in soluble solids but fruit quality was unaffected when cherry trees were soil drenched with paclobutrazol. A preharvest spray of 20ppm GA_3 substantially enhanced the paclobutrazol effect on fruit size and colour but also increased fruit firmness, juice acidity and fruit removal force and reduced the incidence and severity of pitting following two weeks of cold storage.

Chang and Byun (1987) observed that fruit coloration was delayed by paclobutrazol treatment and reduction in the soluble solid content was observed in young cv. Tsugaru apple trees.

Elfving *et al.* (1987) concluded that foliar application of daminozide and paclobutrazol application delayed fruit maturation and ripening at harvest in the year of treatment. There was little effect on juice soluble solids or mean fruit weight, following 24 weeks of air storage treated fruits were firmer and displayed less core browning than untreated fruits. Wang and Steffens (1987) observed that fruits of apple trees treated in April with paclobutrazol (lg/tree) maintained greater firmness and has less internal breakdown than control fruits after 7 months in storage at 0^{o}C. However respiration, soluble solids, fructose, glucose, sucrose and maleic acid contents of the fruit after 0^{o}C storage and during ripening at 20^{o} were not affected.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation on the effects of paclobutrazol on flowering, fruit set and yield in Alphonso mango was carried out at the Division of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. The study was carried out from October 1992 to July 1993. The experimental details pertaining to the materials used and the techniques adopted are presented in this chapter.

3.1 General description

3.1.1 Location

The experimental mango orchard is situated at 12^{o} 56' N latitude and 77^{o} 35' E longitude and at an elevation of 930 meters above MSL. Some of the relevant weather parameters recorded at the station during the experimental period are presented in Appendix - I.

3.1.2 Soil

The topography of the experimental orchard is fairly uniform with a gentle gradient towards the eastern side. The orchard soil is lateritic with a pH of 5.6 and an electrical conductivity of 0.09 m $mhos/cm^2$.

3.2 Experimental plant material

Thirty six uniform Alphonso mango trees which had yielded well in the season of 1992 were selected for the experiment. These 19 year old trees were of uniform vigor and grafted onto the polyembryonic rootstock Nekkare and were receiving uniform agronomic practices. The previous years yield data of these experimental trees are presented in Appendix - II.

3.3 Details of the experiment

Paclobutrazol a gibberellin biosynthesis inhibitor was used to induce flowering during off year (1993) in Alphonso mango trees using Cultar (contains 25% paclobutrazol w/v) of Imperial Chemical Industries PLC., England.

3.3.1 Treatment details

The following were the different treatments imposed to Alphonso mango trees during the first week of October 1992.

T_1 : Soil drenching of paclobutrazol at 4g a.i. per tree
T_2 : Soil drenching of paclobutrazol at 6g a.i. per tree
T_3 : Soil drenching of paclobutrazol at 8g a.i. per tree
T_4 : Soil drenching of paclobutrazol at 10g a.i. per tree

T_5 : Foliar spray of paclobutrazol at 4g a.i. per tree

T_6 : Foliar spray of paclobutrazol at 6g a.i. per tree

T_7 : Foliar spray of paclobutrazol at 8g a.i. per tree

T_8 : Foliar spray of paclobutrazol at 10g a.i. per tree

T_9 : Control

Replications

Four trees per treatment

Design

Randomised Complete Block Design (RCBD)

Four different concentrations were applied to mango trees both through soil drench and foliar spray along with a control tree. In case of soil drench the soil in the drip circle of 1 mt width is dug for half a foot deep and ten litres of paclobutrazol solution was applied during the first week of October 1992. In case of foliar spray the required quantity of chemical was dissolved in 10 litres of water along with 0.1% Teepol and sprayed till drip.

3.4 Observations recorded

Observations pertaining to the effects of paclobutrazol on flowering, fruit set, yield, physical and chemical composition of fruit, postharvest behaviour and organoleptic qualities were recorded as described here.

3.4.1 Number of panicles per square meter area of the canopy

A square block of one meter area was prepared with bamboo sticks. It was randomly placed on the tree at four different points and the number of inflorescences present within each block were counted during January 1993 and the average worked out.

3.4.2 Total number of panicles produced per tree

Each treated tree was divided into four quarters with a line rope and the number of inflorescences present in each quarter counted during the third week of January 1993. The total number of inflorescences produced per tree was computed as the sum of inflorescences from all the four quarters of each tree.

3.4.3 Length of panicle

Twenty five panicles in each tree were randomly selected and their length measured using a meter scale during the last week of January 1993.

3.4.4 Breadth of panicle

In each tree twenty five panicles selected for length measurement were used to measure the breadth at the broadest point, again using a meter scale.

3.4.5 Number of secondary branches per panicle

In each of the twenty five panicles, the number of secondary branches on the main axis were counted.

3.4.6 Number of fruits set per panicle

The number of fruits set in each panicle were counted, in each of the 25 panicles, when the fruits had attained 'pea size'.

3.4.7 Fruit number

The number of fruits harvested from each treated tree was counted at the time of harvest, and the data expressed as fruit number per tree.

3.4.8 Fruit yield

The fruits harvested from each tree were weighed using a balance and expressed in kilograms as fruit yield per tree.

3.4.9 Length of fruit

The length of the fruit from stalk end to the apex of fruit was determined at harvest, with the help of vernier callipers and expressed in centimeters.

3.4.10 Breadth of fruit

The breadth of the fruit was determined as the maximum linear distance between two shoulders of the fruit with the help of vernier callipers, and expressed in centimeters.

3.4.11 Thickness of fruit

The thickness of the fruit was measured as the linear distance between the two cheeks of the fruit with the help of vernier callipers, and expressed in centimeters.

3.4.12 Average fresh fruit weight

Immediately after the harvest of the fruit the stalk was removed and the weight of the raw fruit was recorded in grams.

3.4.13 Volume of fruit

Fruit volume of ten fruits from each tree was determined by the conventional water displacement method, and the mean computed.

3.4.14 Specific gravity of fruit

This was computed as the ratio of fresh weight of fruit to its volume.

3.4.15 Average fruit weight (ripe)

The fruits were ripened at room temperature and their ripe weight recorded in grams.

3.4.16 Peel weight of the fruit

The peel of ten ripe fruits was separated and the weight recorded in grams. The per cent weight of peel to that of total fruit weight was also computed.

3.4.17 Stone weight of the fruit

The stones of ten ripe fruits were separated from the pulp and their weight recorded in grams. The per cent weight of stone to that of total fruit weight was also computed.

3.4.18 Pulp weight of the fruit

Mango pulp, after separation from the peel and stone was weighed and the weight expressed in grams.

3.4.19 Pulp recovery

The pulp recovery from the ripe fruits was determined by the following formula.

$$\text{Pulp recovery (\%)} = \frac{\text{Weight of pulp (g)}}{\text{Ripe fruit weight (g)}} \times 100$$

3.4.20 Total Soluble Solids (TSS) of fruit pulp

The juice extracted by crushing the ripe pulp from the two halves of each fruit, separately, was strained through muslin cloth and used for measuring total soluble solids. TSS was determined by using a Erma hand refractometer (0^{o} to 32^{o} range) and expressed as ^{o} Brix.

3.4.21 Titratable acidity of pulp

A composite sample of 10 g was blended with distilled water using a pestle and mortar. The volume was made upto 100 ml and filtered. An aliquot of 10 ml was taken and titrated against 0.1 N NaOH to the phenolphthalein end point and expressed as per cent citric acid.

3.4.22 Total sugar content of the pulp

The content of total sugars present in the ripe fruit pulp was estimated by the phenol-sulphuric acid method (Dubios et al., 1951).

3.4.23 Reducing sugar content of the pulp

The reducing sugar content of the ripe Alphonso mango pulp was estimated by the dinitro salicylic acid method developed by Millar (1972).

3.4.24 Non-reducing sugar content of the pulp

The non-reducing sugar content was computed by the formula.

Non reducing sugar = Total Sugar - Reducing Sugar

3.4.25 Days taken for ripening

Fully mature Alphonso mango fruits were harvested and the date of harvesting recorded. These fruits were ripened at room temperature and the date at which the fruits were ripe recorded. The difference between these two dates was considered as the number of days taken for ripening.

3.4.26 Physiological loss in weight (PLW)

At harvest, the raw mango fruits were weighed and the raw weight of fruits recorded. The fruits were then ripened at room temperature and at the proper stage of ripeness the weight of the fruit was recorded. The physiological loss in weight was then calculated as ;

$$\text{Physiological loss in weight (\%)} = \frac{\text{Raw weight of the fruit (g)} - \text{Ripe weight of the fruit(g)}}{\text{Raw weight of the fruit (g)}} \times 100$$

3.4.27 Firmness of fruit

The firmness of representative ripe mango fruits was measured in terms of pressure required to rupture the fruit pulp. It was determined using a hand penotrometer (International Engineering Concessionaries Ltd., England) and the same is expressed in kg/cm^2 (0-5kg/cm^2 range).

3.4.28 Incidence and extent of spongy tissue

Ten ripe fruits from all the nine treatments were cut on both the sides and the occurrence of spongy tissue symptom was noted. The incidence of spongy tissue was calculated by the following formula.

$$\text{Incidence of spongy tissue (\%)} = \frac{\text{Number of fruits exhibiting spongy tissue symptom}}{\text{Total number of fruits examined.}} \times 100$$

The extent of spongy tissue in each fruit was recorded by visually estimating the extent of affected tissue in both halves of each fruit by assigning scores between 0 and 10, zero when there was no spongy tissue, and ten when the entire pulp was affected.

3.4.29 Incidence of stem end rot

Ripe fruits exhibiting stem end rot symptoms (circular black patch in and around stalk end of the fruit) were counted in each treatment lot, and the incidence of stem end rot was calculated as

$$\text{Stem end rot (\%)} = \frac{\text{Number of fruits exhibiting stem end rot symptoms}}{\text{Total number of fruits examined}} \times 100$$

3.4.30 Organoleptic evaluation

The organoleptic evaluation of ripe mango fruit for quality attributes such as appearance, color, flavor, texture, and overall appearance was assessed by a panel of five judges who scored on a 10 point Hedonic scale (Amerine et al., 1965). The chart used for evaluation of the ripe fruits is presented in Appendix III.

3.5 Statistical analysis of experimental data

The analysis of variance for the treatments was carried out as per Sundara Raj et al., 1972).

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Studies on the effect of paclobutrazol on flowering, fruit set, yield and quality of Alphonso mango were conducted between October 1992 and July 1993. The results of this study are presented in this chapter.

4.1 Effect of paclobutrazol on flowering

In order to determine the effect of paclobutrazol on flowering and panicle characters in Alphonso mango, the number of panicles produced per square metre area of the canopy, total number of panicles produced per tree, length and breadth of the panicle, and number of secondary branches per panicle were recorded; the relevant data is presented in Table 1.

4.1.1 Number of panicles per square metre area of the canopy

Significant differences were observed between paclobutrazol treated and untreated trees. Soil drenching with paclobutrazol at 8g a.i. per tree produced the maximum number of panicles per square metre area of the canopy (97.0) followed by 10g a.i. per tree (92.0). Similarly, foliar application of paclobutrazol at 10g a.i. per tree produced the maximum number of panicles per square metre area of the canopy (90.25) and this was followed by 6g a.i. per tree (80.25). However, the least number of panicles (48.75) was recorded in untreated trees.

4.1.2 Total number of panicles produced per tree

All the paclobutrazol treatments, both soil drenching and foliar spray, resulted in a significant increase in the number of panicles produced (Table 1). The highest number of panicles per tree (914.50) was recorded in trees that received 8g a.i. paclobutrazol through soil drenching. From among the foliar spray treatments of paclobutrazol, the highest number of panicles per tree (854.75) were produced in trees that had received 10g a.i. of paclobutrazol. The least number of panicles (464.00), however, was recorded in untreated trees.

4.1.3 Length of the panicle

All the paclobutrazol treatments resulted in a significant reduction in the length of the mango panicle (Table 1). Short panicles length of 19.10 cm and 20.05 cm were recorded in trees which had received 8g a.i. paclobutrazol per tree through soil drench and foliar spray, respectivley. The panicles in the untreated trees, were on the other hand, atleast 28.82 cm in length.

4.1.4 Breadth of the panicle

With respect to the breadth of panicles also, a similar trend was observed as with the length (Table 1). A panicle breadth of 20.32 cm was noticed in untreated trees, whereas in trees treated with 10 and 8g a.i. paclobutrazol per tree through soil drenching and foliar spray, panicle breadth was reduced to 14.25 and 14.65 cms, respectivley.

4.1.5 Number of secondary branches per panicle

All the paclobutrazol treatments increased, significantly, the number of secondary branches produced per panicle as compared to control (Table 1). A maximum of 26.12 secondary branches were recorded in trees treated with 10g a.i. paclobutrazol through soil drenching. Whereas in untreated trees it was only 20.96. Foliar sprays of paclobutrazol at different concentrations were found to increase the secondary branches, although no consistent pattern was detected. In any case, secondary branch production was higher than in control trees.

Table 1. Effect of paclobutrazol on panicle production and panicle characters in mango cv. Alphonso

Treatments	No. of panicle/ m^2 area of the canopy	Total no. of panicles produced/ tree	Length of the panicle (cm)	Breadth of the panicle (cm)	No. of secondary branches/ panicle
Soil drenching with PBZ					
4g a.i./tree	71.75	772.00	24.60	17.07	21.16
6g a.i./tree	82.75	854.75	23.65	16.45	22.20
8g a.i./tree	97.00	914.50	19.10	14.81	25.52
10g a.i./tree	92.00	886.00	20.10	14.25	26.12
Foliar spray of PBZ					
4g a.i./tree	75.25	740.00	24.77	16.57	23.39
6g a.i./tree	80.25	760.50	22.55	16.37	23.53
8g a.i./tree	57.00	676.25	20.05	14.65	24.07
10g a.i./tree	90.25	854.75	20.22	15.30	25.51
Control	48.75	464.00	28.82	20.32	20.96
SEm±	7.16	52.28	0.95	0.42	0.85
CD at 5%	20.91	152.61	2.78	1.22	2.47
C.V. %	18.56	13.59	8.42	5.19	7.18

4.2 Effect of paclobutrazol on fruits set and yield

The influence of paclobutrazol on fruit set, fruit weight and fruit characters are presented in Tables 2 and 3.

4.2.1 Number of fruits set per panicle

All the paclobutrazol treatments were effective in increasing the number of fruits set per panicle over control (Table 2, Fig. 1). Soil drenching treatments resulted in higher fruit set as compared to foliar sprays, but in untreated trees it was the least (10.42). A maximum of 24.31 and 24.15 fruits were set, when the trees were soil drenched with paclobutrazol at 8 and 10 g a.i. per tree respectively. Similarly, foliar sprays of paclobutrazol at 10g a.i. per tree resulted in the maximum number of fruits set per panicle (23.97).

4.2.2 Average weight of fruit

With respect to the fresh weight of fruits, foliar sprays of paclobutrazol resulted in the production of larger fruits as compared to soil drenching treatments (Table 2). The maximum fruit weight of 275.15g was recorded from trees that were sprayed with 4g a.i paclobutrazol per tree and this was followed by 6g a.i. per tree (268.84g).

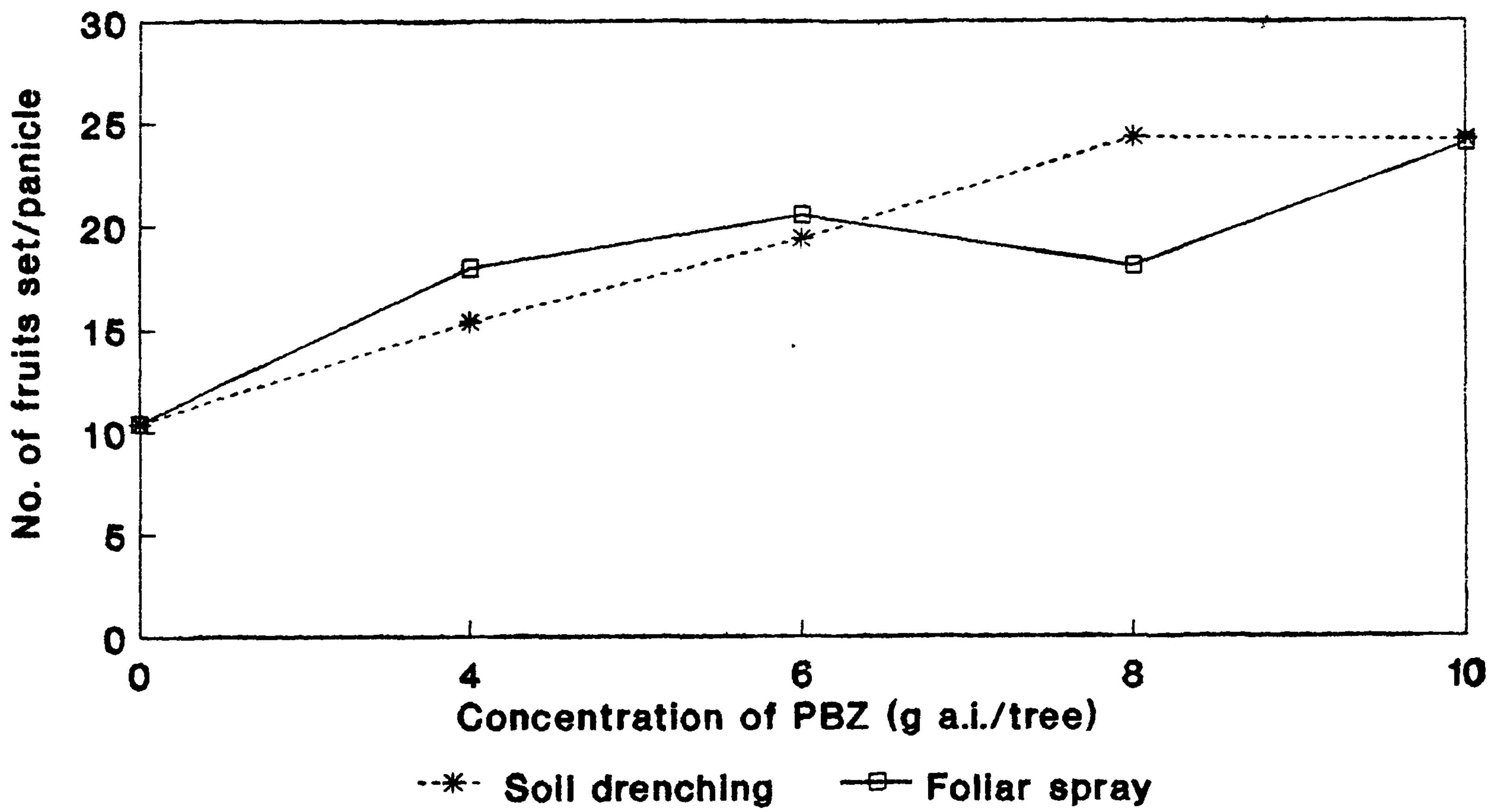

Fig.1. Effect of paclobutrazol on number of fruits set per panicle in mango cv. Alphonso

4.2.3 Number of fruits per tree

Soil drenching as well as foliar sprays of paclobutrazol increased significantly the number of fruits produced per tree, in comparison to control trees (Table 2, Fig. 2). Here, soil drenching was very effective at 8g a.i. per tree (300 fruits per tree) and was followed by 10g a.i. per tree (270 fruits per tree). Among the foliar spray treatments, paclobutrazol at 10g a.i. per tree produced the maximum number of fruits (255); untreated trees produced the least number of fruits (9.75) (Plate 1 to 9).

4.2.4 Fruit yield - weight of fruits per tree

All the paclobutrazol treatments resulted in a significant increase in fruit yield per tree (on weight basis) when compared to control trees (Table 2, Fig. 3). As with fruit numbers, soil drenching was more effective than foliar sprays. Soil drenching with paclobutrazol at 8 g a.i. per tree resulted in the highest fruit yield (66.70 Kg fruits per tree) and foliar sprays of paclobutrazol at 10g a.i. per tree were also effective (61.41 kg per tree). But in untreated trees, the fruit yield was the lowest (2.49 Kg per tree).

Table 2. Fruits set and yield of Alphonso mango trees as influenced by application of paclobutrazol

Treatments	No. of fruits set/ panicle	Average fruit weight (raw)g	Fruit yield	
			Number/ tree	kg/ tree
Soil drenching with PBZ				
4g a.i./tree	15.34	234.99	241.00	41.18
6g a.i./tree	19.38	216.90	239.50	51.73
8g a.i./tree	24.31	222.51	300.75	66.70
10g a.i./tree	24.15	248.93	270.00	65.52
Foliar spray of PBZ				
4g a.i./tree	18.00	275.15	191.00	52.72
6g a.i./tree	20.53	268.84	196.75	52.84
8g a.i./tree	18.08	263.07	94.00	24.51
10g a.i./tree	23.97	242.33	255.00	61.41
Control	10.42	254.16	9.75	2.49
SEm$\pm$	2.09	12.17	30.22	7.13
CD at 5%	6.11	35.54	88.21	20.83
C.V. %	21.64	9.84	30.25	17.23

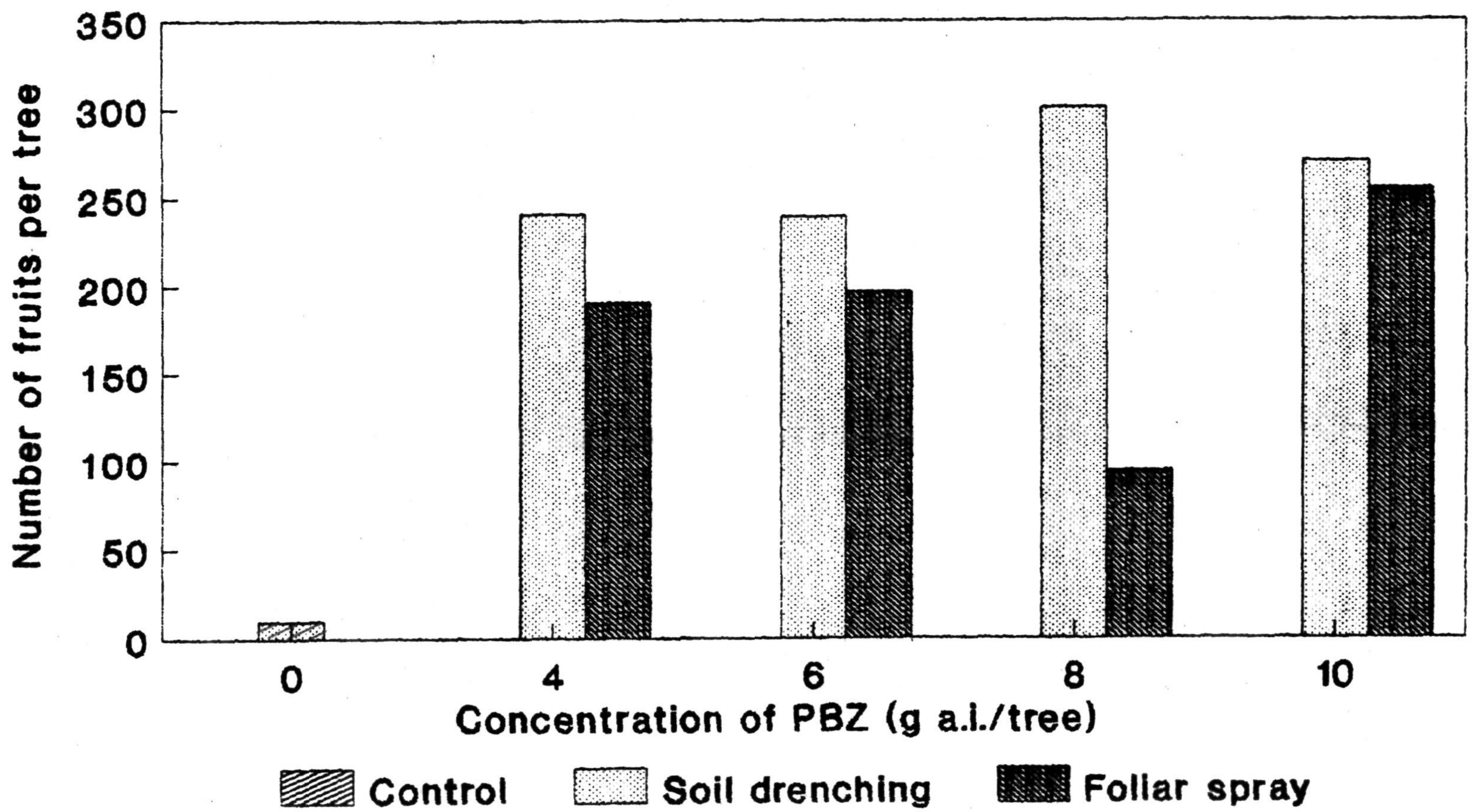

Fig.2. Effect of paclobutrazol on number of fruits produced per tree in Alphonso mango

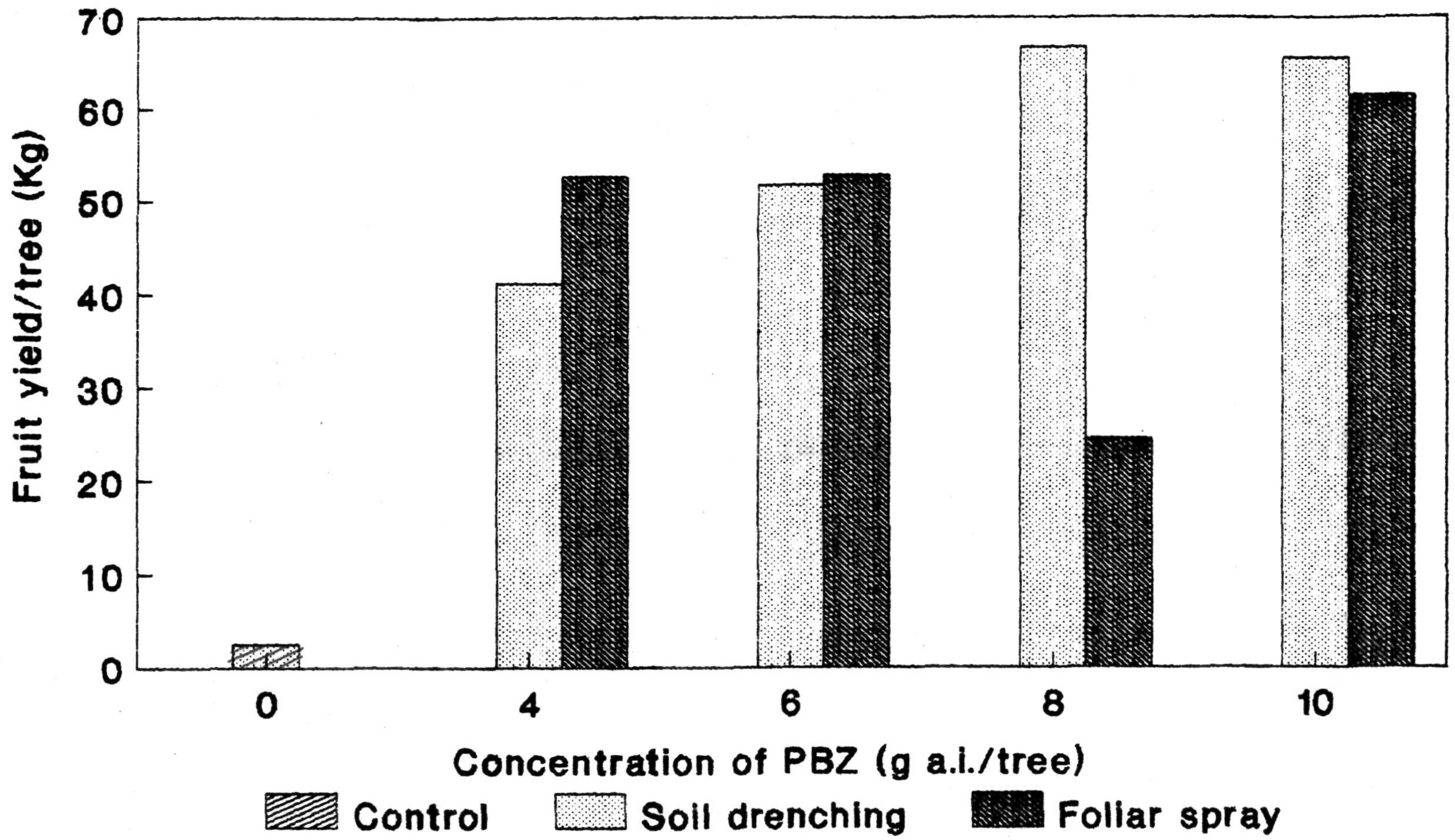

Fig.3. Influence of paclobutrazol on fruit yield/tree of Alphonso mango

PLATE 4. Fruit yield in Alphonso mango tree as affected by soil application of paclobutrazol at 10g a.i. per tree

PLATE 5. Effect of foliar spray of paclobutrazol at 4g a.i. per tree in mango cv. Alphonso

PLATE 6. Influence of paclobutrazol (foliar spray) at 6g a.i. per tree in mango cv. Alphonso


PLATE 1


PLATE 2


PLATE 3

PLATE 1. Effect of soil drenching with paclobutrazol at 4g a.i. per tree in mango cv. Alphonso

PLATE 2. Influence of paclobutrazol (Soil drenching) at 6g a.i. per tree in mango cv. Alphonso

PLATE 3. Regulation of fruiting in Alphonso tree as influenced by soil application of paclobutrazol (8g a.i. per tree)

PLATE 4

PLATE 5

PLATE 6

PLATE 7. Regulation of fruiting in Alphonso tree as influenced by foliar spray of paclobutrazol at 8g a.i. per tree

PLATE 8. Fruit yield in Alphonso mango tree as affected by foliar spray of paclobutrazol at 10g a.i. per tree

PLATE 9. Control (untreated) Alphonso mango tree

PLATE 7

PLATE 8

PLATE 9

4.2.5 lenth of the fruit

4.2.5 Length of the fruit

With respect to the length of the mature fruits, there were significant differences between paclobutrazol treated trees and untreated trees (Table 3). Although differences in fruit length between the various paclobutrazol treatments was minimal, longer fruits of 9.23 cm were produced when trees were sprayed with paclobutrazol at 4 g a.i. per tree, but fruits from trees sprayed with 8g a.i. per tree of paclobutrazol were not very different (9.13 cm).

4.2.6 Breadth of the fruit

The distance between the two cheeks which represents the breadth of fruit was the highest, in trees sprayed with 4g a.i. of paclobutrazol per tree (7.66 cm) and was closely followed by 6g a.i. paclobutrazol (7.62cm). The breadth of fruits was the lowest in 6g a.i. paclobutrazol (7.05 cm) treated trees (soil drenching). All the paclobutrazol soil drench treatments decreased fruit breadth in comparison to control; this reduction, however, was not statistically significant.

4.2.7 Thickness of fruit

It is clear from Table 3 that there were no significant differences between the different paclobutrazol treatments, with reference to the thickness of the fruit. However, the maximum thickness (7.35 cm) was recorded in the 4g a.i. foliar spray treatment as against 7.08cm in control trees. All the soil drenching paclobutrazol treatments produced thinner fruits as compared to control.

4.2.8 Volume of fruit

Volume of the fruit again was not influenced . significantly by any of the paclobutrazol treatments (Table 3). However, the maximum fruit volume was recorded in trees which were sprayed with 4g a.i. per tree (236.37 ml). Trees that received different concentrations of paclobutrazol through soil drenching produced fruits of smaller size (volume) than control (222.19 ml).

4.2.9 Specific gravity of fruit

Paclobutrazol applied through soil drenching and foliar sprays, at different concentrations, did not influence the specific gravity of fruits (Table 3). In all the treatments the specific gravity of fruits was more than one, and it was highest in control (1.18) and least in trees which were sprayed with paclobutrazol at 6 g a.i. per tree (1.12). Further, negligible

Table 3. Effect of paclobutrazol on the physical characters of mango fruits cv. Alphonso

Treatments	Length (cm)	Breadth (cm)	Thickness (cm)	Volume (ml)	Specific gravity
Soil drenching with PBZ					
4g a.i./tree	8.44	7.35	6.95	204.68	1.16
6g a.i./tree	8.37	7.05	6.91	186.90	1.16
8g a.i./tree	8.32	7.22	6.84	192.29	1.17
10g a.i./tree	8.82	7.49	7.07	220.62	1.16
Foliar spray of PBZ					
4g a.i./tree	9.23	7.66	7.35	236.37	1.14
6g a.i./tree	9.07	7.62	7.31	227.86	1.12
8g a.i./tree	9.13	7.61	7.21	231.51	1.16
10g a.i./tree	8.79	7.33	7.01	211.07	1.15
Control	9.06	7.52	7.08	222.19	1.18
SEm±	0.21	0.12	0.15	12.45	0.04
CD at 5%	0.62	0.36	NS	NS	NS
C.V. %	4.81	3.33	4.32	11.59	7.04

differences in specific gravity were observed among the paclobutrazol treatments.

4.3 Effect of paclobutrazol on ripe weight and physical composition of mango fruits

4.3.1 Ripe weight of fruits

The average weight of ripe fruits from untreated trees was 211.56 g. Compared to control, foliar sprays of paclobutrazol resulted in the production of large sized fruits except at highest concentration (10g a.i. per tree). The maximum ripe weight of 230.77g per fruit was recorded in the trees that were sprayed with 4 g a.i. of paclobutrazol per tree followed by 6 g a.i.per tree (226.22g). Soil drenching of paclobutrazol (10g a.i. per tree) resulted in higher fruit weight (ripe) (216.49g) as compared to fruits from untreated trees (Table 4). Decrease in fruit weight over control was noticed when trees were soil drenched with paclobutrazol both at 6 and 8g a.i. per tree.

4.3.2 Pulp weight of fruits

Soil drenching as well as foliar spray treatments resulted in a significant increase in pulp weight of Alphonso mango (Table 4). The highest pulp weight of 161.62g was recorded in trees sprayed with 6 g a.i of paclobutrazol and this treatment was followed by 8g a.i. per tree (156.10g). However, soil drenching with paclobutrazol at 6 as well as 8 g a.i. per tree resulted in lower pulp weights (127.27g and 130.09g respectively) as compared to untreated trees (134.75g).

4.3.3 Pulp recovery

All the paclobutrazol treatments increased in the pulp recovery from fruits as compared to control (Table 4). The highest pulp recovery of 71.46 per cent was recorded in fruits from trees sprayed with 6 g a.i of paclobutrazol and this was followed by 4g a.i.treatment (70.67 per cent) and 10g a.i. per tree (70.57 per cent) through soil drench. But fruits from untreated Alphonso trees yielded the least pulp recovery (63.77 per cent).

4.3.4 Peel weight of fruits

There were no significant differences in the peel weight of fruits from trees treated with paclobutrazol at various concentrations (Table 4). However, soil drenching with paclobutrazol at lower concentrations (4g a.i. per tree) resulted in fruits with less peel content (14.56 per cent). From among foliar spray of paclobutrazol, only at 6g a.i.per tree resulted in least peel weight (15.46 per cent) where as other

Table 4. Effect of paclobutrazol on the physical composition and pulp recovery in mango fruits cv. Alphonso

Treatments	Average fruit weight (ripe) g	Pulp* weight (g)	Peel** weight (g)	Stone*** weight (g)
Soil drenching with PBZ				
4g a.i./tree	203.52	144.32 (70.67)	29.63 (14.56)	28.72 (14.11)
6g a.i./tree	191.05	127.27 (66.60)	31.76 (16.64)	31.06 (16.26)
8g a.i./tree	191.02	130.09 (68.17)	31.19 (16.33)	29.55 (15.47)
10g a.i./tree	216.49	153.23 (70.57)	34.64 (16.00)	29.55 (13.65)
Foliar spray of PBZ				
4g a.i./tree	230.77	153.37 (66.74)	38.59 (16.72)	33.31 (14.43)
6g a.i./tree	226.22	161.62 (71.46)	34.97 (15.46)	29.58 (13.07)
8g a.i./tree	224.92	156.10 (69.30)	38.14 (16.96)	30.69 (13.64)
10g a.i./tree	202.77	141.64 (69.48)	32.50 (16.03)	27.38 (14.49)
Control	211.56	134.75 (63.77)	34.14 (16.14)	29.39 (13.89)
SEm$\pm$	9.44	7.38	2.20	1.58
CD at 5%	27.57	21.54	NS	NS
C.V. %	8.95	10.20	12.77	10.62

* Figures in parentheses represents the pulp recovery
** Figures in parentheses represents per cent weight of peel to total fruit weight
*** Figures in parentheses represents stone weight to total fruit weight

concentrations of paclobutrazol with respect to peel content were on par with control trees.

4.3.5 Stone weight of fruits

Stone weight was not influenced significantly by any of the paclobutrazol treatments (Table 4) the least stone weight (13.07 per cent) was observed when the trees were sprayed with 6g a.i.per tree followed by soil drenching at 10g (13.65 per cent). Rest of the paclobutrazol treatments have not yielded encouraging results.

4.4 Effect of paclobutrazol on chemical composition of mango fruit

4.4.1 Total soluble solids

The data on the total soluble solids content of ripe Alphonso mango fruits as influenced by paclobutrazol are presented in Table 5. The total soluble solids content was not significantly influenced by any of treatments. The highest TSS value was recorded in the case of soil application of paclobutrazol at 6g a.i. per tree (16.53^{o}B). Although the TSS content of fruits was enhanced by most of the paclobutrazol treatments, differences in TSS content between treated and untreated fruits were small and failed to achieve any statistical significance.

4.4.2 Titratable acidity

There was a significant difference in the titratable acidity of Alphonso mango fruits when the trees were sprayed or soil drenched with paclobutrazol (Table 5). Although a slightly lower level of titratable acidity (0.25 per cent) was recorded in fruits from trees soil drenched with paclobutrazol at 8 g a.i. per tree, it was statistically on par with titratable acidity of fruits from control trees (0.26 per cent) or when the trees were sprayed with 4 and 10 g a.i. of paclobutrazol per tree. The titratable acidity of the pulp was the highest when the trees were sprayed (6g a.i. per tree) or soil drenched with paclobutrazol at 10 g a.i. per tree (0.39 and 0.36 per cent, respectively).

4.4.3 Sugar acid ratio

Significant differences were observed between the paclobutrazol treated and control trees for the sugar acid ratio of the fruits (Table 5, Fig. 4). Soil drenching with paclobutrazol at 6g a.i. per tree recorded a highest sugar-acid ratio of 62.74 and was followed by 8g a.i. per tree (59.35). Similarly, from

Table 5. Fruit quality of Alphonso mango as influenced by application of paclobutrazol

Treatments	TSS (^{o}B)	Titratable acidity (% citric acid)	TSS/acid ratio
Soil drenching with PBZ			
4g a.i./tree	15.45	0.34	45.95
6g a.i./tree	16.53	0.27	62.74
8g a.i./tree	15.01	0.25	59.35
10g a.i./tree	15.35	0.36	46.20
Foliar spray of PBZ			
4g a.i./tree	14.79	0.26	57.18
6g a.i./tree	15.73	0.39	40.31
8g a.i./tree	14.89	0.31	49.26
10g a.i./tree	13.63	0.26	52.86
Control	14.01	0.26	53.49
SEm±	0.67	0.02	4.59
CD at 5%	**NS**	0.08	13.43
C.V. %	8.98	18.88	17.71

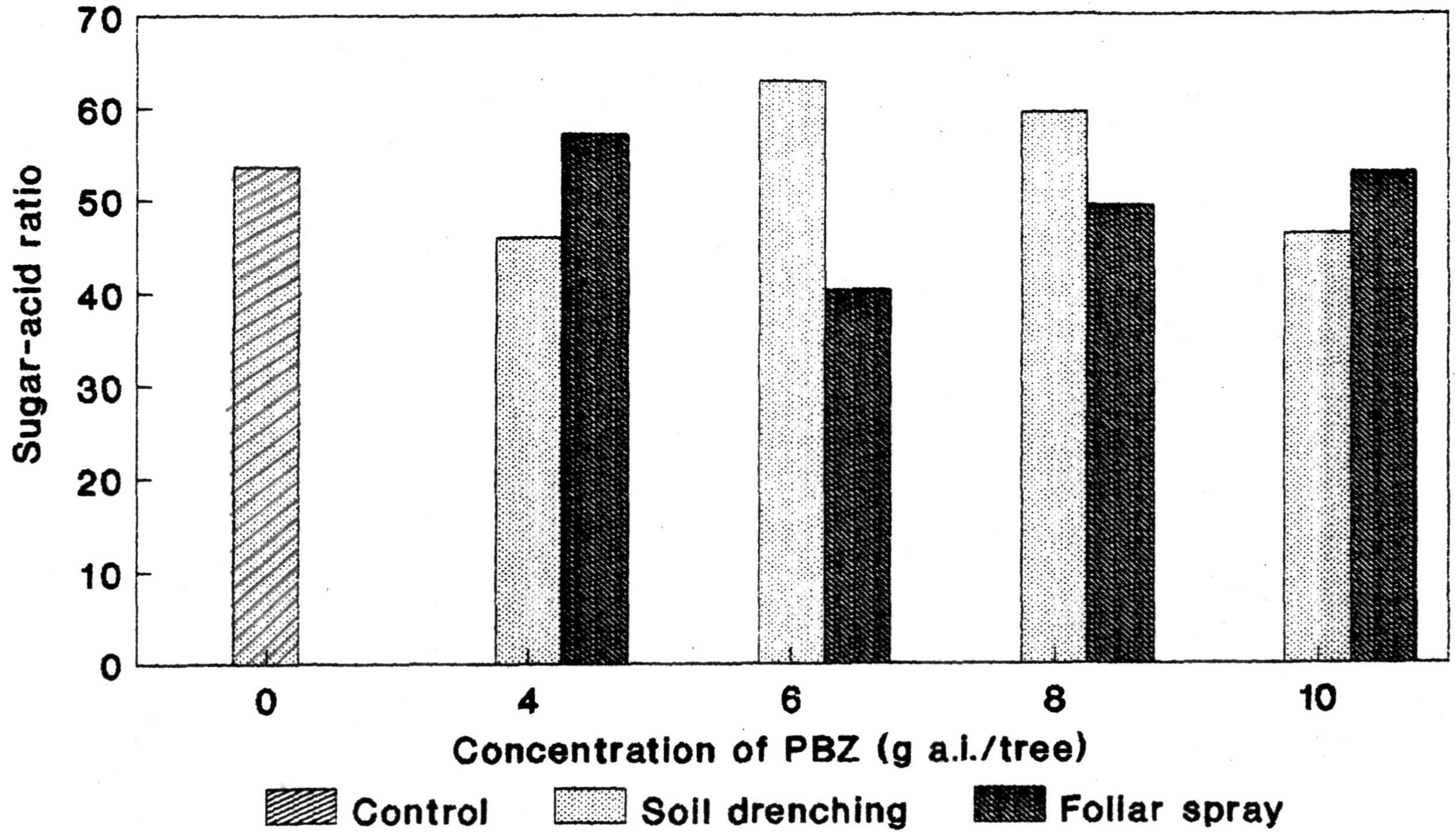

Fig.4. Influence of paclobutrazol on sugar-acid ratio of Alphonso mango pulp

among the foliar sprays of paclobutrazol, 4g a.i. per tree recorded the highest sugar-acid ratio (57.18); fruits from control trees recorded 53.49. But foliar sprays of paclobutrazol at 6 and 8g a.i. per tree resulted in fruits with very low TSS/acid ratios (40.31 and 49.26, respectively).

4.4.4 Total sugar

All the treatments were statistically on par with control with respect to the total sugar content of fruits, but a reduction in the total sugar level was evident with higher concentrations of paclobutrazol (Table 6). The highest total sugar content of 13.92 per cent was noticed when the trees were soil drenched or sprayed with paclobutrazol at 4g a.i. per tree. Further, increase in paclobutrazol concentrations resulted in a decline in the sugar content. The least total sugar of 12.29 per cent was noticed when the trees were soil drenched with paclobutrazol at 10g; fruits from untreated trees recorded 13.57 per cent sugar.

4.4.5 Reducing sugars

The data regarding reducing sugars are presented in Table 6. All the paclobutrazol treatments were on par with control although the highest reducing sugar of 2.90

per cent was recorded when the trees were sprayed with paclobutrazol at 6g a.i. per tree; this value however was not statistically higher than control. The other paclobutrazol treatments resulted in a reduction in the reducing sugar content of the fruits.

4.4.6 Non-reducing sugars

All the paclobutrazol treatments were on par with control with respect to the non-reducing sugar content of fruits (Table 6). Non-reducing sugar values of more than 11 per cent were recorded when Alphonso trees were soil drenched or sprayed with paclobutrazol at 4g a.i. per tree. Increasing the paclobutrazol concentration resulted in lowering of the non-reducing sugar content. The least non-reducing sugar of 9.61 was recorded in trees that were soil drenched with paclobutrazol at 10g a.i. per tree.

4.5 Effect of paclobutrazol on post-harvest behaviour of mango fruit

4.5.1 Number of days taken for ripening

Soil drenching and foliar sprays of paclobutrazol at different concentrations applied to Alphonso mango trees revealed that there was a significant increase in the number of days taken for fruits to ripen, with an

Table 6. Effect of paclobutrazol on total,reducing and non-reducing sugar content of mango fruits cv. Alphonso

Treatments	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
Soil drenching with PBZ			
4g a.i./tree	13.92	2.78	11.14
6g a.i./tree	13.22	2.72	10.49
8g a.i./tree	12.77	2.60	10.16
10g a.i./tree	12.29	2.69	9.61
Foliar spray of PBZ			
4g a.i./tree	13.91	2.79	11.11
6g a.i./tree	13.44	2.90	10.54
8g a.i./tree	13.17	2.75	10.42
10g a.i./tree	12.45	2.65	9.80
Control	13.57	2.90	10.67
SEm±	0.15	0.05	0.13
CD at 5%	0.45	0.17	0.39
C.V. %	2.36	4.26	2.60

increase in the concentration of paclobutrazol. The highest concentration of paclobutrazol (10g a.i. per tree) either through soil drench or through foliar spray delayed the ripening of fruits by nearly five days in comparison to control (Table 7, Fig. 5).

4.5.2 Physiological loss in weight

There was a significant difference in the physiological loss in weight of Alphonso mango fruit when the trees were treated with paclobutrazol either through soil drench or through foliar spray. Further, it is also evident from Table 7 that the least loss in weight (PLW) of 11.80 per cent was observed when trees were soil drenched with paclobutrazol at 6g a.i. per tree. The highest physiological loss in weight of 19.70 per cent was observed in control fruits.

4.5.3 Firmness of fruit

The data on the effect of paclobutrazol on firmness of ripe fruits presented in Table 7 indicates that there was a significant increase in the firmness of fruit. The highest firmness of 2.17 kg/cm^2 when mango trees were sprayed with paclobutrazol at 10g a.i. per tree. Fruits from untreated tree recorded a loss in firmness value of 0.79 kg/cm^2. It also evident from Fig. 6 that

Table 7. Postharvest behaviour of Alphonso mango fruits as influenced by application of paclobutrazol

Treatments	Number of days taken for ripen-ing	Physiological loss in weight (%)	Firmness of fruit (kg/cm^2)
Soil drenching with PBZ			
4g a.i./tree	12.70	12.78	1.08
6g a.i./tree	13.49	11.80	1.90
8g a.i./tree	14.01	12.17	2.00
10g a.i./tree	14.65	12.89	2.15
Foliar spray of PBZ			
4g a.i./tree	13.27	14.37	1.00
6g a.i./tree	13.65	11.89	1.62
8g a.i./tree	14.36	15.34	1.93
10g a.i./tree	15.35	15.09	2.17
Control	10.90	19.70	0.79
SEm±	0.26	1.57	0.03
CD at 5%	0.76	4.59	0.09
C.V. %	3.85	22.46	4.12

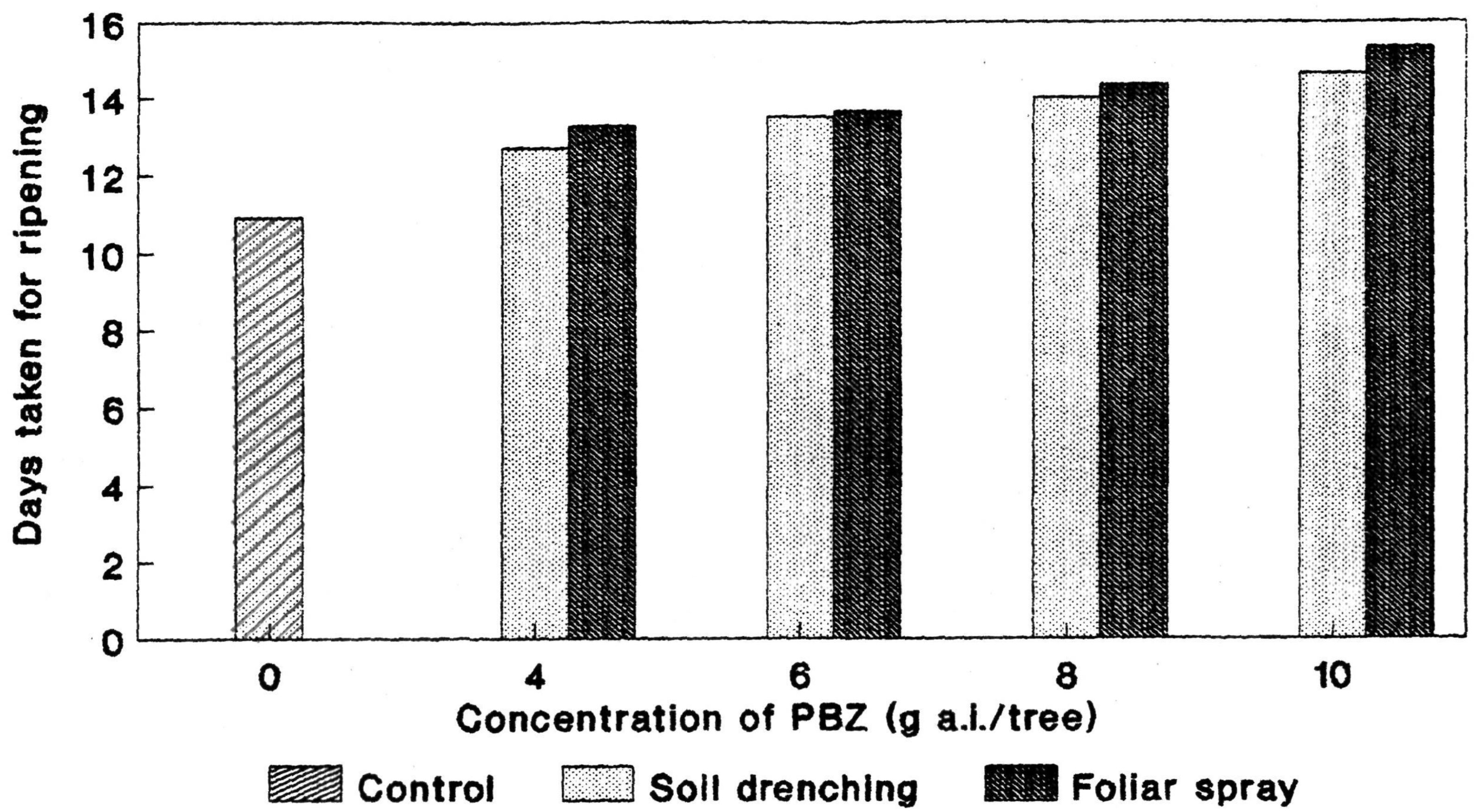

Fig.5. Effect of paclobutrazol on number of days taken for ripening in Alphonso mango fruits

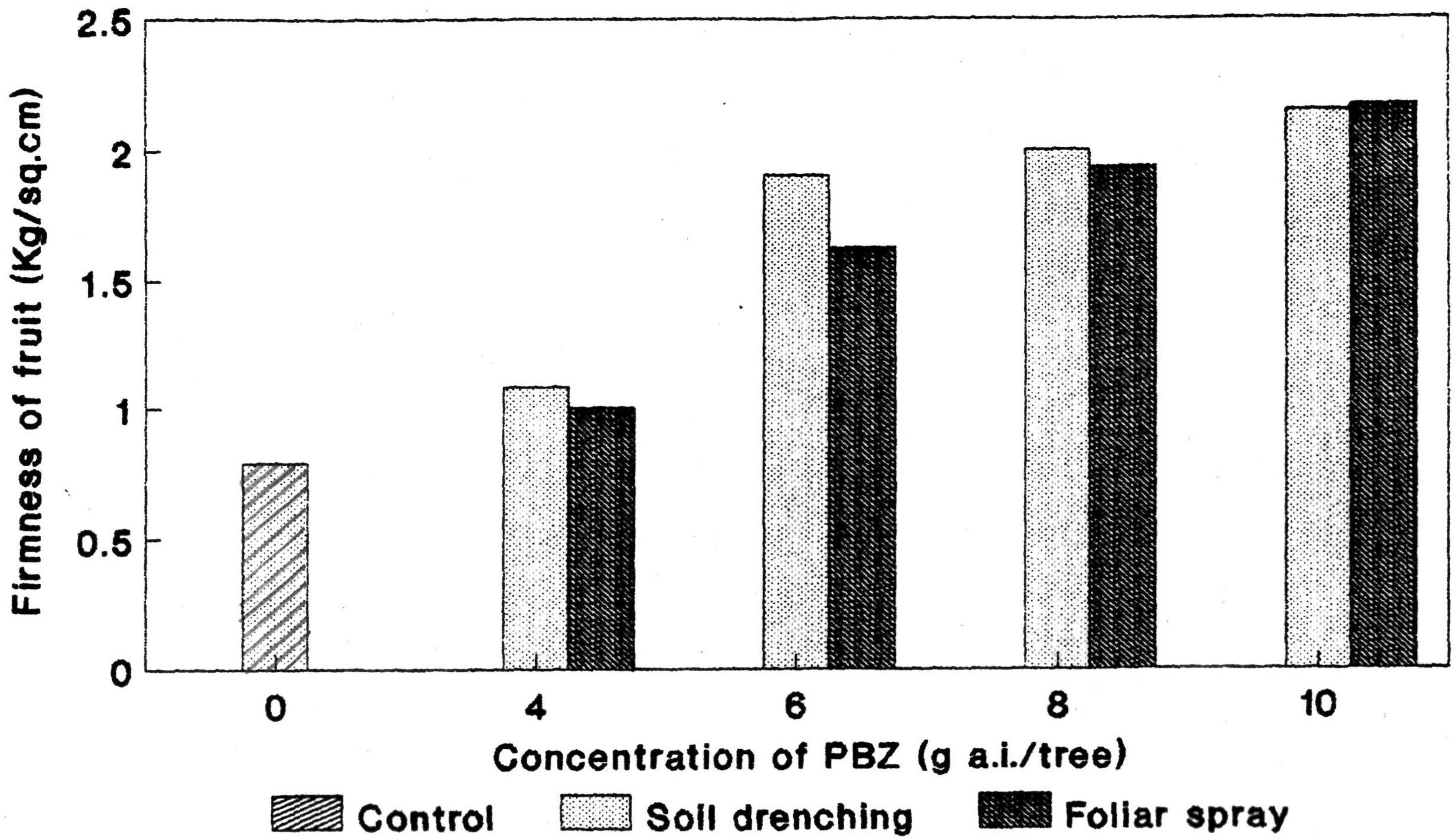

Fig.6. Effect of paclobutrazol on firmness of Alphonso mango fruits

an increase in the concentration of paclobutrazol resulted in the significant increase in firmness of fruits.

4.5.4 Incidence of spongy tissue

There was a reduction in the incidence of spongy tissue with the paclobutrazol treatments (Table 8). Soil drenching of paclobutrazol at 10g a.i. per tree recorded the least incidence of spongy tissue (24.93 per cent) and was followed by (28.50 per cent) 8g a.i. of paclobutrazol when aplied either through soil drench or foliar sprays. Another important findings from the soil drenching of paclobutrazol to mango trees is that with the increase in the concentration of paclobutrazol the incidence of spongy tissue decreased in Alphonso fruits. Untreated trees produced the highest incidence of spongy tissue (67.83 per cent) as compared to all the paclobutrazol treatments (Fig. 7).

4.5.5 Extent of spongy tissue

All the paclobutrazol treatments significantly reduced the extent of spongy tissue when trees were sprayed or soil drenched with paclobutrazol (Table 8). With an increase in the concentration of paclobutrazol, there was a decrease in the extent of spongy tissue.

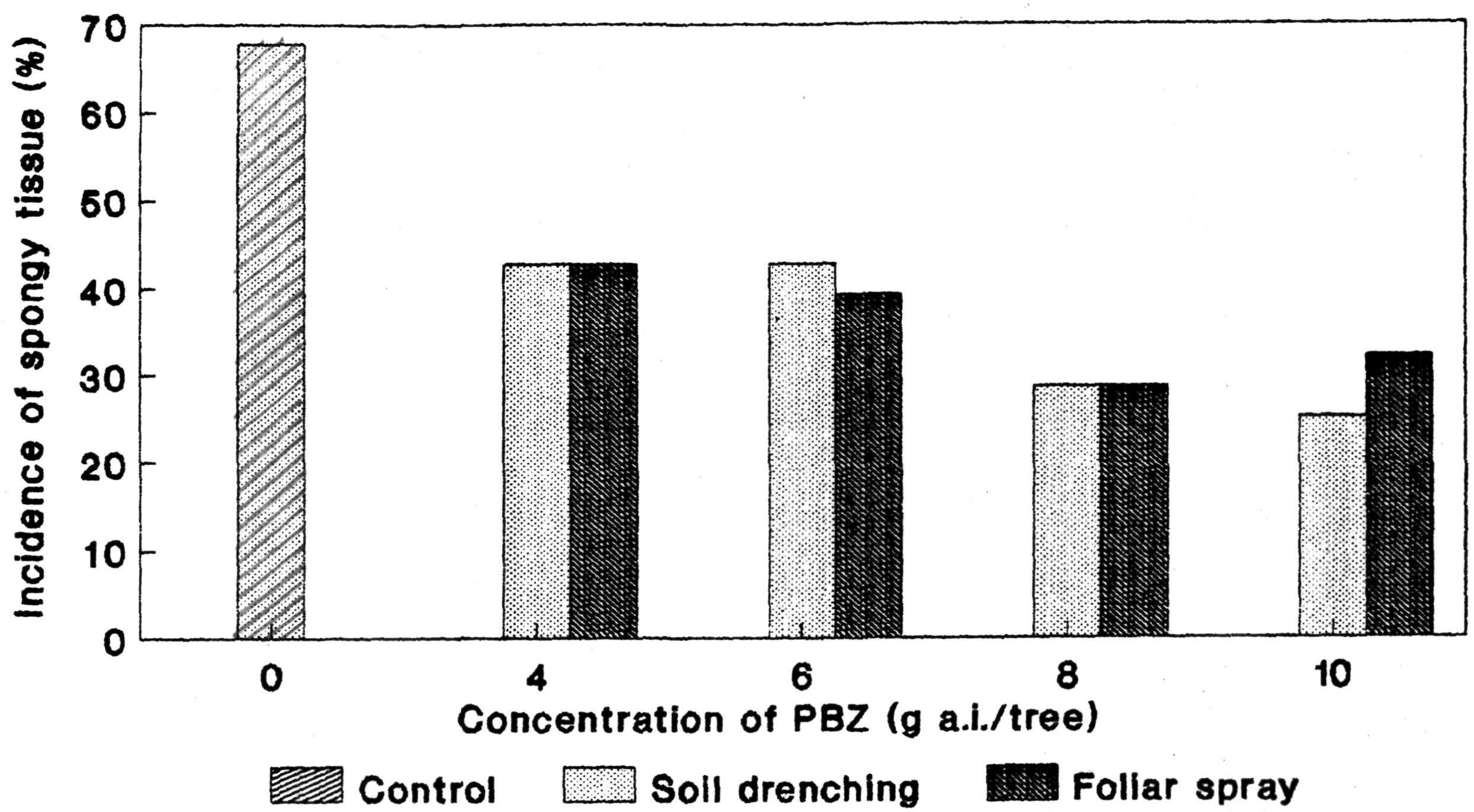

Fig.7. Effect of paclobutrazol on incidence of spongy tissue disorder in ripe Alphonso mango fruits

Both foliar sprays and soil drenching of paclobutrazol at 10g a.i. per tree reduced significantly the extent of spongy tissue (1.48 and 2.07 score out of 10 respectively). Fruits from control trees on the other hand exhibited the maximum extent of spongy tissue (6.24 score out of 10).

4.5.6 Incidence of stem end rot

The incidence of stem end rot was maximum in fruits from untreated trees (28.50 per cent). The least incidence of stem end rot of 17.83 per cent was recorded when the trees were either sprayed (6g a.i. per tree) or soil drenched (8g a.i. per tree) with paclobutrazol (Table 8).

4.6 Effect of paclobutrazol on organoleptic qualities of ripe Alphonso mango fruits

Organoleptic evaluation was done to assess the quality of Alphonso fruits from different treatments for quality attributes such as colour, taste, aroma, texture and firmness of pulp etc. The scores obtained for the quality parameters are presented in Table 9 (Plate 10 and 11).

Table 8. Effect of paclobutrazol on the incidence of spongy tissue and stem end rot disease in ripe Alphonso mango fruits

Treatments	Spongy tissue		Incidence of stem end rot (%)
	Incidence (%)	Extent (for 10 score)	
Soil drenching with PBZ			
4g a.i./tree	42.80	3.76	21.39
6g a.i./tree	42.80	3.19	21.39
8g a.i./tree	28.50	2.33	17.83
10g a.i./tree	24.93	2.07	21.39
Foliar spray of PBZ			
4g a.i./tree	42.80	3.80	22.83
6g a.i./tree	39.23	3.80	17.83
8g a.i./tree	28.50	2.95	24.94
10g a.i./tree	32.07	1.48	21.41
Control	67.83	6.24	28.50
SEm±	0.04	0.29	4.94
CD at 5%	0.14	0.85	NS
C.V. %	25.55	17.74	45.04

4.6.1 Fruit colour

It is clear from Table 9 that there were no significant differences among the paclobutrazol treatments. Soil application of paclobutrazol (4g a.i. per tree) resulted in a good coloration whereas fruits from control trees were rated to be poor in their colour.

4.6.2 Pulp colour

There were no significant differences for pulp colour between paclobutrazol treated and untreated fruits (Table 9). Good pulp colour was observed when trees were soil drenched with paclobutrazol (10g a.i. per tree). On the other hand poor pulp colour was noticed when the trees were soil drench with paclobutrazol (6g a.i. per tree). Foliar sprays of paclobutrazol at various concentration were not different from control with respect to pulp colour.

4.6.3 Pulp taste

The taste of Alphonso pulp was not adversely affected by any of the paclobutrazol treatments. On the other hand the scores obtained for pulp taste were higher for fruits from paclobutrazol treated trees in comparison to fruits from untreated trees. Spraying paclobutrazol at either 4 or 6 g a.i. per tree were the best treatments.

4.6.4 Pulp aroma

Although paclobutrazol treated fruits were rated better by the judges than fruits from untreated trees for pulp aroma, such differences failed to acheive statistical significance. Paclobutrazol applied through soil drenches or through foliar sprays, thus was not detrimental with regard to the pulp aroma.

4.6.5 Pulp texture

As with pulp aroma, fruits from trees treated with paclobutrazol were better than those from control trees, but statistically, such differences were not significant. The ratings for pulp texture of paclobutrazol treated fruits, evaluated by the panel of judges, were generally 5 to 10 per cent higher than that for untreated fruits, depending on the paclobutrazol treatments.

4.6.6 Pulp firmness

There appeared to be no promotive influence of paclobutrazol on fruit firmness, recorded when the fruits had reached the edible ripe stage. The increase

Table 9. Organoleptic evaluation of Alphonso mango fruits from paclobutrazol treated trees

Treatments	Fruit colour	Pulp colour	Pulp taste	Aroma of pulp	Texture of pulp	Firmness of pulp
Soil drenching with PBZ						
4g a.i./tree	7.12	7.06	6.85	6.56	6.85	6.79
6g a.i./tree	6.78	6.93	7.24	6.89	7.18	7.06
8g a.i./tree	6.72	7.37	7.08	6.93	7.18	7.01
10g a.i./tree	7.02	8.01	7.18	7.20	7.02	6.97
Foliar spray of PBZ						
4g a.i./tree	6.93	7.50	7.75	7.00	6.68	6.47
6g a.i./tree	6.45	7.64	7.77	7.50	7.20	6.95
8g a.i./tree	7.04	7.43	6.68	6.66	6.81	6.55
10g a.i./tree	6.45	7.89	6.62	7.43	7.31	7.43
Control	5.95	7.16	6.37	6.31	6.51	6.45
SEm±	0.34	0.40	0.33	0.34	0.25	0.31
CD at 5%	NS	NS	NS	NS	NS	NS
C.V. %	10.29	10.98	9.50	10.04	7.44	9.18

PLATE 10. Soil drenching of paclobutrazol at 4,6,8 and 10g a.i. per tree on fruit quality in mango cv. Alphonso

PLATE 11. Foliar spray of paclobutrazol at 4,6,8 and 10g a.i. per tree on fruit quality in mango cv. Alphonso

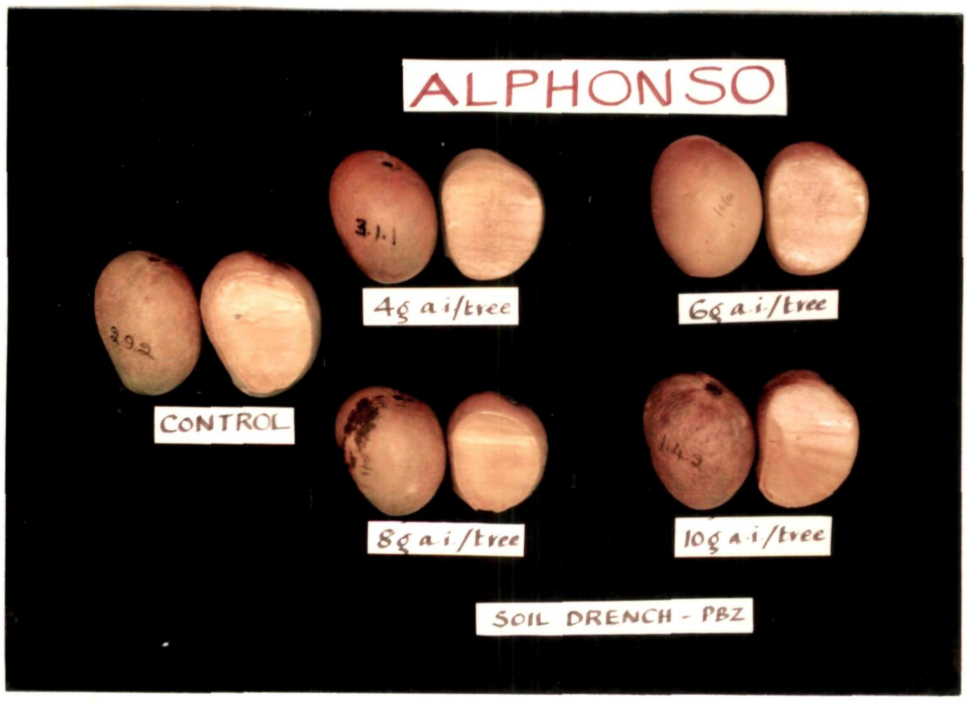

PLATE 10

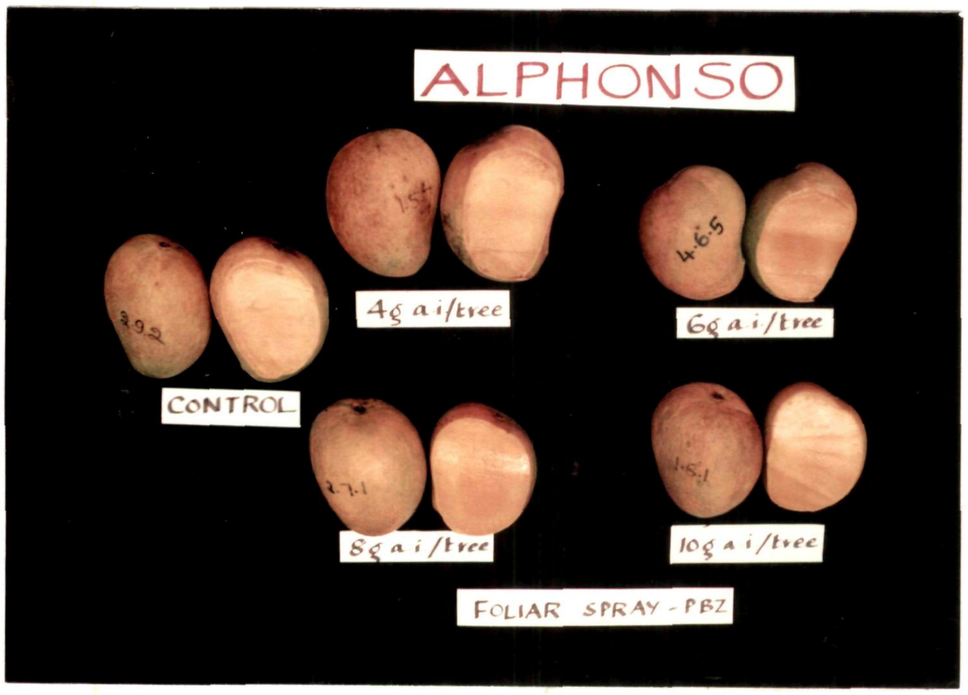

PLATE 11

in pulp firmness of fruits from paclobutrazol treated trees was not statistically different from that of fruits from untreated trees. Among the paclobutrazol treatments tried in the study, foliar sprays of 10g a.i. per tree appeared to have the greatest influence on pulp firmness (15 per cent increase over control).

DISCUSSION

V. DISCUSSION

The present study was conducted with the objective of determining the influence of paclobutrazol (PP333), a potent gibberellin biosynthesis inhibitor, on flowering, fruit yield and fruit quality of Alphonso mango, a variety known to bear in alternate years. The results of the study are discussed here, in this chapter in the light of present findings and other relevant reports in the literature.

5.1 Influence of paclobutrazol on flowering and fruit set

Paclobutrazol application both as soil drenches and as foliar sprays brought about flowering in trees that were expected to produce no crop in the year of treatment induction. Soil drenching of paclobutrazol at 8g a.i. per tree resulted in the maximum number of panicles produced per square metre area of the canopy as well as panicles per tree; foliar sprays of paclobutrazol at 10g a.i. per tree was also equally effective. When the total number of panicles produced per tree was considered, soil drenching treatments were slightly superior than foliar sprays of paclobutrazol. The promotive influence of paclobutrazol on flowering has been well documented in the literature not only with respect to mango (Kulkarni, 1988; Tongumpai et al., 1989; Tongumpai et al., 1991; Charnivichit and Tongumpai, 1991; Vuillaume, 1991; Winston, 1992 and Kurian and Iyer, 1993a) but also in several other fruit crops like apple (Buban, 1986), plum (Williams, 1984), peach (Erez, 1986) etc. Even from Maharastra (India) profuse flowering in Alphonso mango was observed during 'off' year by the application of paclobutrazol (Burondkar and Gunjate, 1991). This effect of paclobutrazol on flowering is generally thought to be the result of its inhibitory influence on biosynthesis of gibberellins. Paclobutrazol the growth retardant is known to be effective in inhibiting the gibberellin biosynthesis in plants by blocking the conversion of kaurene to kaurenoic acid (Voon et al., 1989). Thus in many fruit crops where gibberellins are inhibitory to flowering, paclobutrazol has been found to bring about flower induction. In mango particularly it has been demonstrated that higher GA_3 levels are antagonistic to the formation of flower primordia and that low levels of endogenous gibberellins but with higher levels of auxins favour flower bud formation; exogenous application of GA_3 inhibits flowering in mango (Kachru et al., 1971). It has long been recognized that flowering in mango is generally associated with reduced vegetative growth often induced by moisture stress. Paclobutrazol thus reduces the endogenous gibberellin level which is a prerequisite for flower initiation. Whether paclobutrazol influences flowering by any other mechanism is not known since flowering in mango itself is very complex, and a rather poorly understood phenomenon (Chacko, 1991). Since the hormonal concept of flowering in mango assumes the cyclic synthesis of a floral stimulus in the leaves it has been hypothesised that paclobutrazol may promote flowering by influencing the synthesis of this floral stimulus (Kulkarni, 1988). Evidence for a such a floral stimulus is however yet to come. But if the ratio between growth promoters and inhibitors is important for flowering, paclobutrazol reduces the level of the flower inhibitor (gibberellins) so that the proper ratio of promoters to inhibitors for flower induction is reached.

The method of paclobutrazol application is known to influence significantly the response it is expected to produce. Uptake and movement studies have shown that root uptake of paclobutrazol can be an efficient method by which a constant supply of the chemical can be maintained to the growing apex in the plant. But Lever

(1985) has rightly pointed out that tree size, rooting pattern, water and chemical distribution in the soil and soil physical properties may alter the suitability of this method of application. Several trials have been conducted in the past particularly in temperate fruit crops like apple, peach, etc. to determine the most efficient method of paclobutrazol application for tree size control (Williams, 1984; Quinlan and Richardson, 1984). With mango, however, little information is available on this aspect. For instance, Kulkarni (1988) concluded that foliar sprays were ineffective. Similarly Kurian and Iyer (1993a) suggested soil drenching to be effective for tree size control and induction of flowering in mango. In the present study foliar sprays promoted flowering, but soil drenching treatments were generally better with respect to most of the attributes studied. It is known that whenever paclobutrazol is applied through foliar sprays, uptake is from the young green shoots, with woody stems taking up very little. It may therefore be possible that paclobutrazol applied as foliar sprays were effective since the chemical entered the tree through shoot tips, young shoots and leaves. But soil drenching treatments will be more effective since the chemical is systemic and xylem mobile, moving upward with the transpiration stream.

Mango flower panicle characters like length, spread and number of secondary branches were recorded and it was found that paclobutrazol generally reduced the size of the panicle. This again, could be the effect of paclobutrazol on gibberellin biosynthesis and such an observation has been reported earlier by Kulkarni (1988), Winston (1992) and Kurian and Iyer (1993a).

With respect to the number of fruits set per panicle it was observed that all the paclobutrazol treatments significantly promoted number of fruits set per panicle when compared to panicles from untreated trees. Infact flowering itself was very poor in the untreated trees. It is very clear in mango that fruit set is primarily dependent on the number of hermoprodite flowers produced per panicle. Thus, in this study, higher fruit set in paclobutrazol treated trees may be due to lowered endogenous gibberellin levels which can result in higher proportion of hermoprodite flowers. Infact Kurian and Iyer (1993a) observed higher percentage of bisexual flowers when the Alphonso mango trees were treated with paclobutrazol. Thus, in the present study one can clearly conclude that higher fruits set per panicle is due to higher percentage of hermoprodite flowers which was induced by the treatment of paclobutrazol.

5.2 Influence of paclobutrazol on fruiting

Paclobutrazol treatments did not appear to influence the fresh weight of individual fruits. At least, no consistent trends were detectable with respect to paclobutrazol's influence on fruit weight. It is known that paclobutrazol, when applied early in the season, can supress vegetative growth and bring about reallocation of carbohydrate reserves in the plant (Anon, 1984). In the present study, a slight reduction in the fruit weight with some of the paclobutrazol treatments may be of no consequence compared to flowering. In any case paclobutrazol may have influenced the allocation of carbohydrate reserves since treated trees were able to produce 200 to 300 fruits per tree and still support their growth till maturity.

Fruit yield was significantly enhanced by all the paclobutrazol treatments in comparision to control. Here again soil drenching treatments were superior to foliar spray treatments and the best treatment was 8g a.i. per tree, which produced 300 fruits per tree. Undoubtedly, this enormous increased yield in treated trees is due to the influence of paclobutrazol on increased flowering as well as higher fruit set per panicle. And this influence of paclobutrazol has been well documented in mango (Kulkarni, 1988; Feungchan et al., 1989; Goguey, 1990; Burondkar and Gunjate, 1991; Vuillaume, 1991; Winston, 1992 and Kurian and Iyer, 1993b) and in other fruit crops (Costa and Biasi, 1986; Delgado et al., 1986; Jaumien et al., 1986; Shearing et al., 1986; Tonutti et al., 1986 and Jones et al., 1988).

5.3 Influence of paclobutrazol on physical character and composition of Alphonso mango fruits

The influence of the various paclobutrazol treatments both through soil drench as well as foliar spray on the physical characters of fruits was not significant. Similarly the volume of fruits from paclobutrazol treated trees was not influenced much and so was the specific gravity. Kurian and Iyer (1993b) have made similar observations in their study on Alphonso mango.

The various paclobutrazol treatments tried in the present study did not influence the quality of mango fruits significantly. For instance, the total soluble solids of the fruit pulp was only slightly higher with the soil drenching treatments and not significantly different from untreated fruits with the foliar spray treatments. Kurian and Iyer (1993b) on the other hand, observed a small reduction in TSS of treated fruits particularly at higher concentrations of paclobutrazol. The acidity of the pulp, again was markedly influenced by the treatments but no clear trends were seen. The ratio of sugars to acid, which is recognised as a good index for better fruit quality was the highest with the 6g a.i. per tree treatment although the 8 g a.i. per tree treatment was equally good. Very little information is available in the literature regarding the influence of paclobutrazol on quality of fruits, but the present study clearly suggests that the edible quality of fruits from paclobutrazol treated trees were not adversely affected. Support for such an observation also comes from the work of Kurian and Iyer (1993b).

5.4 Influence of paclobutrazol on organoleptic qualities and postharvest behaviour of Alphonso mango fruits

The organoleptic evaluation of ripe fruits conducted as a part of the present study indicated that with respect to all the qualities judged, paclobutrazol treated fruits were infact, rated slightly better than control fruits. Better fruit quality may be due to proper source-sink relation in the plant either by direct or indirect allocation of carbohydrate resources for flowering and fruiting (Anon, 1984). Although paclobutrazol had no or very little influence on the reducing and non-reducing sugar content of the pulp, it appeared to promote the firmness of the fruits; paclobutrazol treated fruits took longer to ripen, lost less weight during ripening and were firmer after ripening in comparision to fruits from untreated trees. This delay in ripening and increase in firmness could be the result of paclobutrazol's positive influence on calcium accumulation. Although not with mangoes, paclobutrazol have been shown to improve the calcium status of apple fruits (Greene, 1986). A similar argument can be made for paclobutrazol's influence on the incidence and extent of spongy tissue. It was observed that mango fruits from paclobutrazol treated trees exhibited lesser incidence of spongy tissue. Although not conclusively proven, spongy tissues has been regarded as a calcium deficiency disorder (Gunjate *et al*., 1979). So that paclobutrazol application reduces the incidence of spongy tissue disorder by promoting the accumulation of calcium in the fruit pulp. Lesser incidence of stem end rot disease was noticed in the fruits from paclobutrazol treated trees, but higher incidence was noticed in fruits from untreated trees. This may be attributed to greater effect on the control of postharvest disease of fruits by paclobutrazol.

The present study has thus demonstrated the usefulness of paclobutrazol for induction of profused flowering, higher fruit set and yield during the 'off' year in the biennial bearing mango varieties like Alphonso. All the trees selected for the paclobutrazol treatments in this study were expected to produce no or very little crop during 1993. But with paclobutrazol application all the trees produced acceptable yields. Soil application of paclobutrazol was more effective in inducing flowering, higher fruit set and yield when compared to foliar spray. Infact soil application of paclobutrazol was more easy and cheapest method than the foliar spray. From among the different concentrations of soil drenching of paclobutrazol, 8g a.i. per tree was found to be the best treatment. In this treatment flowering intensity was doubled, fruit set was two and a half times greater and the fruit yield per tree was very high in comparision to control trees. Any of the paclobutrazol treatments did not have any adverse effects on the edible quality of the fruit, however, a slight improvement in fruit color, pulp color, aroma and taste of pulp was noticed in the treated trees. Thus paclobutrazol has a greater scope in inducing regular yields in mango even from typical alternate bearing variety like Alphonso.

The study also indicates the necessity for more research on

a) Consistency of the chemical

b) To study whether paclobutrazol application is needed every year or in alternative years.

c) Adverse effect of paclobutrazol on plant growth and tree vigour.

d) Its effect on productive life span of plant.

SUMMARY

VI. SUMMARY

In the present investigation an attempt was made to study the effect of paclobutrazol on flowering, fruit set, fruit yield, and quality of mango cv. Alphonso. The results obtained are summarised below.

1. In comparision to untreated trees, all paclobutrazol treated trees induced flowering in the off year. However, soil drenching with paclobutrazol at 8g a.i. per tree induced maximum number of panicles per square metre area of the canopy as well as total number of panicles produced per tree. Among the foliar spray treatments, 10g a.i. per tree was found to be the best. Significant reductions in the length and breadth of the panicle were observed when paclobutrazol was soil drenched at 8g a.i. per tree or sprayed at 10g per tree. Both soil drenching and foliar spray of paclobutrazol at 10g a.i. per tree produced the maximum number of secondary branches per panicle.

2. Maximum fruit set as well as fruit yield (both in terms of number of fruits per tree and on weight basis) was recorded when the trees were soil drenched with paclobutrazol at 8g a.i. per tree.

3. Paclobutrazol treatments did not influence the physical characters of the fruit. However foliar spray of paclobutrazol at 4g a.i. per tree was found to be the best with respect to length, breadth, thickness and volume of fruits, but the paclobutrazol treated trees were on par with control fruits for specific gravity of the fruit.

4. Maximum ripe weight of fruit and pulp weight was observed when Alphonso trees were sprayed with 4 and 6g a.i. of paclobutrazol per tree respectively. But peel weight and stone weight were not significantly influenced by paclobutrazol treatments. Maximum pulp was recovered when the trees were sprayed with paclobutrazol at 6g a.i. per tree followed by soil drenching at 10g a.i. per tree and the least from untreated trees.

5. When compared to control trees there was not much change in TSS or titratable acidity of the pulp brought about by paclobutrazol treatments. But the highest sugar-acid ratio was observed when the trees were soil drenched with paclobutrazol at 6g a.i. per tree. Among the foliar spray of paclobutrazol, 4g a.i. per tree was found to be the best. Similarly with respect to total sugar, reducing sugar and non- reducing sugar content,

there were no significant differences between fruits from paclobutrazol treated and untreated trees.

6. It was observed that the process of ripening was retarded to an extent of five days when the trees were sprayed with paclobutrazol at 10g a.i. per tree. Similarly, the physiological loss in weight of fruits was significantly different from control trees, and it was the least when the trees were soil drenched with paclobutrazol at 6g a.i. per tree. Even the firmness of the ripe fruit was maximum when the trees were either soil drenched or sprayed with paclobutrazol at 10g a.i. per tree.

7. With respect to organoleptic evaluation of fruits, paclobutrazol treatments did not have any adverse effects on the edible quality of fruits such as taste, aroma, texture and firmness of pulp or even the fruit colour; all the different paclobutrazol treatments were on par with control trees.

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* Original not seen

APPENDICES

Appendix - I

Meteorological data indicating mean monthly Normal (1975-91) and actual (1992-93) for the experimental period at G.K.V.K., Bangalore 65.

Months	Total Rainfall (mm)			Mean Maximum temperature (°C)			Mean minimum temperature (°C)			Mean humidity (%)			Bright sunshine (hrs)			Open pan evaporation		
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D
October	132.6	107.6	-27.0	28.0	27.3	-0.7	18.1	18.3	0.2	0.4	72	1.6	6.7	5.9	-0.8	5.1	4.9	-0.2
November	75.8	70.8	-5.0	26.7	26.5	-0.2	16.3	17.5	1.2	0.4	70	-0.4	6.9	6.1	-0.8	4.7	4.5	-0.2
January	1.6	0.0	-1.6	27.0	27.6	-0.6	13.5	12.5	-1.0	62.1	54.6	-7.5	9.2	8.9	-0.3	5.5	5.1	-0.4
February	8.0	0.0	-8.0	29.8	29.0	-0.8	15.2	14.4	-0.8	55.4	49.8	-6.6	9.9	9.9	0.0	6.6	6.5	0.1
March	10.2	0.1	10.1	32.5	31.6	0.7	17.9	18.8	0.9	46.5	55.5	9.0	9.6	8.6	1.0	7.7	6.8	0.9
April	39.6	32.8	6.8	33.8	32.8	1.0	20.4	21.2	0.8	53.7	53.5	0.2	9.3	9.5	0.2	7.7	8.0	0.3
May	103.7	5.1	96.6	33.1	33.8	-0.7	20.4	20.6	0.2	58.5	59.4	0.9	8.7	9.2	0.5	6.6	7.3	-0.7
June	77.1	144.9	67.8	29.6	29.5	-0.5	19.0	19.1	0.1	68.8	69.9	1.1	5.5	5.8	2.3	6.5	6.8	0.3
July	107.8	58.4	49.4	24.1	27.8	3.7	18.6	19.1	0.5	72.5	72.0	-0.5	4.7	4.25	-0.4	5.9	6.0	0.2

N = Normal (1975-91)
A = Actual (1992-93)
D = Deviation from normal (A-D)

APPENDIX - II

Yield data of the experimental Alphonso mango trees from 1987 to 1992

Tree Code (Row/tree)	Fruit yield (Number of fruits/tree)					
	1987	1988	1989	1990	1991	1992
8/3	144	410	95	430	220	355
8/5	142	358	148	295	190	378
9/6	245	348	38	384	198	340
9/7	198	287	0	265	175	225
9/8	215	295	0	215	327	230
10/2	215	323	95	325	168	210
11/2	31	395	0	370	92	320
12/4	115	485	0	410	195	298
12/6	210	475	1	480	192	198
13/2	195	287	0	410	110	308
13/3	108	392	0	450	85	310
14/5	235	560	188	180	345	175
14/9	212	380	2	110	188	270
14/10	265	292	0	435	195	292
15/3	164	455	58	230	150	217
15/4	262	410	0	285	152	255
16/4	215	430	121	295	160	325
16/6	115	597	180	408	250	255
16/7	156	597	121	410	230	320
16/10	96	466	0	120	98	192
17/3	62	392	0	176	75	176
17/4	137	322	0	235	72	275
17/5	84	328	90	75	95	105
18/3	142	455	5	425	25	282
18/5	142	410	0	175	70	190
18/7	227	420	0	375	215	235
19/5	142	425	0	475	53	264
19/7	197	510	0	385	150	385
19/8	183	455	0	240	145	327
19/9	148	355	0	195	175	220
20/5	95	410	0	365	63	110
20/6	148	246	24	410	150	192
20/8	164	475	173	325	145	380
20/9	75	437	0	428	92	330
21/7	166	430	0	415	92	255
21/8	115	525	27	355	250	295

Appendix - III

Organoleptic evaluation score card for mango fruit

Date: Name:

Using the hedonic scale in display would you please rate each of the samples by placing a number in the appropriate column.
Rank the samples from higher to lower score in descending order of acceptability

	R_1	R_2	R_3	R_4
Treatments	123456789	123456789	123456789	123456789
Characters				
1. Fruit color				
2. Pulp character				
a. Colour				
b. Taste				
c. Aroma				
d. Texture				
e. Firmness				

Remarks:

Hedonic scale:

Like extremely - 10
Like very much - 9
Like moderately - 7
Like slightly - 6
Liked nor disliked - 5

Dislike slightly - 4
Dislike moderately - 2
Dislike very much - 1
Dislike extremely - 0

Signature with date
and designation