

**STUDIES ON THE PHYSIOLOGY OF GROWTH,
FLOWERING AND FRUIT DEVELOPMENT
IN MANGO (*Mangifera indica* L.)**

A THESIS
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BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
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By

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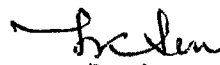
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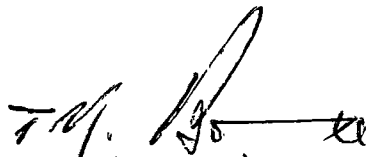
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CHAPTER—I

INTRODUCTION

INTRODUCTION

Mango (Mangifera indica L.) is considered to be the king of fruits as it is the most important fruit crop of India and constitutes an important horticultural asset of the country. It occupies about 40 per cent of the total area under fruits. Because of its wide adaptability to various soil and climatic conditions, it is under cultivation in many countries of the globe but nowhere this fruit is so highly valued as in India, where it alone occupies an area of 1.02 million hectare with an annual production of 8.83 million tonnes (Chadha, 1985). Except the hilly regions and coastal belts, mango is cultivated throughout the length and breadth of India upto an elevation of 915 metres from the sea level. Among the different states, as quoted by Majumder and Sharma (1985), Uttar Pradesh occupies the maximum area (3.13 lakh ha) followed by Bihar (1.2795 lakh ha), Andhra Pradesh (1.2709 lakh ha), Orissa (0.725 lakh ha), Kerala (0.6253 lakh ha), West Bengal (0.57 lakh ha) and Tamil Nadu (0.3917 lakh ha).

Because of its delicious taste, manifold utility and nutritive value, mango has been acknowledged as an excellent fruit. Mango fruit is a rich source of carbohydrate as well as vitamin A and C and contains 86.1% moisture, 0.6% proteins, 0.63% mineral matters including calcium, phosphorus, iron, etc., 1.1% fibre, 11.8% carbohydrate, 4800 I.U. vitamin A and 13 mg vitamin C per 100 g pulp. It is also a good source of vitamin B (Singh et al., 1963).

In West Bengal the soil and climatic conditions of most of the districts except the hills of Darjeeling district are suitable for the successful cultivation of mango. However, its commercial cultivation is restricted mainly in the districts of Malda, Murshidabad, Nadia, 24-Parganas (North) and Hooghly. Malda is the pioneer mango producing district having an area of 20 thousand hectares under mango cultivation, Fazli being the leading commercial cultivar. In Malda, mango grows abundantly. Unfortunately, due to continuous management neglect, most of the existing orchards are in a declining condition. Cultural operations are seldom done in mango orchards except occasional use of insecticidal sprays in the flowering season. Consequently, the plants have become uneconomic and yield per plant is very low. The role of nutrients on growth and yield of mango orchards is nowadays being increasingly realised by the growers. But the research findings are meagre, specially with respect to micronutrients. Ruehle (1951) has reported that among the fruit trees, mango appears to have the maximum capability to recover by proper application of fertilizers. Although nitrogen, phosphorus and potassium play a vital role in promoting the plant vigour and productivity, micronutrients help in the uptake of the major nutrients.

Deficiency of these elements has not been well reported in India, but beneficial effect of micronutrient sprays has been suggested. However in Florida, symptoms of Fe, Mn, Zn, B and Cu deficiency have been observed in the cultivars Haden and Zill (Smith and Scudder, 1951). Zinc deficiency was first reported from Florida (Lynch and

Ruehle, 1940) and subsequently from Israel (Oppenheimer and Gazit, 1961) and according to these investigations deficiency of this nutrient caused deformed leaves with a rosette formation near the tip of the flush and retardation of the growth, which could be corrected by spraying 1 per cent zinc sulphate. In three-year old mango plant, Minessy et al. (1974) observed that the soil application of 50 to 100 g/tree of chelated iron corrected bud malformation and in the mature mango trees, a single soil application at 1 lb/tree corrected malformation, increased flowering and fruit yield. Rajput et al. (1976) observed that 0.8 per cent foliar application of boric acid improved growth, flowering, yield and fruit quality. In an experiment Rath et al. (1980) found that application of boron and zinc increased fruit size and quality of mango. Fruit drop is a major problem affecting fruit yield in mango particularly in the 'off' year. In mango, there is a heavy drop of hermaphrodite flowers and young fruits amounting to 99 per cent or more (Mukherjee, 1949). According to Sen (1939), only 13 to 28 per cent of the bisexual flowers in cultivars Bombai, Langra and Fazli have been found to set fruits out of which only 0.1 to 0.25 per cent reached maturity. In spite of the profuse flowering and a very high initial fruit set the ultimate retention of harvestable produce is often very low due to abscission of hermaphrodite flowers and fruits at various stages of development. Thus, the fruit drop in mango assumes an important aspect which is directly related to economic cultivation of the crop. Singh et al. (1959b) reported that aqueous solutions of NAA at 30 and 40 ppm and of 2,4-D at 10 ppm applied to Fajri mangoes 6 weeks after full bloom reduced fruit drop from 52

per cent to 22 and 28 per cent, respectively.

Roy et al. (1963) reported that NAA and 2,4-D at 1, 5, 10 and 15 ppm were sprayed twice on Gulabkhas, Himsagar, Langra and Bombai to reduce the fruit drop. Maurya et al. (1973) sprayed 2,4-D, NAA and 2,4,5-T each of 20, 40 or 60 ppm after every 15 days from pea stage to till harvest and observed that 2,4-D at 20 ppm retained the highest percentage (8.4%) of fruits followed by 40 ppm whereas under control it was only 5 per cent. Most of the mangoes produced in India are consumed locally. About 12,500 tonnes of fresh and 16,480 tonnes of processed mangoes are exported and 25 per cent of the produce are totally spoilt. Increased production will not fulfil the total requirement unless the fruits are harvested at the proper stage of maturity. It is imperative to assess the proper harvest maturity, so that the fruits can reach the market in properly ripe condition and fruit quality is not impaired. The physico-chemical changes during the progressive development of mango fruits have been studied by different workers. Lakshminarayana et al. (1970) observed that the mango fruits cv. Alphonso continued to increase in weight until harvest and they reached harvest maturity in 16 weeks after fruit set. Specific gravity of fruits was considered as an index to determine the harvest maturity by Mukherjee (1959). In mango cv. Langra, Teotia et al. (1968) found that acidity and starch content were relevant in predicting maturity, while the starch:acidity ratio provided a good index for maturity. Singh et al. (1976a) found highly significant correlation between T.S.S. and total sugar content, specific gravity and

total sugars, specific gravity and starch content during the maturity of fruits.

In view of the foregoing consideration, the following experiments have been carried out at Mango Research Centre of Bidhan Chandra Krishi Viswavidyalaya and some private orchards in Malda district during the period of 1982 to 1985 on cvs. Fazli and Langra.

I) Effect of three levels of zinc, iron and boron and their interactions on growth, flowering, yield and fruit quality of mango cv. Fazli.

II) Effect of zinc, iron and boron in combination with urea on vegetative growth, flowering, yield and fruit quality of mango cv. Fazli.

III) Effect of different chemicals on fruit retention, yield and quality of mango cv. Fazli.

IV) Physico-chemical changes during growth and development of fruits in cvs. Fazli and Langra.

CHAPTER—II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

I. Effect of zinc, iron and boron on growth, yield and fruit quality.

Effect of zinc :

Mallik and Singh (1959) reported that absence of Zn reduced the leaf size to the maximum extent, followed by B. Zn also caused great reduction in general growth of mango trees. Zn deficiency in the mango groves in Israel caused very small deformed leaves with a rosette formation near the tip of the flush. Shoot growth was retarded prior to development of clear symptoms at leaf Zn content below 20 ppm and spraying with 1% zinc sulphate or 0.2% zinc oxide corrected the condition. Soil application, dusting, and use of pellet were not effective (Oppenheimer and Gazit, 1961). Martin et al. (1975) stated that zinc deficiency was found to be the cause of severe malformation in mature mango trees which became unproductive. Foliar spray of zinc sulphate or zinc oxide was effective. Rajput et al. (1976) also tried foliar application of zinc sulphate at 0.2-0.8% in a single spray to the bearing trees cv. Chausa in the month of January and found that treatments increased length of the terminal shoot, the number and area of leaves/shoot and leaf fresh and dry weight and effectiveness increased with increase in the zinc concentration. Singh and Rajput (1976) further observed that spraying of zinc sulphate at 0.2 to 0.8% in mango trees cv. Chausa during January increased terminal shoot length, leaf number and leaf area/shoot, the number of

hermaphrodite flower/panicle and yield. Fruit sugar, ascorbic acid and T.S.S. contents were also enhanced and the best results were obtained with the highest dose. While working on mango trees cv. Dashehari, Nijjar et al. (1976) observed that in zinc deficient leaves zinc content was about 27.5 ppm compared with 35.2 ppm in healthy plants and the leaf zinc content increased to 42.5 and 92.5 ppm when sprayed in February with $ZnSO_4$ at 0.2 and 0.4% respectively. The new flush was free from deficiency after 72 hours. Daulta et al. (1981) reported that spraying of Zn or CCC (Chloromequat) on January, had no appreciable effect on flower type (Staminate, pistillate or hermaphrodite) in 13-year old mango trees cv. Dashehari but fruit set was greatly increased by 1% Zn or 500 or 1000 ppm CCC. Highest fruit retention (36.4%) and best quality fruits were obtained at 0.8% Zn.

Effect of iron :

Stewart and Leonard (1957) reported that application of chelated iron (FeEDTA) @ 100 g/tree/year on mature orange and grape fruit tree enhanced the growth and weight of the new shoots. Webb and Hallas (1966) found that 70 ppm Fe in strawberry was optimum for increasing vegetative growth and yield. Application of 30 ppm Fe in Washington Navel Orange caused higher fruit weight and concentration of sugar in the juice (Wallihan et al., 1967). In case 2½ year old mango trees, Minessy et al. (1971) found that soil application of 50 or 100 g/tree of chelated iron (as chelated 138 which contains 6-7% Fe) corrected moderate or severe bud deformity condition. Foliar application was not

effective. In three year old mango plant in alkaline clay loam soil, Minessy et al. (1974) observed that soil application of 50 to 100 g/tree of Chelated Fe as chel-138 corrected moderate to severe symptoms of bud malformation. Foliar application at 10 g/litre was ineffective. In case of mature mango trees a single soil application at 1 lb/tree corrected malformation, increased flowering and yield from 5 fruits/tree in the first year to 212 and 468 fruits in the second and third year respectively.

Effect of boron :

In mango cv. Langra, Rajput et al. (1976) observed that foliar application of boric acid (0.8%) significantly improved growth, flowering, fruiting and fruit quality. Spraying of boric acid at 0.2, 0.4, 0.6 or 0.8 per cent on mango trees cv. Langra caused significant increase in leaf numbers and dry weight. Leaf N content was increased to 1.86 per cent by 0.2 per cent B, as against 1.82 per cent under control, but was reduced by higher rates (Singh, 1977). In 13-year old mango trees cv. Langra, Rath et al. (1980) found that spraying with B or Zn each of 0.2-0.8 per cent at full bloom increased fruit length, diameter and fruit weight. Application of B+Zn at high rates (0.6 and 0.8%) increased total sugars, ascorbic acid, acidity and T.S.S. contents of fruit.

II. Effect of growth substances on fruit drop :

Flower and fruit drop are two serious problems in mango cultivation causing low harvest and low marketable produce. Luckwill (1948) found that the periods of active hormone production were associated

with the periods of low fruit drop in apple. Gokhale and Kanitkar (1951) reported that treatment of Alphanso mango fruits (12 to 25 mm diameter) with 25 ppm of NAA and 2,4-D as aqueous spray checked the post setting drop to a considerable extent and gave 17 to 23 per cent more yield compared to control. Mukherjee (1953) stated that external and internal factors such as occurrence of mango hopper, mango mealy bug, powdery mildew and anthracnose and nutritional deficiency affected mango fruit drop. According to Chadha and Singh (1964a) intensity of fruit drop in mango could be divided into three distinct phases such as, 1) Pin-head drop, 2) Post setting drop and 3) May drop. 'Pinhead-drop' consisted mainly of shrivelled floral organs and shedding of hermaphrodite flowers and small pinhead like fruits below 4 mm in diameter. 'Post setting drop' being major drop, continued from pea stage to ball stage of development and 'May drop' was economically the most important drop and extended almost over the entire month of May and June.

Kennard and Winters (1956), however, failed to find any positive effect of 2,4,5-T spray application (50 to 200 and 800 ppm) in checking fruit drop in 3 and 6 weeks old fruits of mango cv. Amini.

Effect of spray applications of 2,4,5-T and 2,4,5-TP at 10 and 20 ppm on April 15 and second spray on May 13th on the fruits of the Karela Bhagalpur cultivar was reported by Singh (1957). Both the concentrations of 2,4,5-TP were effective in checking the fruit drop as compared to other treatments. 2,4,5-TP at 20 ppm gave the best result and recorded 13.2 per cent higher fruit retention over control.

Aqueous solutions of NAA at 30 and 40 ppm and 2,4-D of 10 ppm when applied to Fajri mangoes 6 weeks after full bloom fruit drop was reduced from 52% to 22 and 28% respectively (Singh et al., 1959b). The growth substances caused increase in fruit size, titratable acidity and the ascorbic acid content and reduced the oozing of sap from the stalk end.

Singh et al. (1959a) found that 2,4-D and NAA (10, 20, 30 and 40 ppm) spray applications on mango cv. Fajri resulted 28.61 and 29.69 per cent fruit drop respectively as against 53.90 per cent under control. Fruit drops were substantially low at 30 and 40 ppm, suggesting a greater control of fruit drop with higher doses.

Gill (1960) found that spraying of NAA, NAAM, 2,4-D, 2,4,5-T and 2,4,5-TP in concentrations of 10, 20, 30 and 40 ppm on April 16 in the cultivar of Langra failed to lead to any valid conclusion. Later applications made on May 4 and 20, June 7 also did not show any noticeable effect on fruit retention. Nevertheless, with May 4 application, the effect of NAA increased with increasing concentrations upto 40 ppm. The concentration effect was significant both at 10 and 40 ppm when application was made on June 7, though it was difficult to explain the weaker influence of the intermediate doses. According to Sturrock (1961) fruit expansion was associated with endosperm formation.

Mallik (1961) reported that NAA at 10 ppm gave the most effective results in comparison with water spray and weekly irrigation with ten gallons (45 lit) of water until harvest in the cultivar of Langra.

The best time for spray application was May and according to the author spray needed to be repeated three times at weekly intervals.

Application of 2,4-D, 2,4,5-TP and NAA each at 20, 40, 60 and 80 ppm on May 5 showed large and significant effect in reducing the post-set fruit drop in Dashehari. 2,4-D proved to be the best and gave a fruit retention of 56, 83, 77 and 83 per cent under 0, 20, 40, 60 and 80 ppm concentrations respectively (Singh et al., 1961).

Rao (1961) applied 2,4-D at 8, 10, 12, 30 and 40 ppm, NAA at 10, 20, 30 and 40 ppm, GA at 150, 300 and 600 ppm separately and in combination with 2,4-D (10 ppm) to prevent the fruit drop in the Neelum cultivar of mango and found that 2,4-D at 30 and 40 ppm were effective in reducing fruit drop to the extent of 50.9 and 52.8 per cent when compared with control.

Srivastava (1962) from his investigations on Dashehari cultivar observed that the fruit drop occurred in the first three weeks after fruit set and that fruit drop could effectively be controlled by spraying NAA at 25 and 50 ppm; but the effect of NAA at 50 ppm was superior to all other treatments.

Chadha and Singh (1963) studied the effect of spray applications of 2,4-D, NAA and 2,4,5-T each at 20, 40 and 60 ppm on May 8 in Langra cultivar of mango. 2,4-D at 40 ppm was the only treatment to cause any significant reduction in fruit drop.

Roy et al. (1963) reported that NAA and 2,4-D both in concentrations of 1, 5, 10 and 15 ppm were sprayed twice on Gulabkhas,

Himsagar, Langra and Bombai mango cultivars to reduce fruit drop. In Gulabkhas spraying of 2,4-D at 10 ppm and NAA at 5 ppm reduced fruit drop during 1958 and 1959, respectively. 2,4-D at 5 ppm reduced the drop during 1958 in the cultivar Himsagar and both the chemicals at 10 ppm proved to be equally good in 1959. Spray application of 2,4-D at 5 ppm was the most effective treatment for Langra and Bombai at Sabour and in the cultivar Bombai fruit drop was reduced from 82.9 per cent in control to 60.5 per cent under treatment.

According to Rao and Rao (1963) in the cultivar of Neelum, application of 2,4-D at 30 ppm six weeks after fruit set reduced fruit drop from 82.5 per cent to 50.4 per cent. In another experiment using various strengths of 2,4-D, NAA, GA and GA + 2,4-D however, no significant effect was observed.

Arora and Singh (1964) investigated the effect of different concentrations of 2,4-D, NAA, 2,4,5-T, 2,4,5-TP and some mixtures of these on fruit drop of Dashehari and Langra mangoes during 1960-61. According to them plant regulators reduced fruit drop to some extent but the results were not consistent. The promising treatments were 2,4-D (10-20 ppm), NAA (40 ppm) and NAA (40 ppm) + GA (5 ppm). They however pointed out that higher concentration of 2,4-D generally increased fruit drop.

Chadha and Singh (1964b) found that the rate of fruit drop was very high in the initial stage of fruit growth, when development was very rapid but gradually slowed down as the fruit reached a

substantial size. By 19th May, when Langra and Dashehari fruits attained 90-95% of their size, fruit drop had almost ceased. This stage was not reached until 9th June in case of Fajri, a late maturing cultivar characterized by a longer period of fruit drop.

Singh and Arora (1965) observed that in the mango cultivars, Dashehari and Langra fruit drop started immediately after fruit set and continued upto the time of harvest, but its intensity decreased after about 4 weeks. The hormonal activity of the seeds was reported to be greater in the adhering fruits than in the abscising fruits, especially early in the season and fruit drop in earlier stage was due to low auxin content.

Gill and Mukherjee (1967) revealed that 2,4-D at concentration lower than 20 ppm resulted in increased fruit harvest by 30 to 50 per cent over control in the cultivar of Bombay green at Delhi condition when spraying was done in the last week of April. In case of Chousa, application of 2,4-D, NAA and 2,4,5-T as aqueous sprays in concentrations ranging from 5 to 60 ppm were further made and 2,4-D proved better than other chemicals.

In an experiment Langra plants were sprayed with 5, 10 and 25 ppm of NAA, GA and 2,4,5-T once, twice and thrice at full bloom, pea and marble stages. Only NAA at 5 ppm caused significantly higher fruits retention when sprayed at all the three stages. In the another experiment GA and NAA were sprayed on 'Langra' cultivar in concentrations of 25, 50 and 100 ppm at full bloom stage, no significant response was however obtained (Teotia et al., 1967).

In an experiment mango plants of the cultivar Khasa were sprayed with 4 levels of planofix at 15, 30 or 45 days after fruit set. Among the 4 levels of planofix the most effective one was 1.0 ml planofix per gallon when sprayed after 30 days of fruit set (Jagirdar and Choudry, 1967).

Veera and Das (1971) sprayed 2,4-D, NAA, GA or 2,4,5-T each at 10, 20 or 40 ppm 4 times on Baganapalli cultivar of mango. The treatments particularly NAA at 40 ppm increased fruit size and weight. Excepting GA, other treatments proved effective in increasing T.S.S. and ascorbic acid contents of fruits and the maximum values were attained with the highest rate of NAA and 2,4-D, respectively. The highest and lowest titratable acidity were obtained with the treatments 40 ppm 2,4-D and 10 ppm of GA, respectively. T.S.S./acid ratio was markedly reduced by 40 ppm GA and it was the highest with 40 ppm NAA.

Prasad and Pathak (1972) reported that when newly set mango fruits were sprayed with methyl ester of NAA at 25, 50, 75 or 100 ppm fruit retention was more. Maximum retention was had with the lowest concentration.

According to Maurya et al. (1973) three growth regulating chemicals viz., 2,4-D, NAA and 2,4,5-T each at 20, 40 or 60 ppm were sprayed after every 15 days from pea stage to harvest maturity. 2,4-D at 20 ppm retained highest percentage (8.4%) of fruits followed by 40 ppm of the same regulator whereas under control retention was only 5%. All the treatments retained significantly higher per cent of fruits excepting 2,4,5-T at 60 ppm.

According to Kalyanasundaram (1974) in Mulgoa mango, initial fruit set was 11.25 fruits/panicle and ultimately 98.65% fruits dropped. The aqueous spray of 2,4,5-T at 10, 20, 30, 50 and 60 ppm on three weeks old fruit bearing panicles did not have any effect on fruit drop.

Rao et al. (1976) from an experiment conducted in Lucknow reported that spraying of growth retardant Alar at 100 ppm was efficacious in checking fruit drop in Dashehari cultivar of mango at pea stage of the fruit.

Singh and Singh (1976) reported the favourable effects of NAA and 2,4-D in checking fruit drop in Langra. Among the various doses used in the trial NAA at 10 ppm and 2,4-D at 10 and 15 ppm caused the maximum retention of fruits.

Lelyveld and Oostrum (1978) stated that spraying of mango trees with silver nitrate prevented fruit abscission by inhibiting peroxidase activity. They found that silver nitrate was associated with ethylene production in mango.

Aravindakshan et al. (1979) sprayed planofix (Containing NAA) at 10, 20 or 30 ppm on Neelum cultivar of mango twice at 15 day intervals in the 1st, 2nd or 3rd week after fertilization during the mustard, pea and marble stage respectively and found that planofix improved fruit set over the control. The most effective stage for application was the marble stage which gave 28.2 per cent fruit set at the optimal concentration (20 ppm) and 27.8 and 24.0 per cent at 10 and 30 ppm respectively as against 19.28 per cent under control.

NAA and 2,4-D each at 5, 10, 20 and 40 ppm levels were tried to find out the effective dose for control of fruit drop (Anonymous, 1979). 20 ppm NAA and 10 ppm 2,4-D recorded better fruit retention.

Rajput and Ram (1979) tried with NAA (0, 20, 30 and 40 ppm), 2,4-D (0, 5, 10 and 15 ppm) and GA₃ (0, 10, 20 and 30 ppm) to study their effect on fruit set, fruit retention and fruit quality of Langra, Dashehari and Fazri cultivars of mango. These chemicals when sprayed thrice at 15 days intervals significantly increased fruit set, fruit retention and fruit quality. Higher concentration had better effect.

According to Ram and Sirohi (1979) plant growth regulators were sprayed on panicles and foliage when fruitlets were at pinhead and pea stage in cvs. Chousa^a and Dashehari. They observed that number of mature fruits harvested in treated ones always increased by more than 1½ times over controls.

From a two years study with NAA and 2,4-D (5, 10, 20 and 40 ppm) Rameshwar and Rao (1979) obtained best fruit retention and yield during 1977 by applying NAA followed by 2,4-D both at 20 ppm concentration. During 1978 both the chemicals at 5 ppm exhibited better retention and yield. The lowest fruit drop of 94% was recorded with 2,4-D at 20 ppm during 1977.

Rao et al. (1979) concluded that urea at 2% appeared to be beneficial in controlling fruit drop while 4% increased drop in Dashehari. But in Baganpalli 4% urea was also beneficial. In another experiment they found that three sprays of Gibberellic acid helped to reduce fruit drop in Dashehari.

Singh and Pathak (1979) observed that plant growth regulators produced differences in respect of percentage of fruit retention, size, weight and quality of fruits. NAA at 15 ppm was effective in retaining highest percentage of fruits followed by NAA 20 ppm.

Singh and Ram (1983) opined that among the several chemicals applied at three different stages on 12 year-old trees, NAA at 40 ppm gave the best fruit retention when applied at the prebloom stage. At the pea stage CCC (chloromequat) at 200 ppm gave the best result and at the marble stage AgNO_3 at 200 ppm recorded maximum fruit retention.

III. Physico-chemical changes during growth and development.

Physical changes :

Mango takes about 3-4 months from the time of fruit set to maturity and ripeness (Singh, 1978). Physico-chemical changes during their progressive development stages have been studied by different workers in the various parts of the world. Increase in fruit weight during developmental period was studied by Mukherjee (1959).

According to Anantanarayanan and Pillai (1968) the fruit maturity period of 16 cultivars studied by them varied from 83-121 days in the main season and 107-137 days in the off-season in the district of Kenya Kumari. In the cultivar of Langra the fruits attained their maturity in 114-116 days from fruit set at Basti condition (Teotia et al., 1968). Rao et al. (1970) worked with the cultivar of Baneshan and found that in earlier fruit developmental stages, the sep

exuding from stalk on picking the fruit was thin, opalescent, aromatic, oily and gummy. As fruits developed, exudate became thicker, colourless and lost its gummy character but retained its oily feel. Krishnamurthy and Subramanyam (1970) considered weight of mango fruits as a parameter for determining optimum maturity of Pairi mangoes and according to them the weight of a mature fruit should be 260 ± 20 g and the colour should be olive green. Lakshminarayana et al. (1970) observed that the mango fruits cv. Alphonso continued to increase in weight until harvest and the fruits reached harvest maturity in 16 weeks after fruit set. Menchu (1973) found that in mango fruits cv. Mamey the harvesting time was reached in 90 days after fruit set though the fruit attained their greatest size and weight 60 days after fruit set. The pH level of exudate from the stalk end of both Dashehari and Langra gradually fell at the later picking dates as reported by Mann et al. (1975). Mann and Singh (1976) found that lenticel numbers/unit area declined with increasing fruit maturity of Dashehari, but with Langra they remained fairly constant. Palatability was associated with later picking with both the cvs. and was accompanied by a change in lenticel colour from creamy white to brown. Malevski et al. (1977) advocated skin colour of fruits as a criterion to judge fruit maturity in case of Haden mangoes. In two year studies with the cultivar Dashehari, Shukla and Bajpai (1978) observed that the optimum time of harvest maturity was 92 days after fruit set and they found that skin colour and lenticel characteristics were the most practical maturity determinants. Mature fruits were characterized by Scheele's green skin colour

accompanied by a light yellow blush and the lenticels being primrose yellow. Dabhade and Khedkar (1980) observed increase in fruit size and weight until the stage of maturity.

Change of specific gravity :

Popenoe and Long (1957) observed that specific gravity of fruit was related to fruit maturity in mangoes. Popenoe et al. (1958) reported that the starch content and specific gravity of hard fruit and the total soluble solids of soft fruit were closely associated with maturity of Haden and Zill mangoes. Specific gravity of fruit was used as an index to determine the harvest maturity in mangoes by Mukherjee (1959). In the cultivar of Langra, the specific gravity, acidity and starch content were considered relevant in predicting maturity, while the starch:acidity ratio provided a good index for harvesting according to Teotia et al. (1968). Jacob (1970) observed specific gravity of 1.02 at harvest maturity in Haden mangoes. According to Gangwar and Tripathi (1973) in the Cultivar of Dashehari and Langra under Basti condition, the specific gravity of newly set fruits were high and specific gravity decreased rapidly during the first month but increased again until maturity about 5 weeks later. Singh et al. (1976a) observed that in the cultivar of Neelum specific gravity of 1.037 determine the fully mature stage.

Change of acidity :

The changing responses in acidity of mango fruits during their gradual progress of development have been studied by number of

workers. De and Debnath (1966) reported that a local cultivar of mango in East Pakistan showed gradual increase in titratable acidity until near maturity, after which acidity decline with ripening. Acidity in the flesh rose from 2.17 per cent in small fruit to 3.05 per cent at near maturity, but during maturation and ripening stage the acidity decreased to 0.7 per cent. The concentration of citric acid and malic acids decreased in Alphonso mangoes during ripening according to Modi and Reddy (1967).

Teotia et al. (1968) in the variety of Langra found that acidity and starch content were relevant in predicting maturity, while the starch:acidity ratio provided a good index for maturity. In the variety of Alphonso the acidity reached a peak value during the 7th week after fruit set and declined at harvest (Lakshminarayan et al., 1970). Askar et al. (1972) carried out studies on three growth stages in the cultivar of Pairi, Zibda and Baladi and found that in the first stages the acidity rose while in the 2nd stage it decreased gradually. Gangwar and Moti (1974) reported that starch and acidity which had an impact on maturity ranged from 6.12 to 11.72 per cent and 0.115 to 1.689 per cent respectively. They also found that change of colour, specific gravity and starch content were the most appropriate parameters to predict the proper time of harvesting. Baqui et al. (1977) found changes in the different type of acids in mango fruits during their development. According to them, throughout the maturation of mango fruit, citric and glyoxylic acids increased steadily. As the fruits matured the levels of isocitrate lyase, malate

lyase and alanine:glyoxylate aminotransferase increased and reached maximum values before the time of harvesting. At and after harvest the levels of malate lyase and alanine:glyoxylate aminotransferase began to decrease but the level of isocitrate lyase remained high until after harvest. The amounts of citric and glyoxylic acids decreased when the fruit ripened after harvest. Sarkar et al. (1979) studied biochemical changes at six stages in the Fazli, Gopalbhog and a local cultivar and found that tartaric acid content was negatively correlated with sugar content at early stage of ripening but in the later stage citric acid was very important for sugar synthesis.

Changes of starch content :

Mango fruits are rich sources of carbohydrates and various experiments have been carried out by different investigators on them during their progressive developmental stages. Popenoe and Long (1957) while working with Florida mangoes observed a regular increase in starch content with maturity but according to them it could not be used as a commercial measure of maturity. Later, Popenoe et al. (1958) opined that in the cultivar of Haden and Zill mangoes the starch content and specific gravity of hard fruits were closely associated with mango maturity and the direct measurement of the percentage of starch in the flesh was the best method for estimating the degree of maturity in hard green fruit. Continuous accumulation of starch in the fruit pulp upto preripe stage was reported by Mukherjee (1959) and according to him starch content might prove useful in determining the time

for picking. Teotia et al. (1968) and Gangwar and Tripathi (1973) reported that starch content of mango fruits were relevant in determining the time of maturity in the cultivar of Langra. Singh et al. (1976a) studied Neelum mango fruits in which highly significant correlation between specific gravity and starch content existed during maturity. In the cultivar Dashehari, Tandon and Kalra (1983) observed that starch accumulation was slow at first, later increased with concomitant acceleration of amylase activity. Starch content and amylase activity declined after 91 days of growth.

Changes of T.S.S. and sugar content :

Popenoe et al. (1958) studied biochemical changes in the Haden and Zill mangoes and found that total soluble solids of soft mango fruits were closely associated with mango maturity as indicated by palatability. Mukherjee (1959) reported absence of any systemic trend in sugar content of fruits during fruit development. The percentage of reducing sugar was several times higher than that of the non-reducing sugar through out the period of development. De and Debnath (1966) observed that total sugars in the pulp of fruits increased from 3.1 to 9.45 per cent during ripening and 1.94 per cent of it consisted of reducing sugars. In the cultivar Kanchamitha, the sugar content rose from 0.48 to 2.6 per cent and nearly all of these were reducing sugars. In Alphanso mangoes the sugar content of fruits declined throughout the period of growth. Reducing sugars were present in higher concentrations than non-reducing sugars and accumulation of starch continued with growth and development, Lakshminarayana

et al. (1970).

Krishnamurthy and Subramanyam (1970) reported that sugar accumulation was maximal at about the time of the climacteric peak in respiration and sucrose was the predominant sugar in the cultivar of Pairi. Askar et al. (1972) demonstrated three growth stages in the mango cultivars, viz., Pairi, Zibda and Baladi. In the first stage, among other constituents starch and sugar content declined. During the second stage sharp rise in starch occurred and during third stage, ripening was characterized by a sharp drop in starch with a sharp rise in sugars. Total soluble solids gradually increased during their growth and ripening in the cvs. Pairy, Zibda and Baladi (Askar et al., 1972). Gangwar and Tripathi (1973) carried investigations on Dashehari and Langra mangoes and reported that content of total soluble solids increased during growth. Organoleptic tests showed a correlation between quality and total soluble solids content. Kapur (1974) worked with Dashehari, Safed (Malihabad) and Samar Bahisht cultivars of mango and observed that sugar content was at low level in the young fruits and there was very little rise in sugar as the fruits grew in bulk and weight and the ascorbic acid content was at highest level in the young fruit and relatively more amount occurred in the skin. As the fruit grew, there was a gradual loss of reducing sugars and ascorbic acid. Mazumder (1976) worked with Himsagar, Sorikhas and Peyaraphuli mangoes found that in the early stage of development the sugar content was highest in Peyaraphuli but at later stages the sugar content was highest in Himsagar. In the Neelum

mangoes Singh et al. (1976a) found highly significant correlation between T.S.S. and total sugar content, specific gravity and total sugars and specific gravity and starch content during the maturity of fruits and fruit maturity was characterized by specific gravity 1.037, T.S.S. 11.6%, total sugar 8.1-8.2% and starch content 6.6-6.7%. Singh et al. (1976a) observed, a highly significant correlation between total soluble solids and total sugar content in the cultivar of Neelum during ripening and the fully mature fruit contained 11.6% T.S.S. According to Chattopadhyaya et al. (1978) reducing and total sugar contents of the peel and flesh of both Himsagar and Bombai cultivars increased markedly during harvest, accompanied by a sharp decline in polysaccharide content. Sugar contents were higher in the flesh than in the peel. According to Singh et al. (1978) the specific gravity, T.S.S. percentage and starch:acid ratio were the best indices of maturity in the cultivar of Taimura and Sukul. Dabhade and Khedkar (1980) pointed out T.S.S. increased gradually during fruit growth and maturity. Sharma and Biswas (1981) reported the highest T.S.S. contents in the cvs. Himsagar, Bhabani Chawras, Misarikant and Ranibhog during their maturity. They also reported (1981) the highest per cent of total sugar in the cultivar of Chakraborty Khas (30.3%). Dashehari mangoes at each successive picking stage had higher β -carotene, total soluble solids, reducing and total sugar contents as reported by Kalra and Tandon (1983).

Changes of ascorbic acid content :

Spencer et al. (1956) while working with cvs. Amini, Mulgoa, Pico and Turpentine (native) observed that vitamin C content of fruits followed a downward trend and it declined from an average of 88 mg to 22 mg and the decline was most during 5 to 10 weeks after fruit set. The final 4-6 weeks of fruit maturation was accompanied by little changes in ascorbic acid content. They also reported that highest concentration of vitamin C in ripe mangoes was present in the peel and in the flesh adhering to the husks compared to edible portion. Singh and Chadha (1961) reported that ascorbic acid content of Langra, Dashehari and Fajri fruits decreased during the first 7 weeks after fruit set and then remained at a fairly constant level upto harvest. They also found that ascorbic acid content decreased with increase in fruit size and also with little or too much sunshine. Askar et al. (1972) working with the cvs. Pairy, Zibda and Baladi in three growth stages, observed that the vitamin C content continued to fall gradually. Gangwar and Tripathi (1973) reported that ascorbic acid content increased during growth. The ascorbic acid was at highest level in the young fruit and was relatively more in the skin but gradually decreased during fruit growth (Kapur, 1974). Mukherjee and Tewari (1979) reported that the ascorbic acid content was high at the marble stage and declined at the start of stone stage in the cultivar of Langra and Dashehari. Thomas and Oke (1980) found that the vitamin C level in the peel of mature unripe Alphanso, Dashehari, Langra and

Pairi mango fruits were at 199-214, 131, 542-597 and 250 mg/100 gm fresh weight respectively and corresponding levels in the pulp were at 89-103, 30, 114-143 and 41 mg/100 gm. The ascorbic acid content was high at initial stage of Totapuri and Pairi mangoes which decreased during growth and development as reported by Dabhade and Khedkar (1980).

CHAPTER—III

MATERIALS AND METHODS

MATERIALS AND METHODS

Experimental site :

The experiments were carried out at the Mango Research Centres of Bidhan Chandra Krishi Viswavidyalaya located at Mathurapur and Ratua and in two private orchards at Ratua and Najirpur in the district of Malda, West Bengal. The location of the experimental site was $87^{\circ}45'50''$ E longitude and $24^{\circ}40'20''$ N latitude in the northern hemisphere with an altitude of 25 metres above the sea level.

Climatic conditions :

The climatic conditions prevailing during the period of investigations as observed and recorded at the Malda meteorological observatory are presented in Table 1.

Soil condition of the experimental site :

The soil of the experimental site was sandy loam in texture and sufficiently deep. The soil samples were collected from the mango orchard at several locations of the experimental orchards at 30 cm depth. They were then mixed to make a composite sample for analysis. The analysed data on soil nutrient status of different orchards are

Table 1. Monthly record of mean temperature, rainfall and relative humidity during the period from June, 1982 to August, 1985.

Months	Temperature(°C)		Rainfall (mm)	R. H. (%)	
	Maximum	Minimum		Maximum	Minimum
<u>1982</u>					
June	33.31	25.11	240.3	90.33	72.30
July	33.06	26.58	155.4	91.06	71.61
August	31.92	26.02	345.9	92.64	77.87
September	30.08	25.29	118.8	92.26	68.70
October	31.98	21.02	48.3	93.61	55.71
November	28.41	17.16	20.5	95.33	56.95
December	24.82	10.88	Nil	94.56	47.20
<u>1983</u>					
January	20.86	8.83	47.6	94.66	47.10
February	26.52	10.73	3.3	89.07	35.21
March	31.85	15.32	6.3	80.83	27.71
April	33.96	19.96	29.1	74.03	43.83
May	34.18	23.29	84.9	85.43	59.70
June	37.01	26.23	139.8	82.57	56.53
July	33.28	26.13	251.3	92.71	73.61
August	32.26	25.88	114.8	91.56	75.00
September	31.73	25.73	259.6	93.83	78.80
October	30.66	22.38	115.1	91.15	67.70
November	28.97	16.59	Nil	92.81	47.44
December	24.30	10.85	54.3	92.07	48.43

Contd...

Contd...Table 1.

Months	Temperature(°C)		Rainfall (mm)	R. H. (%)	
	Maximum	Minimum		Maximum	Minimum
<u>1984</u>					
January	22.82	10.33	52.6	95.26	49.80
February	25.41	12.01	18.3	85.31	44.37
March	34.00	17.04	8.7	84.57	31.76
April	36.74	21.66	15.2	82.20	36.03
May	33.55	24.41	48.4	87.16	61.96
June	32.04	25.76	24.7	90.45	76.16
July	31.81	25.50	268.9	94.25	79.50
August	32.49	25.96	195.3	92.61	76.61
September	31.58	24.84	202.6	94.90	74.10
October	31.87	22.56	57.2	91.41	63.54
November	28.88	15.24	Nil	87.66	45.76
December	25.62	10.70	2.5	92.87	43.41
<u>1985</u>					
January	25.19	10.71	Nil	94.23	42.38
February	26.12	11.64	11.4	90.82	40.82
March	30.25	16.12	31.5	83.58	44.09
April	35.15	20.77	2.6	81.23	42.10
May	39.18	24.62	73.2	74.37	37.44
June	33.82	25.90	183.2	89.21	72.24
July	31.91	25.74	418.3	93.03	80.35
August	32.30	26.02	409.8	90.61	78.00

presented below.

Nutrient content of the soil

	<u>Mathurapur</u>	<u>Najirpur</u>	<u>Ratua</u>
i) Soil pH	7.6	7.2	7.5
ii) Organic carbon (%)	0.44	0.52	0.49
iii) Total nitrogen (%)	0.05	0.03	0.04
iv) Available phosphorus (kg/ha)	26	28	25
v) Available potash(kg/ha)	377	298	325
vi) Available zinc (ppm)	6.15	6.31	7.38
vii) Available iron (ppm)	64.45	65.01	60.34
viii) Available boron(ppm)	1.6	1.6	1.70
ix) Electrical conductivity (mmhos/cm)	0.13	0.10	0.12

Duration of the experiment :

The experiments were laid out in October, 1981 and continued for four consecutive years upto 1985.

Materials :

The investigations were carried out on mango trees of cultivars Fazli and Langra which are abundantly grown in Malda. Four-year old young plants and 30 years old bearing trees of Fazli were selected for the study. To carryout the experiment on physico-chemical changes during the growth and development of Langra, fruits were collected from the healthy plants of 30 years in age.

Experiment Ia : Effect of three levels of zinc, iron and boron and their interactions on growth, flowering, yield and fruit quality of young mango cv. Fazli.

Age of the plant - 4 years (at the time of starting the experiment)

Design - Randomized Block (28 plants/block)

Treatments - Factorial with one augmented control (27+1)

Replication - 3

Total number of experimental plants - 84

Spacing - 12 m x 12 m

Nutrients and doses -	Zn ₁ 0.1%	Zn ₂ 0.2%	Zn ₃ 0.4%
	Fe ₁ 0.1%	Fe ₂ 0.2%	Fe ₃ 0.4%
	B ₁ 0.1%	B ₂ 0.2%	B ₃ 0.4%

Forms of nutrients :

Zn as zinc sulphate

Fe as ferrus sulphate

B as borax

Treatment combinations :

Zn ₁ Fe ₁ B ₁	Zn ₂ Fe ₁ B ₁	Zn ₃ Fe ₁ B ₁
Zn ₁ Fe ₁ B ₂	Zn ₂ Fe ₁ B ₂	Zn ₃ Fe ₁ B ₂
Zn ₁ Fe ₁ B ₃	Zn ₂ Fe ₁ B ₃	Zn ₃ Fe ₁ B ₃
Zn ₁ Fe ₂ B ₁	Zn ₂ Fe ₂ B ₁	Zn ₃ Fe ₂ B ₁
Zn ₁ Fe ₂ B ₂	Zn ₂ Fe ₂ B ₂	Zn ₃ Fe ₂ B ₂
Zn ₁ Fe ₂ B ₃	Zn ₂ Fe ₂ B ₃	Zn ₃ Fe ₂ B ₃
Zn ₁ Fe ₃ B ₁	Zn ₂ Fe ₃ B ₁	Zn ₃ Fe ₃ B ₁
Zn ₁ Fe ₃ B ₂	Zn ₂ Fe ₃ B ₂	Zn ₃ Fe ₃ B ₂
Zn ₁ Fe ₃ B ₃	Zn ₂ Fe ₃ B ₃	Zn ₃ Fe ₃ B ₃

Time of nutrient spray application - June and October.

Before spraying, the micronutrient solutions were adjusted to a neutral reaction by adding required quantity of lime.

Besides foliar spray of micronutrients, N:P:K @ 400 g, 200 g and 400 g per plant were applied in two equal split doses. Half of the total quantity was applied in the month of June and the remaining half in the month of October.

Irrigation :

Irrigation was given during the period of investigation as and when required.

Weeding :

The orchards were ploughed twice and the base of the trees upto the drip line was kept more or less free from weeds by manual weeding.

Experiment Ib : Effect of three levels of zinc, iron and boron and their interactions of flowering, yield and fruit quality of bearing mango trees cv. Fazli.

Design - Randomized Block

Treatments - Factorial with one augmented control (27+1)

Nutrient and doses - Same as Experiment Ia.

Replication - 3

Age of the trees - 30 years

Total number of experimental trees - 84

Spacing - 15 m x 15 m

Treatment combinations - Same as Experiment Ia.

Time of spray application - June and October

Besides foliar application of micronutrients, N:P:K @ 1 kg, 0.5 kg and 1 kg fertilizers per plant were applied in two equal split doses. Half of the total quantity was applied in the month of June and the rest half in the month of October.

Plant protection :

Insecticides and fungicides were sprayed from time to time to keep the pests (mango hopper, mealy bug, fruitfly, shoot borer, termites etc.) and diseases (powdery mildew, anthracnose, diplodia stem end rot, leaf blight etc.) under control.

Experiment II : Effect of Zn, Fe and B in combination with urea on vegetative growth, flowering, yield and fruit quality of mango cv. Fazli.

Age of the plants - 4 years (at the time of starting the experiment)

Design - Randomized Block

Treatments - 7

1. Zn 0.2% + 1% urea
2. Zn 0.4% + 1% urea
3. Fe 0.2% + 1% urea
4. Fe 0.4% + 1% urea
5. B 0.2% + 1% urea
6. B 0.4% + 1% urea
7. Control.

Replication - 4

Number of plants under each replication - 1

Total number of experimental plants - 28

Spacing - 12 m x 12 m

Time of spraying - June and October.

Besides foliar application of micronutrients and urea a normal dose of N:P:K @ 400 g, 200 g and 400 g was applied in two split doses in the month of June and October.

Irrigation :

The plants were irrigated as and when required.

Weeding :

The orchards was kept more or less free from weeds by ploughing and removing the weeds manually.

Plant protection :

Regular plant protection measures were taken to control pests and diseases.

Experiment III : Effect of different chemicals on fruit retention, yield and fruit quality of mango cv. Fazli.

Age of the trees - 20 years

Design - Randomized Block

Treatments - 11

1. Gibberellic acid - 20 ppm
2. Gibberellic acid - 40 ppm
3. 2,4-dichlorophenoxyacetic acid - 10 ppm

4. 2,4-dichlorophenoxyacetic acid - 20 ppm
5. Naphthaleneacetic acid - 20 ppm
6. Naphthaleneacetic acid - 40 ppm
7. 2,4,5-trichlorophenoxyacetic acid - 10 ppm
8. 2,4,5-trichlorophenoxyacetic acid - 20 ppm
9. Almon (a formulation of NAA) - 500 ppm
10. Almon (a formulation of NAA) - 1000 ppm
11. Control.

Replication - 4

Number of plants under each replication - 1

Total number of experimental plants - 44

Time of spraying :

Two spray applications were made. First spraying was done at pea stage and the second spraying was done at marble stage. The chemicals were applied in aqueous solution by thoroughly drenching the whole tree.

Cultural practices :

Selected plants were manured with 50 kg of well rotted cow-dung manure and N:P:K @ 500 g, 250 g and 500 g per plant per year. Regular plant protection measures were adopted.

Experiment IV : Physico-chemical changes during growth and development of fruits in cvs. Fazli and Langra.

Design - Randomized Block

Replication - 3

Number of fruits in each sampling - 4

The physico-chemical changes taking place during various stages of fruit development in cvs. Fazli and Langra and their chemical composition were recorded at 15 days interval starting from marble stage of fruit growth.

Observations and collection of data :

The following steps were taken in recording data.

1. Plant height :

Data on plant height was measured from a fixed point at the ground level to top flush by means of a measuring pole and a ladder.

2. Trunk girth :

The girth of the trunk was measured by measuring tape at the marked fixed point above the ground level.

3. Spread of the crown :

Spread of the crown in east-west and north-south direction were measured by measuring tape.

4. Percentage of flowering :

Flowering percentage was recorded when the plant was in full bloom stage.

5. Sex ratio :

In the full bloom stage 4 panicles per plant were taken from different locations on the plant. Male flowers and hermaphrodite flowers were counted and ratio between male:hermaphrodite flowers were determined.

6. Percentage of fruit retention :

First count was made before spraying and subsequent data were collected time to time at each spraying to calculate the percentage of fruits retained.

7. Number of fruits per plant :

Total number of fruits were counted per plant at harvesting time.

8. Weight of fruit :

Ten fruits were taken from each plant randomly and average weight was recorded.

9. Yield :

The yield per plant was calculated by multiplying the fruit number with average weight of fruit.

10. Size of the fruit :

Length and breadth of fruit were measured with the help of a measuring tape.

11. Specific gravity :

Specific gravity of fruit was determined by displacement of water.

12. Pulp:fruit ratio :

Pulp:fruit ratio was calculated by dividing the fruit weight by pulp content of that fruit and pulp content was determined by subtracting stone weight and peel weight from fruit weight.

13. Total soluble solids :

Total soluble solids (T.S.S.) of fruit was estimated with the help of a refractometer, which was washed with distilled water. A drop of squeezed out and strained juice was instilled on the plate to record the refractometer reading, calibrated in °Brix at 20°C.

14. Total sugar :

The total sugar content of the mesocarp samples was determined by titrimetric procedures. Firstly the non-reducing sugar content of pulp samples was converted into reducing sugar by acid hydrolysis. After conversion the sugar of the aqueous solution were determined by titrating against the freshly made mixture containing equal volumes of Fehling's solution A and B and using methylene blue as indicator (A.O.A.C. 1970).

15. Reducing sugar :

The reducing sugar content of the aqueous extract were determined by titrating against the Fehling's solution as stated above.

16. Non-reducing sugar :

The non-reducing sugar percentage of fruit pulp were determined by subtracting the value of reducing sugars content from that of the total sugars and multiplying the values with 0.95 (A.O.A.C. 1970).

17. Total titratable acidity :

The acidity percentage of fruit pulp was determined by

titrating the aqueous extract of known quantity of fruit juice against N/10 NaOH using phenolphthaleine as an indicator and the quantities were expressed in terms of citric acid.

18. Sugar/acid ratio :

Sugar/acid ratio was determined by dividing the total sugar percentage with acidity percentage.

19. Chemical analysis of soil :

Methods of analysis.

- a) pH - pH of the soil was determined with glass electrode pH meter using soil:water ratio 1:2.5.
- b) Organic carbon - Organic carbon was determined by Walkley and Black's method as described by Jackson (1967).
- c) Cation exchange capacity (C.E.C.) - Cation exchange capacity of soil was determined according to the method of Schollenberger and Simon (1945).
- d) Total nitrogen - Total nitrogen of soil was determined by Kjeldahl's method as described by Jackson (1967).
- e) Available phosphorus - Available phosphorus of the soil was determined by Dickman and Bray's (1940) chlorostannous reduced molybdophosphoric blue colour method in a hydrochloric acid system as described by Jackson (1967).
- f) Available potassium - Available potassium was determined by leaching the soil with neutral normal ammonium acetate and estimating potassium by Flame Photometer (Jackson, 1967).

g) Available zinc and iron - The available Zn and Fe of the soil samples were estimated by extracting the soils with 0.005 MDTPA solution adjusted to pH 7.3 (soil:extractant 1:2) following the method of Lindsay and Norvell (1978) and determining the concentration of the elements in the extract by an Atomic Absorption Spectrophotometer (Perkin Elmer, Model, 2380).

h) Available boron - The available boron content of the soil samples were estimated by extracting the soil with hot water (copper distilled) in the ratio 1:2::soil:water and determining the concentration of the element colorimetrically by Carmin method (Hatcher and Wilcox, 1950).

20. Chemical analysis of leaf and shoot :

a) Methods of sampling - In order to estimate the nitrogen, phosphorus and potassium contents of leaves and shoots under different treatments of experiment. Samples were collected in vegetative, flowering and at preharvest stage.

b) Estimation of nitrogen - Nitrogen percentage of leaves and shoots were estimated by micro-kjeldahl method (Jackson, 1967).

c) Estimation of phosphorus - The phosphorus content in leaves and shoots were determined by Vandomolybdate yellow colour method and was read at 670 m μ in a colorimeter (Jackson, 1967).

d) Estimation of potassium - The potassium content in leaves and shoots were determined by Flame Photometry.

The concentration of N, P and K were expressed as percentage of dry weight of leaves and shoots.

Method of statistical analysis :

Statistical analysis of the data was obtained by the analysis of variance method (Panse and Sukhatme, 1978). Angular transformation of data on percentage was done as per Snedecor (1959) Angle = $\text{Arc. Sin } \sqrt{\text{percentage}}$.

CHAPTER—IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Experiment Ia: Effect of three levels of Zn, Fe and B and their interactions on growth, yield and fruit quality of mango cv. Fazli.

Young plants.

Plant height :

The data presented in Table 2 revealed that in 1984 and 1985 plant height increased significantly when Zn and B were applied at higher rates. A reverse trend was, however, observed in 1983. Application of 0.4 per cent Zn caused 52.74 and 52.07 cm increase in plant height in 1984 and 1985 respectively. Similarly B at the same concentration also resulted in 54.41 and 54.37 cm increase in height in the said year. The effect of Fe was not significant in all the three years.

The increase in plant height varied significantly among the different treatments of Zn + Fe, Zn + B and Fe + B in all the three years. The highest increase of 63.22 cm was recorded under Zn_3Fe_3 treatment in 1984. The same treatment also caused 53.77 cm increase in height in 1985. The treatment Zn_3B_1 augmented the height by 66.22 and 61.00 in 1984 and 1985, respectively. The maximum increases in height of 62.66 and 58.55 cm were observed when plants were treated with Fe_2B_3 (Fe 0.2 and B 0.4%). The efficacy of treatments was, however, less pronounced in 1983.

Among the various second order interactions, treatments $Zn_2Fe_1B_3$ (64.66 cm), $Zn_3Fe_3B_1$ (76.33 cm) and $Zn_2Fe_2B_3$ (62.66 cm)

Table 2. Effect of three levels of Zn, Fe and B and their interactions on height of the plant (expressed as increase over last year)

Zn levels	Increase in height(cm)			Fe levels	Increase in height(cm)			B levels	Increase in height(cm)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	44.29	44.48	45.85	Fe ₁	30.70	49.96	50.22	B ₁	32.72	48.48	48.70
Zn ₂	30.14	43.81	47.85	Fe ₂	32.33	45.81	47.85	B ₂	35.07	38.03	42.70
Zn ₃	29.18	52.74	52.07	Fe ₃	35.59	45.25	47.70	B ₃	35.81	54.41	54.37
S. Em ±	1.30	2.65	1.04		1.30	2.65	1.04		1.30	2.65	1.04
C.D. at 5%	3.64	7.42	2.90		N.S.	N.S.	N.S.		N.S.	7.42	2.90
					1984				1985		
Zn x Fe				Fe ₁	47.77	51.88	33.77	Fe ₃	47.88	48.22	41.44
Zn ₁	51.22	37.55	44.11		53.66	39.00	38.77		46.66	49.00	47.88
Zn ₂	37.55	24.77	28.11		48.44	46.55	63.22		56.11	46.33	53.77
Zn ₃	18.33	34.66	34.55								
S. Em ±		2.25			4.59				1.81		
C.D. at 5%		6.30			12.85				5.03		
Zn x B				B ₁		B ₂	B ₃	B ₁		B ₂	B ₃
Zn ₁	50.77	37.88	44.22		37.66	44.44	51.33		37.44	45.22	54.88
Zn ₂	27.11	27.88	35.44		41.55	34.00	55.88		47.66	40.66	55.22
Zn ₃	20.33	39.44	27.77		66.22	35.66	56.33		61.00	42.22	53.00
S. Em ±		2.25				4.59				1.81	
C.D. at 5%		6.30				12.85				5.03	

Contd....

Contd. ... Table 2.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	34.44	22.88	49.77	49.44	49.55	50.88	50.77	46.11	53.77
Fe ₂	25.77	44.44	26.77	46.55	28.22	62.66	44.33	40.66	58.55
Fe ₃	38.00	37.88	30.88	49.44	36.33	50.00	51.00	41.33	50.77
S. Em ±		2.25			4.59			1.81	
C.D. at 5%		6.30			12.85			5.03	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	60.66	28.66	64.33	33.66	57.33	52.33	38.66	47.33	57.66
Fe ₂	29.33	51.66	31.66	53.66	38.66	63.33	44.33	41.66	58.66
Fe ₃	63.33	33.33	36.66	25.66	37.33	38.33	29.33	46.66	48.33
Zn ₂	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	22.33	25.66	64.66	60.66	38.00	62.33	53.33	30.33	56.33
Fe ₂	30.66	30.33	13.33	17.66	35.33	64.00	28.33	56.00	62.66
Fe ₃	28.33	27.66	28.33	46.33	28.66	41.33	61.33	35.66	46.66
Zn ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	20.33	14.33	20.33	54.00	53.33	38.00	60.33	60.66	47.33
Fe ₂	17.33	51.33	35.33	68.33	10.66	60.66	60.33	24.33	54.33
Fe ₃	23.33	52.66	27.66	76.33	43.00	70.33	62.33	41.66	57.33
Zn ₀ Fe ₀ B ₀		22.66			42.33			46.33	
S. Em ±		3.90			7.95			3.14	
C.D. at 5%		10.92			22.26			8.71	

N.S. = Not significant.

promoted plant height to the maximum extent, respectively in 1983, 1984 and 1985 as compared to 22.66, 42.33 and 46.33 cm under control. Apart from these treatments, few other treatments also enhanced the height significantly.

Trunk girth :

A perusal of data recorded in Table 3 revealed that all the micronutrients used in this experiment have brought about significant variation in enhancing the trunk girth in all the years. Among the nutrients, Zn and B promoted trunk girth with the increase in concentration, while in case of Fe, the trunk girth was maximum under the lowest concentration in almost all the years. The data also indicated that trunk girth was maximum in 1985 and was lowest in 1983. In 1985, the highest increase in trunk girth was under 0.4 per cent concentration of Zn (4.71 cm) and B (4.65 cm) and 0.2 per cent of Fe (4.46 cm).

Like the individual effect, the various first and second order interactions also significantly increased the trunk girth. Of the various interactions Zn_3Fe_1 , Zn_3B_3 and Fe_2B_3 proved most effective in this regard in almost all the years of the investigation. The maximum increase in girth was noticed with $Zn_2Fe_3B_3$ (3.03 cm) in 1983, with $Zn_1Fe_1B_3$ (5.50 cm) in 1984 and $Zn_3Fe_3B_2$ (5.58 cm) in 1985. The corresponding figures under control were 1.30, 3.43 and 4.34 cm.

Spread of the plant head :

It was revealed from the data recorded in Tables 4.1 and 4.2 that in 1983 the highest rate of Zn enhanced the spread of the canopy

Table 3. Variation in trunk girth due to treatment with three levels of Zn, Fe and B and their interactions (expressed as increase over last year)

Zn levels	Increase in trunk girth (cm)			Fe levels	Increase in trunk girth (cm)			B levels	Increase in trunk girth (cm)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	1.84	3.90	4.28	Fe ₁	2.15	3.95	4.32	B ₁	1.87	3.25	3.93
Zn ₂	2.01	3.18	3.97	Fe ₂	1.90	3.84	4.46	B ₂	2.03	3.80	4.39
Zn ₃	2.19	4.16	4.71	Fe ₃	2.01	3.44	4.18	B ₃	2.15	4.19	4.65
S. Em ±	0.02	0.03	0.052		0.02	0.03	0.052		0.02	0.03	0.052
C.D. at 5%	0.05	0.07	0.147		0.05	0.07	0.147		0.05	0.07	0.147
<u>Zn x Fe</u>											
		1983	1984	1985		1984	1985		1985	Fe ₂	Fe ₃
Zn ₁	2.19	1.32	2.03	Fe ₃	Fe ₁	Fe ₂	Fe ₃		Fe ₁	Fe ₂	Fe ₃
Zn ₂	2.15	1.89	2.01		4.21	4.05	3.45		4.36	4.68	3.93
Zn ₃	2.11	2.50	1.98		3.40	3.59	2.54		3.92	4.17	3.82
S. Em ±		0.03			4.26	3.89	4.33		4.81	4.54	4.79
C.D. at 5%		0.08				0.05				0.091	
						0.13				0.256	
<u>Zn x B</u>											
		B ₁	B ₂	B ₃	B ₁	B ₂	B ₃		B ₁	B ₂	B ₃
Zn ₁	1.91	1.62	2.00		3.23	4.19	4.29		4.25	4.18	4.41
Zn ₂	1.80	2.23	2.01		2.31	3.42	3.81		3.06	4.41	4.44
Zn ₃	1.89	2.25	2.44		4.21	3.80	4.47		4.47	4.58	5.09
S. Em ±		0.03				0.05				0.091	
C.D. at 5%		0.08				0.13				0.256	

Contd...

Contd....Table 3.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	2.08	2.25	2.11	3.85	3.76	4.26	3.99	4.40	4.57
Fe ₂	1.94	1.84	1.93	3.41	3.66	4.47	4.25	4.11	5.04
Fe ₃	1.58	2.02	2.40	2.49	4.00	3.87	3.54	4.66	4.33
S. Em ±		0.03			0.05			0.091	
C.D.at 5%		0.08			0.13			0.256	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	2.15	1.91	2.51	3.93	3.21	5.50	4.01	3.84	4.86
Fe ₁									
Fe ₂	1.51	0.90	1.56	3.50	5.43	3.23	4.88	4.99	4.16
Fe ₃	2.09	2.07	1.93	2.27	3.94	4.14	3.86	3.72	4.21
Zn ₂	2.55	2.30	1.60	2.82	4.37	3.01	3.34	4.86	3.57
Fe ₁									
Fe ₂	2.03	2.25	1.41	2.81	2.72	5.26	3.41	3.67	5.43
Fe ₃	0.84	2.15	3.03	1.30	3.18	3.16	2.43	4.71	4.34
Zn ₃	1.55	2.54	2.24	4.80	3.71	4.28	4.63	4.51	5.30
Fe ₁									
Fe ₂	2.30	2.37	2.84	3.94	2.81	4.94	4.46	3.65	5.53
Fe ₃	1.83	1.85	2.26	3.90	4.90	4.19	4.33	5.58	4.46
Zn ₀ Fe ₀ B ₀		1.30			3.43			4.34	
S. Em ±		0.05			0.08			0.15	
C.D.at 5%		0.15			0.23			0.44	

to the maximum extent in both the directions. However, differential effect was observed in 1984 and 1985 with same chemical. In these years no significant variation was recorded in North-South direction. Spraying of 0.1 per cent iron proved effective in this regard than other concentration used in the experiment, in all the years. In 1985, Fe failed to exhibit any significant effect to increase the spread of canopy in North-South direction. As regards the effect of boron it was observed that as much as 51.66 and 55.48 cm spread of the canopy in East-West direction was noted when sprayed at 0.4 per cent in 1983 and 1984 respectively, whereas 46.18 cm was noted in 1985 under B_2 (0.2%). B_2 treatment showed beneficial effect with respect to spread of plant canopy in North-South direction as compared to other concentrations in 1983 and 1985 whereas such effect was obtained under B_3 in 1984 (62.03 cm).

The various first order interactions of Zn, Fe and B resulted in significant variation in enhancing the East-West and North-South spread of the plant canopy. Among the various combinations of Zn and Fe, Zn_2Fe_1 , Zn_1Fe_1 and Zn_2Fe_1 proved most effective in increasing the spread of the canopy in East-West direction, while treatments Zn_3Fe_3 , Zn_2Fe_2 and Zn_3Fe_3 showed similar effect in North-South direction in the year 1983, 1984 and 1985 respectively. Among the interactions of Zn and B, Zn_3B_3 , Zn_1B_3 and Zn_3B_3 treatment, with respect to East-West and Zn_3B_3 , Zn_2B_3 and Zn_3B_3 treatments with respect to North-South direction caused maximum spread of the canopy in the years 1983, 1984 and 1985 respectively. The treatment Fe_3B_3 proved effective in all the

years with regard to spread of canopy in the East-West direction whereas differential effect was noted in North-South direction. Among the three years, the highest increase of 80.55 cm in North-South direction was recorded under Fe_1B_1 in 1984.

The various second order interactions caused a wide and significant variation among the treatments in all the three years in both the directions and the variation was maximum in 1983. As much as 88.33 and 85.33 cm plant spread occurred in 1983 and 1984, respectively under the treatment $Zn_3Fe_3B_3$ and in 1985 under $Zn_1Fe_1B_2$ plant spread was 62.33 cm as compared to 40.33, 43.66 and 39.66 cm under control in East-West direction. The same treatments caused 67.33, 92.66 cm spread of canopy in 1983, 1984 and 52.66 cm in North-South direction in 1985 as compared to 47.66, 57.33 and 45.66 cm under control.

Percentage of flowering shoots :

The data recorded in Table 5 indicated that zinc at 0.2 and 0.4 per cent augmented the percentage of flowering shoots significantly over 0.1 per cent in 1985. The effect of Fe and B was also not pronounced and failed to bring about any significant effect in all the three years. In the 'on' years (1983 and 1985) Fe at higher rates showed beneficial effect in this regards, whereas reverse trend was observed in the 'off' year (1984). The effect of concentrations of B was not consistent.

Among the various first order interactions of Zn, Fe and B,

Table 4.1. Effect of three levels of Zn, Fe and B and their interactions on east-west spread of canopy (expressed as increase over last year)

Zn levels	Increase in spread(cm)			Fe levels	Increase in spread(cm)			B levels	Increase in spread(cm)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	25.18	51.00	37.51	Fe ₁	49.74	53.14	50.55	B ₁	33.40	41.92	39.62
Zn ₂	45.37	48.11	46.55	Fe ₂	40.25	43.74	43.48	B ₂	39.25	47.51	46.18
Zn ₃	53.77	45.81	45.62	Fe ₃	34.33	48.03	35.66	B ₃	51.66	55.48	43.88
S.Em ±	0.98	1.43	1.12		0.98	1.43	1.12		0.98	1.43	1.12
C.D. at 5%	2.76	4.01	3.15		2.76	4.01	3.15		2.76	4.01	3.15
					1983	1984	1985		1983	1984	1985
<u>Zn x Fe</u>				Fe ₁				Fe ₁			
Zn ₁	30.66	22.77	22.11	Fe ₂	58.77	47.11	47.11	Fe ₂	49.66	34.11	28.77
Zn ₂	61.33	44.11	30.66	Fe ₃	52.77	51.77	39.77	Fe ₃	55.11	48.33	36.22
Zn ₃	57.22	53.88	50.22		47.88	32.33	57.22		46.88	48.00	42.00
S.Em ±	1.70				2.48				1.95		
C.D. at 5%	4.78				6.94				5.46		
<u>Zn x B</u>				B ₁				B ₁			
Zn ₁	23.88	26.66	25.00	B ₂	36.44	53.88	62.66	B ₂	35.66	47.44	29.44
Zn ₂	34.33	45.33	56.44	B ₃	56.44	36.22	51.66	B ₃	45.55	45.55	48.55
Zn ₃	42.00	45.77	73.55		32.88	52.44	52.11		37.66	45.55	53.66
S.Em ±	1.70				2.48				1.95		
C.D. at 5%	4.78				6.94				5.46		

Contd....Table 4.1.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	48.33	54.11	46.77	50.44	55.22	53.77	49.22	55.55	46.88
Fe ₂	42.77	38.77	39.22	40.00	48.22	43.00	45.00	51.44	34.00
Fe ₃	9.11	24.88	69.00	35.33	39.11	69.66	24.66	31.55	50.77
S. Em ±		1.70			2.48			1.95	
C.D. at 5%		4.78			6.94			5.46	
Zn x Fe x B									
Zn ₁									
Fe ₁	50.33	27.33	14.33	48.33	57.66	70.33	58.00	62.33	28.66
Fe ₂	10.66	47.33	10.33	39.33	65.66	36.33	24.66	58.33	19.33
Fe ₃	10.66	5.33	50.33	21.66	38.33	81.33	24.33	21.66	40.33
Zn ₂									
Fe ₁	30.33	83.33	70.33	65.33	52.66	40.33	47.66	58.33	59.33
Fe ₂	66.33	35.33	30.66	45.33	37.66	72.33	61.66	47.66	35.66
Fe ₃	6.33	17.33	68.33	58.66	18.33	42.33	27.33	30.66	50.66
Zn ₃									
Fe ₁	64.33	51.66	55.66	37.66	55.33	50.66	42.00	46.00	52.66
Fe ₂	51.33	33.66	76.66	35.33	41.33	20.33	58.66	48.33	47.00
Fe ₃	10.33	52.00	88.33	25.66	60.66	85.33	22.33	42.33	61.33
Zn ₀ Fe ₀ B ₀									
S. Em ±		40.33			43.66			39.66	
C.D. at 5%		2.95			4.29			3.38	
		8.28			12.03			9.47	

Table 4.2. Effect of three levels of Zn, Fe and B and their interactions on north-south spread of the canopy (expressed as increase over last year)

Zn levels	Increase in spread(cm)			Fe levels	Increase in spread(cm)			B levels	Increase in spread(cm)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	34.96	54.37	40.14	Fe ₁	41.37	63.18	40.25	B ₁	27.07	47.37	36.25
Zn ₂	34.14	51.18	40.59	Fe ₂	31.77	55.37	40.14	B ₂	44.37	52.44	43.92
Zn ₃	42.25	56.29	40.85	Fe ₃	38.22	43.29	41.18	B ₃	39.92	62.03	41.41
S. Em ±	1.28	1.88	0.91		1.28	1.88	0.91		1.28	1.88	0.91
C.D. at 5%	3.59	N.S.	N.S.		3.59	5.27	N.S.		3.59	5.27	2.52
Zn x Fe											
		1983			1984				1985		
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃		
Zn ₂	50.66	32.44	21.77	69.88	47.22	46.00	45.66	40.11	34.66		
Zn ₃	32.11	36.11	34.22	60.22	61.33	32.00	37.44	43.44	40.88		
S. Em ±	41.33	26.77	58.66	59.44	57.55	51.88	37.66	36.88	48.00		
C.D. at 5%		2.22			3.26			1.57			
		6.23			9.12			4.37			
Zn x B											
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃		
Zn ₂	30.55	47.88	26.44	47.11	63.33	52.66	36.77	46.00	37.66		
Zn ₃	24.88	35.88	41.66	39.11	46.55	67.88	41.44	40.22	40.11		
S. Em ±	25.77	49.33	51.66	55.88	47.44	65.55	30.55	45.55	46.44		
C.D. at 5%		2.22			3.26			1.57			
		6.23			9.12			4.37			

Contd...

Contd... Table 4.2.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	27.88	64.77	31.44	80.55	58.77	50.22	32.44	49.22	39.11
Fe ₂	25.22	37.11	33.00	44.44	48.55	73.11	37.77	46.00	36.66
Fe ₃	28.11	31.22	55.33	17.11	50.00	62.77	38.55	36.55	48.44
S. Em ±	2.22				3.26			1.57	
C.D. at 5%	6.23				9.12			4.37	
Zn x Fe x B									
Zn ₁									
Fe ₁	51.66	74.66	25.66	88.66	71.33	49.66	45.33	52.66	39.00
Fe ₂	16.66	47.33	33.33	43.33	40.33	58.00	31.33	46.66	42.33
Fe ₃	23.33	21.66	20.33	9.33	78.33	50.33	33.66	38.66	31.66
Zn ₂									
Fe ₁	15.66	50.33	30.33	80.66	54.33	45.66	28.33	47.33	36.66
Fe ₂	48.33	43.66	16.33	29.33	42.00	112.66	52.33	52.66	25.33
Fe ₃	10.66	13.66	78.33	7.33	43.33	45.33	43.66	20.66	58.33
Zn ₃									
Fe ₁	16.33	69.33	38.33	72.33	50.66	55.33	28.66	47.66	41.66
Fe ₂	10.66	20.33	49.33	60.33	63.33	48.66	29.66	38.66	42.33
Fe ₃	50.33	58.33	67.33	34.66	28.33	92.66	38.33	50.33	55.33
Zn ₀ Fe ₀ B ₀		47.66			57.33			45.66	
S. Em ±		3.85			5.64			2.73	
C.D. at 5%		10.78			15.81			7.58	

N.S. = Not significant.

various treatments of Zn and Fe brought about significant variations only in 1983. In this year the largest percentage of flowering shoots (61.04%) was obtained under the treatment Zn_3Fe_3 . No significant variation was noted in 1984 and 1985. Interactions of Zn + B and Fe + B also proved less effective in this respect.

Treatment with Zn + Fe + B caused significantly higher percentage of flowering shoots over control only in 1985 ('on' year). The highest number of shoots produced panicle under the treatment $Zn_2Fe_3B_1$, while under control 41.46 per cent shoots produced panicles.

Sex ratio :

Treatments caused wide range of variation in expressing sex of flowers in the panicle. Relative number of hermaphrodite flowers over male flowers in a panicle was greatest under the treatment $Zn_1Fe_1B_1$ in all the years, while development of male flowers were promoted with $Zn_3Fe_3B_3$. Treatment $Zn_2Fe_2B_1$ also showed a tendency to reduce the proportion of male flowers as compared to other treatments both during 'on' and 'off' years. Trees under control in general recorded an increased proportion of male flowers (Table 6).

Number of fruits/plant :

The data recorded in Table 7 on the number of fruits harvested per plant indicated that irrespective of 'on' and 'off' years, concentrations of Zn and B failed to bring about any significant variation in fruit number, while treatment with Fe brought about a significant variation in fruit number only in 'off' year (1984). In this

Table 5. Percentage of shoots produced panicle under different levels of Zn, Fe and B.

Zn levels	Percentage of flowering shoots			Percentage of flowering shoots			Percentage of flowering shoots					
	1983	1984	1985	1983	1984	1985	1983	1984	1985			
Zn ₁	53.66	32.21	46.11	51.87	35.92	48.95	B ₁	55.78	32.58	50.06		
Zn ₂	53.09	34.40	51.76	54.67	34.25	48.89	B ₂	49.51	34.57	49.91		
Zn ₃	52.66	35.98	51.39	52.16	32.42	51.42	B ₃	53.41	35.42	49.30		
S. Em ±	2.76	1.85	1.26	2.76	1.85	1.26		2.76	1.85	1.26		
C.D. at 5%	N.S.	N.S.	3.54	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		
<u>Zn x Fe</u>		1983			1984			1985				
Zn ₁	Fe ₁	52.20	56.56	51.32	Fe ₂	33.35	32.28	Fe ₃	47.74	42.52	48.06	
Zn ₂	Fe ₁	60.30	54.84	44.12	Fe ₂	32.89	33.83	Fe ₃	50.79	52.81	51.69	
Zn ₃	Fe ₁	43.13	52.62	61.04	Fe ₂	36.50	31.14	Fe ₃	48.33	51.35	54.51	
S. Em ±			4.78			3.21				2.19		
C.D. at 5%			13.40			N.S.				N.S.		
<u>Zn x B</u>		B ₁	B ₂	B ₃		B ₁	B ₂	B ₃		B ₁	B ₂	B ₃
Zn ₁	B ₁	56.22	49.22	54.44	B ₁	25.88	36.39	34.36	B ₁	42.03	47.55	48.74
Zn ₂	B ₁	55.18	52.21	51.87	B ₁	36.33	31.53	35.34	B ₁	55.39	50.17	49.73
Zn ₃	B ₁	55.96	46.91	53.91	B ₁	35.55	35.81	36.58	B ₁	52.75	52.01	49.43
S. Em ±			4.78			3.21					2.19	
C.D. at 5%			N.S.			N.S.					6.14	

Contd...

Contd....Table 5.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	60.84	42.21	52.58	30.68	37.49	39.58	50.59	49.86	46.40
Fe ₂	53.26	57.55	53.20	34.10	34.23	34.41	47.99	49.11	49.57
Fe ₃	53.26	48.79	54.44	32.97	32.00	32.28	51.59	50.74	51.93
S. Em ±		4.78			3.21			2.19	
C.D. at 5%		N.S.			N.S.			N.S.	
Zn x Fe x B									
Zn ₁									
Fe ₁	66.44	38.55	51.62	26.28	35.14	31.55	49.80	48.06	45.36
Fe ₂	57.98	56.31	55.39	21.78	39.12	39.15	37.71	43.97	45.90
Fe ₃	44.24	53.39	56.32	29.57	34.91	32.37	38.59	50.62	55.00
Zn ₂									
Fe ₁	62.18	58.39	60.32	34.54	30.70	44.19	46.73	52.20	53.40
Fe ₂	52.75	61.64	50.14	38.55	33.02	27.11	56.32	51.37	50.75
Fe ₃	50.61	36.61	45.15	35.91	30.87	34.72	60.13	46.94	45.01
Zn ₃									
Fe ₁	53.90	29.68	48.80	31.22	46.65	43.00	55.25	49.34	40.41
Fe ₂	49.07	54.70	54.09	41.98	30.56	36.98	49.95	51.99	52.11
Fe ₃	64.92	56.36	61.84	33.44	30.21	29.76	53.06	54.68	55.78
Zn ₀ Fe ₀ B ₀		42.81			29.93			41.46	
S. Em ±		8.29			5.56			3.80	
C.D. at 5%		N.S.			N.S.			10.64	

N.S. = Not significant
(Data are angularly transformed)

Table 6. Effect of three levels of Zn, Fe and B and their interactions on sex ratio.

Treatments	Distribution of sex (hermaphrodite: male)		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	1:0.97	1:1.44	1:1.67
Zn ₁ Fe ₁ B ₂	1:6.85	1:1.88	1:2.34
Zn ₁ Fe ₁ B ₃	1:2.00	1:5.92	1:3.45
Zn ₁ Fe ₂ B ₁	1:1.67	1:2.02	1:2.37
Zn ₁ Fe ₂ B ₂	1:5.67	1:3.86	1:3.92
Zn ₁ Fe ₂ B ₃	1:7.92	1:2.39	1:4.45
Zn ₁ Fe ₃ B ₁	1:1.40	1:2.52	1:2.28
Zn ₁ Fe ₃ B ₂	1:7.42	1:2.53	1:3.67
Zn ₁ Fe ₃ B ₃	1:1.08	1:4.04	1:3.88
Zn ₂ Fe ₁ B ₁	1:4.36	1:4.27	1:4.56
Zn ₂ Fe ₁ B ₂	1:1.10	1:2.03	1:2.14
Zn ₂ Fe ₁ B ₃	1:2.24	1:4.77	1:4.18
Zn ₂ Fe ₂ B ₁	1:1.79	1:1.89	1:2.35
Zn ₂ Fe ₂ B ₂	1:5.01	1:3.60	1:3.77
Zn ₂ Fe ₂ B ₃	1:1.82	1:2.83	1:2.64
Zn ₂ Fe ₃ B ₁	1:6.63	1:3.02	1:3.75
Zn ₂ Fe ₃ B ₂	1:2.81	1:2.82	1:2.93
Zn ₂ Fe ₃ B ₃	1:4.64	1:5.19	1:4.36
Zn ₃ Fe ₁ B ₁	1:8.47	1:2.64	1:2.92
Zn ₃ Fe ₁ B ₂	1:5.07	1:2.10	1:2.85
Zn ₃ Fe ₁ B ₃	1:2.52	1:1.42	1:2.57
Zn ₃ Fe ₂ B ₁	1:1.42	1:3.95	1:3.28
Zn ₃ Fe ₂ B ₂	1:1.74	1:2.35	1:2.46
Zn ₃ Fe ₂ B ₃	1:1.43	1:2.93	1:3.44
Zn ₃ Fe ₃ B ₁	1:3.51	1:2.97	1:3.83
Zn ₃ Fe ₃ B ₂	1:1.31	1:5.15	1:4.36
Zn ₃ Fe ₃ B ₃	1:7.03	1:5.03	1:5.10
Zn ₀ Fe ₀ B ₀	1:5.42	1:4.16	1:4.83

year, the number of fruits at harvest decreased as the concentration of Fe increased.

Different interactions of Zn and Fe caused a significant variation only in 1985 ('on' year) and the maximum number of fruits (42) were harvested under the treatment Zn_2Fe_2 . In 1983 and 1984 no significant variation was recorded. Among the interaction of Zn+B and Fe+B significant variation was noted only in 1983 ('on' year). The largest number of fruits i.e. 29 and 32 were obtained when the plants were treated with Zn_3B_2 and Fe_1B_1 respectively.

In 1983, the highest number of 40 fruits occurred per plant under the treatment $Zn_1Fe_3B_3$ as against 18 fruits per plant under control. Treatment $Zn_3Fe_1B_1$ also produced significantly larger number of fruits (38) per plant.

Fruit weight :

As regards the individual effect of Zn, Fe and B it was observed that all these chemicals caused significant differences in average fruit weight only in the 'on' years (1983 and 1985) whereas in the 'off' year no significant variation was observed. Both in 1983 and 1985, treatment with Zn at highest concentration resulted in the production of heaviest fruits but no such effect was observed in case of iron and boron (Table 8).

It was also revealed that interactions of zinc and iron, zinc and boron and iron and boron brought about significant variation

Table 7. Number of fruits harvested per plant under different levels of Zn, Fe and B.

Zn levels	No. of fruits/plant			Fe levels	No. of fruits/plant			B levels	No. of fruits/plant		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	22	8	32	Fe ₁	24	10	34	B ₁	24	6	34
Zn ₂	20	7	35	Fe ₂	21	9	34	B ₂	23	7	36
Zn ₃	25	8	38	Fe ₃	23	4	37	B ₃	21	9	36
S. Em ±	1.81	1.54	2.03		1.81	1.54	2.03		1.81	1.54	2.03
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	4.32	N.S.		N.S.	N.S.	N.S.
1983											
<u>Zn x Fe</u>											
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂
	28	14	25	6	11	5	32	27	36	32	27
Zn ₂	20	22	18	11	5	4	29	42	35	29	42
Zn ₃	23	25	25	12	9	3	41	33	41	41	33
S. Em ±		3.14			2.67				3.51		
C.D. at 5%		N.S.			N.S.				9.83		
1984											
<u>Zn x B</u>											
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂
	19	22	26	2	9	11	27	35	34	27	35
Zn ₂	26	17	17	8	5	7	34	35	36	34	35
Zn ₃	27	29	18	6	8	10	40	38	37	40	38
S. Em ±		3.14			2.67				3.51		
C.D. at 5%		8.79			N.S.				N.S.		

Contd...

Contd....Table 7.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	32	23	17	6	10	13	36	32	34
Fe ₂	19	22	21	7	9	10	33	38	30
Fe ₃	21	22	25	3	3	6	32	38	42
S. Em ±		3.14			2.67			3.51	
C.D. at 5%		8.79			N.S.			N.S.	
Zn x Fe x B									
Zn ₁									
Fe ₁									
Fe ₂									
Fe ₃									
Zn ₂									
Fe ₁									
Fe ₂									
Fe ₃									
Zn ₃									
Fe ₁									
Fe ₂									
Fe ₃									
Zn o Fe ₀ B ₀									
S. Em ±									
C.D. at 5%									

N.S. = Not significant.

in fruit weight only in the 'on' years (1983 and 1985). Among the interactions, Zn_2Fe_1 (635.66 g), Zn_3B_1 (650.00 g) and Fe_3B_1 (651.11 g) caused greater increases in fruit weight as compared to control in 1985.

While considering second order interactions it was observed that the average weight of individual fruit was increased by 299.00 g, 135.00 g and 69.33 g under $Zn_3Fe_3B_2$, $Zn_2Fe_3B_2$ and $Zn_3Fe_1B_2$ over control in 1983, 1984 and 1985 respectively.

Fruit yield :

The data recorded in Table 9 indicate that Zn, Fe and B exhibited differential effects in increasing fruit yield. The different concentrations of Zn, brought about significant variations in the year 1983 and 1985 ('on' years) and the maximum yield occurred under Zn_3 . In 1984, however, no significant variation was noted except Fe and the highest yield was recorded under when treated with 0.1 per cent Fe and the yield was decreased as the concentration of Fe increased.

The interactions of Zn+Fe, Zn+B and Fe+B brought about significant variations only in 1983 ('on' year). In other years the experiment showed no effect. In 1983 as much as 15.75, 17.96 and 18.61 kg fruits/plant were obtained under Zn_3Fe_3 , Zn_3B_2 and Fe_1B_1 respectively.

Similar to the first order interactions of Zn, Fe and B their various second order interactions also augmented the yield of

Table 8. Effect of three levels of Zn, Fe and B and their interactions on fruit weight.

Zn levels	Fruit weight (g)			Fe levels	Fruit weight (g)			B levels	Fruit weight (g)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	522.59	623.74	594.70	Fe ₁	528.51	636.96	616.40	B ₁	514.96	628.00	630.00	
Zn ₂	511.55	645.11	610.18	Fe ₂	500.07	630.88	599.03	B ₂	546.18	645.74	598.66	
Zn ₃	556.33	631.96	620.33	Fe ₃	562.22	632.96	609.77	B ₃	529.66	627.07	596.55	
S. Em. ±	3.75	16.39	4.73		3.75	16.39	4.73		3.75	16.39	4.73	
C.D. at 5%	10.49	N.S.	13.25		10.49	N.S.	13.25		10.49	N.S.	13.25	
1983												
Zn x Fe	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	510.77	510.77	546.22	652.77	603.66	614.77	579.77	607.66	596.66	579.77	607.66	596.66
Zn ₂	469.22	535.11	531.33	666.77	628.44	646.11	635.66	582.44	612.44	635.66	582.44	612.44
Zn ₃	605.55	453.33	609.11	597.33	660.55	638.00	633.77	607.00	620.22	633.77	607.00	620.22
S. Em. ±	6.49			28.39			8.20			8.20		
C.D. at 5%	18.18			N.S.			22.95			22.95		
Zn x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	499.55	523.88	544.33	632.44	625.11	613.66	617.77	561.44	604.88	617.77	561.44	604.88
Zn ₂	480.55	494.33	560.77	628.55	693.22	613.55	622.22	613.00	595.33	622.22	613.00	595.33
Zn ₃	564.77	620.33	483.88	623.00	618.88	654.00	650.00	621.55	589.44	650.00	621.55	589.44
S. Em. ±	6.49			28.39			8.20			8.20		
C.D. at 5%	18.18			N.S.			22.95			22.95		

Contd...

Contd...Table 8.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	572.44	489.22	523.88	634.11	654.11	622.66	612.33	638.44	598.44
Fe ₂	472.55	522.55	505.11	644.88	604.22	643.55	626.55	591.77	578.77
Fe ₃	499.88	626.77	560.00	605.00	678.88	615.00	651.11	565.77	612.44
S. Em ±	6.49				28.39				8.20
C.D.at 5%	18.18				N.S.				22.95
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	550.33	430.66	551.33	631.66	678.33	648.33	552.33	574.33	612.66
Fe ₁	461.33	582.66	488.33	650.00	563.33	597.66	644.66	568.66	609.66
Fe ₂	487.00	558.33	593.33	615.66	633.33	595.00	656.33	541.33	592.33
Fe ₃	442.66	502.33	462.66	647.33	698.66	636.33	643.33	666.33	597.33
Zn ₂	537.66	459.33	608.33	635.00	637.66	612.66	588.66	595.33	563.33
Fe ₁	461.33	521.33	611.33	603.33	743.33	591.66	634.66	577.33	625.33
Fe ₂	724.33	534.66	557.66	623.33	585.33	583.33	641.33	674.66	585.33
Fe ₃	418.66	525.66	418.66	649.66	611.66	720.33	646.33	611.33	563.33
Zn ₃	551.33	800.66	475.33	596.00	659.66	691.66	662.33	578.66	619.66
Zn ₀ Fe ₀ B ₀	501.66				608.33			605.33	
S. Em ±	11.25				49.18			14.20	
C.D.at 5%	31.49				N.S.			39.76	

N.S. = Not significant.

TABLE 9. Yield of fruit as affected by three levels of Zn, Fe and B and their interactions.

Zn levels	Yield/plant (kg)			Fe levels	Yield/plant (kg)			B levels	Yield/plant (kg)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	11.80	4.76	22.91	Fe ₁	12.81	6.24	20.98	B ₁	12.67	3.44	21.12	
Zn ₂	10.09	4.23	21.19	Fe ₂	10.34	5.28	20.24	B ₂	12.41	4.51	21.61	
Zn ₃	14.24	5.06	23.78	Fe ₃	12.97	2.53	22.71	B ₃	11.05	6.10	21.21	
S. Em ±	0.99	0.96	1.22		0.99	0.96	1.22		0.99	0.96	1.22	
C.D. at 5%	2.77	N.S.	3.41		N.S.	2.68	N.S.		N.S.	N.S.	N.S.	
		1983			1984				1985			
<u>Zn x Fe</u>												
	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	14.12	7.26	14.02	4.41	6.44	3.44	18.49	16.66	21.72	18.54	24.12	20.93
Zn ₂	9.22	11.89	9.16	7.41	3.22	2.34	25.92	19.95	25.47	2.11	N.S.	
Zn ₃	15.11	11.88	15.75	7.16	6.18	1.83						
S. Em ±		1.71			1.66							
C.D. at 5%		4.81			N.S.							
<u>Zn x B</u>												
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	9.58	10.92	14.90	1.64	5.60	7.05	16.88	19.59	20.41	16.88	19.59	20.41
Zn ₂	12.32	8.35	9.59	4.72	3.22	4.75	20.89	21.32	21.38	20.89	21.32	21.38
Zn ₃	16.12	17.96	8.65	3.96	4.71	6.49	25.59	23.91	21.85	25.59	23.91	21.85
S. Em ±		1.71			1.66							
C.D. at 5%		4.81			N.S.							

Contd... Table 9.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	18.61	11.03	8.81	3.73	6.72	8.26	22.01	20.42	20.53
Fe ₂	9.06	11.50	10.46	4.69	4.85	9.26	20.56	22.68	17.49
Fe ₃	10.35	14.69	13.88	1.89	1.96	3.75	20.80	21.72	25.61
S. Em ±		1.71			1.66			2.11	
C.D. at 5%		4.81			N.S.			N.S.	
Zn x Fe x B									
Zn ₁									
Fe ₁	14.18	14.14	14.04	2.16	4.61	6.47	15.29	20.21	19.99
Fe ₂	8.07	6.63	7.07	1.38	9.43	8.50	16.74	19.52	13.72
Fe ₃	6.48	11.98	23.61	1.38	2.75	6.18	18.61	19.07	27.50
Zn ₂									
Fe ₁	13.91	6.64	7.10	6.71	5.71	9.00	23.29	14.17	18.15
Fe ₂	10.98	10.75	13.95	5.30	2.75	1.60	22.86	25.69	23.82
Fe ₃	12.08	7.65	7.74	2.15	1.21	3.66	16.54	24.08	22.17
Zn ₃									
Fe ₁	27.73	12.30	5.29	2.33	9.85	9.32	27.44	26.89	23.45
Fe ₂	8.13	17.13	10.36	7.41	2.37	8.77	22.09	22.83	14.94
Fe ₃	12.51	24.45	10.29	2.61	1.92	1.44	27.25	21.99	27.16
Zn ₀ Fe ₀ B ₀		9.05			2.93			13.08	
S. Em ±		2.97			2.87			3.65	
C.D. at 5%		8.33			N.S.			N.S.	

N.S. = Not significant.

fruit/plant markedly only in 1983 ('on' year) over control and the yield of fruit varied between 5.29 and 27.73 in 1983. The highest yield was noted under $Zn_3Fe_1B_1$. The corresponding figure under control was 9.05 kg only. The same treatment also gave the highest yield in 1985 (27.44 kg) which was 14.36 kg more over control (13.08kg).

Fruit size (length and breadth) :

Data presented in Tables 10.1 and 10.2 revealed that in 1985, the length as well as breadth of fruits increased appreciably under Zn_3 and B_1 . Iron failed to enhance the length of fruit significantly in all the years. Fruit breadth was however, found to vary significantly only in 1985 under Fe_1 over Fe_2 . In 1983 and 1984 the concentration effect was not consistent in these regards. Similar to Zn, the concentration effect of Fe and B was also not consistent.

The length of fruit varied appreciably only in the 'on' years due to treatments with Zn+Fe, Zn+B and Fe+B. In 1984 no variation in fruit length was observed.

In 1983 and 1985 the length and breadth of fruits varied significantly due to treatments with Zn+Fe+B. In 1983 the maximum length and breadth of 16.76 and 10.96 cm respectively were recorded under the treatment $Zn_3Fe_3B_2$.

Specific gravity :

A perusal of data presented in Table 11 revealed that the concentrations of micronutrients used in this experiment showed no consistent variation on the specific gravity of fruits. It was also

Table 10.1. Effect of three levels of Zn, Fe and B and their interactions on length of fruit.

Zn levels	Length of fruit (cm)			Fe levels	Length of fruit (cm)			B levels	Length of fruit (cm)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	14.24	15.11	14.81	Fe ₁	14.07	15.47	14.89	B ₁	14.08	15.52	15.03	
Zn ₂	14.20	15.89	14.48	Fe ₂	14.11	15.38	14.75	B ₂	14.24	15.82	14.67	
Zn ₃	14.24	15.55	15.17	Fe ₃	14.49	15.74	14.82	B ₃	14.37	15.22	14.75	
S. Em ±	0.19	0.27	0.05		0.19	0.27	0.05		0.19	0.27	0.05	
C.D. at 5%	N.S.	N.S.	0.15		N.S.	N.S.	N.S.		N.S.	N.S.	0.15	
<u>Zn x Fe</u>					1983	1984			1985			
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₂	14.25	14.01	14.45	15.41	14.64	15.28	14.67	14.91	14.83	14.67	14.91	14.83
Zn ₃	13.41	14.81	14.40	16.21	15.33	16.14	14.52	14.12	14.81	14.52	14.12	14.81
S. Em ±	14.56	13.53	14.63	14.80	16.06	15.80	15.47	15.21	14.82	15.47	15.21	14.82
C.D. at 5%	0.33	0.94		0.47	N.S.		0.09	0.26		0.09	0.26	
<u>Zn x B</u>												
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₂	14.14	13.90	14.67	14.93	15.34	15.06	15.07	14.40	14.94	15.07	14.40	14.94
Zn ₃	13.82	13.75	15.04	15.83	16.45	15.40	14.34	14.40	14.71	14.34	14.40	14.71
S. Em ±	14.27	15.06	13.38	15.80	15.66	15.20	15.67	15.22	14.61	15.67	15.22	14.61
C.D. at 5%	0.33	0.94		0.47	N.S.		0.09	0.26		0.09	0.26	

Contd....

Contd... Table 10.1.

FexB	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	14.71	13.68	13.83	15.75	15.66	15.00	14.72	15.13	14.82
Fe ₂	13.82	13.83	14.67	15.74	14.97	15.31	15.04	14.72	14.47
Fe ₃	13.68	15.20	14.60	15.06	16.82	15.34	15.33	14.69	14.96
S. Em ±		0.33			0.47			0.09	
C.D. at 5%		0.94			N.S.			0.26	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	14.63	13.46	14.66	15.13	15.66	15.43	13.86	14.70	15.46
	14.10	13.70	14.23	15.10	14.20	14.63	15.63	14.36	14.73
	13.70	14.53	15.13	14.56	16.16	15.13	15.73	14.13	14.63
Zn ₂	13.40	13.60	13.23	16.30	16.86	15.46	15.53	14.76	12.26
	14.50	13.36	16.56	15.80	14.86	15.23	13.96	14.16	14.23
	13.56	14.36	15.33	15.30	17.63	15.50	14.53	14.26	15.63
Zn ₃	16.10	14.00	13.60	15.83	14.46	14.10	15.76	15.93	14.73
	12.93	14.43	13.23	16.23	15.86	16.10	15.53	15.63	14.46
	13.80	16.76	13.33	15.33	16.66	15.40	15.73	14.10	14.63
Zn ₀ Fe ₀ B ₀		13.26			15.10			14.76	
S. Em ±		0.58			0.82			0.16	
C.D. at 5%		1.63			N.S.			0.45	

N.S. = Not significant.

Table 10.2. Effect of three levels of Zn, Fe and B and their interactions on breadth of fruit.

Zn levels	<u>Breadth of fruit(cm)</u>			Fe levels	<u>Breadth of fruit(cm)</u>			B levels	<u>Breadth of fruit(cm)</u>				
	1983	1984	1985		1983	1984	1985		1983	1984	1985		
Zn ₁	9.44	9.61	9.84	Fe ₁	9.48	9.86	9.93	B ₁	9.38	9.74	10.01		
Zn ₂	9.38	9.83	9.71	Fe ₂	9.33	9.65	9.67	B ₂	9.62	9.74	9.78		
Zn ₃	9.58	9.86	9.94	Fe ₃	9.59	9.78	9.88	B ₃	9.40	9.82	9.70		
S. Em ±	0.09	0.16	0.04		0.09	0.16	0.04		0.09	0.16	0.04		
C.D. at 5%	N.S.	N.S.	0.13		N.S.	N.S.	0.13		N.S.	N.S.	0.13		
<u>Zn x Fe</u>													
		1983				1984				1985			
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	
Zn ₂	9.27	9.36	9.67	9.67	9.55	9.61	9.84	9.83	9.86	9.84	9.83	9.86	
Zn ₃	9.38	9.36	9.41	9.83	9.83	9.83	9.87	9.42	9.82	9.87	9.42	9.82	
S. Em ±	9.80	9.26	9.70	10.08	9.57	9.86	10.07	9.76	9.97	10.07	9.76	9.97	
C.D. at 5%		0.16			0.28			0.08			0.08		
		N.S.			N.S.			N.S.			N.S.		
<u>Zn x B</u>													
		B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	9.38	9.32	9.61	9.55	9.70	9.58	10.0	9.70	9.84	10.0	9.70	9.84	
Zn ₂	9.14	9.42	9.60	10.03	9.82	9.64	9.84	9.67	9.60	9.84	9.67	9.60	
Zn ₃	9.61	10.14	9.01	9.64	9.70	10.24	10.18	9.96	9.66	10.18	9.96	9.66	
S. Em ±		0.16			0.28			0.08			0.08		
C.D. at 5%		0.45			N.S.			N.S.			N.S.		

Contd....

Contd...Table 10.2.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	9.63	9.33	9.50	10.24	9.68	9.66	10.08	10.14	9.56
Fe ₂	9.17	9.44	9.37	9.46	9.52	9.77	9.86	9.67	9.47
Fe ₃	9.33	10.11	9.34	9.52	10.01	9.83	10.07	9.52	10.06
S.Em ±	0.16	0.16			0.28			0.08	
C.D.at 5%	0.45	0.45			N.S.			0.23	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	9.53	8.63	9.66	9.73	10.03	9.26	9.56	9.93	10.03
Fe ₂	9.13	9.46	9.50	9.80	9.20	9.66	10.16	9.66	9.66
Fe ₃	9.50	9.86	9.66	9.13	9.86	9.83	10.26	9.50	9.83
Zn ₂	9.13	9.76	9.26	10.53	9.53	9.43	10.16	10.06	10.40
Fe ₁	9.50	9.00	9.60	9.50	10.06	9.93	9.46	9.63	9.16
Fe ₂	8.80	9.50	9.93	10.06	9.86	9.56	9.90	9.33	10.23
Fe ₃	10.23	9.60	9.56	10.46	9.50	10.30	10.53	10.43	9.26
Zn ₃	8.90	9.86	9.03	9.10	9.30	10.33	9.96	9.73	9.60
Fe ₁	9.70	10.96	8.43	9.36	10.30	10.10	10.06	9.73	10.13
Zn ₀ Fe ₀ B ₀	9.30	9.30			9.56			9.06	
S.Em ±	0.28	0.28			0.49			0.14	
C.D. at 5%	0.79	0.79			N.S.			0.40	

N.S. = Not significant.

observed that specific gravity of fruits increased as the concentration of zinc was increased almost in all the years, whereas a reverse trend was recorded in case of iron and boron.

The various interactions of Zn and Fe caused significant variation in the values of specific gravity of fruits only in 1983. In other years no such variations was noted. However, interactions of Zn+B and Fe+B brought about significant variations only in 1985.

Second order interactions of these nutrients showed significant effect only in the 'on' years. The highest specific gravity of 1.120 and 1.086 were recorded in the year 1983 and 1985 under $Zn_2Fe_3B_1$ and $Zn_3Fe_1B_2$ respectively as against 1.036 and 1.066 under control.

Pulp:fruit ratio :

The data recorded in Table 12, revealed that treatments with micronutrients proved effective in increasing the pulp content of fruits in both 'on' and 'off' years. In 1983 and 1985, the highest pulp content was recorded when plants were treated with 0.1 per cent each of Zn and Fe and 0.4 per cent of B and the pulp:fruit ratio decreased to 1:1.33 and 1:1.36 as compared to 1:1.45 and 1:1.52 under control in the 'on' years respectively. In the year 1984 ('off' year) treatment with $Zn_1Fe_1B_1$ decreased the ratio to 1:1.38 while under control the ratio was 1:1.48.

Total soluble solid (T.S.S.) :

The data on total soluble solid contents of fruit as

Table 11. Variation in specific gravity of fruit due to treatment with three levels of Zn, Fe and B and their interactions.

Zn levels	Specific gravity			Fe levels	Specific gravity			B levels	Specific gravity		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	1.038	1.041	1.052	Fe ₁	1.042	1.047	1.060	B ₁	1.052	1.051	1.058
Zn ₂	1.053	1.049	1.054	Fe ₂	1.044	1.044	1.054	B ₂	1.049	1.044	1.054
Zn ₃	1.057	1.044	1.060	Fe ₃	1.044	1.044	1.052	B ₃	1.047	1.039	1.055
S. Em ±	0.005	0.004	0.002		0.005	0.004	0.002		0.005	0.004	0.002
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.
1984											
Zn x Fe				Fe ₁					Fe ₁		
Zn ₁	1.046	1.040	1.030	Fe ₂	1.038	1.034	1.051	Fe ₃	1.052	1.058	1.046
Zn ₂	1.028	1.060	1.070		1.048	1.058	1.040		1.064	1.047	1.052
Zn ₃	1.051	1.042	1.078		1.054	1.038	1.041		1.064	1.056	1.060
S. Em ±		0.010				0.007				0.004	
C.D. at 5%		0.028				N.S.				N.S.	
1985											
Zn x B				B ₁					B ₁		
Zn ₁	1.044	1.033	1.038	B ₂	1.051	1.040	1.033	B ₃	1.065	1.051	1.041
Zn ₂	1.068	1.047	1.043		1.058	1.042	1.046		1.050	1.055	1.058
Zn ₃	1.044	1.067	1.060		1.045	1.050	1.038		1.058	1.055	1.066
S. Em ±		0.010				0.007				0.004	
C.D. at 5%		N.S.				N.S.				0.012	

Contd....Table 11.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	1.046	1.046	1.033	1.055	1.043	1.043	1.062	1.060	1.058
Fe ₂	1.098	1.054	1.050	1.052	1.046	1.033	1.065	1.053	1.044
Fe ₃	1.072	1.047	1.058	1.047	1.042	1.042	1.046	1.048	1.063
S. Em ±		0.010			0.007			0.004	
C.D. at 5%		N.S.			N.S.			0.012	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
	1.050	1.046	1.043	1.040	1.030	1.043	1.080	1.043	1.033
	1.056	1.040	1.023	1.056	1.040	1.016	1.060	1.083	1.033
	1.026	1.013	1.050	1.056	1.046	1.050	1.056	1.026	1.056
Zn ₂	1.043	1.033	1.010	1.066	1.050	1.030	1.060	1.050	1.083
	1.043	1.066	1.073	1.066	1.046	1.063	1.063	1.043	1.036
	1.120	1.043	1.046	1.043	1.030	1.046	1.026	1.073	1.056
Zn ₃	1.046	1.060	1.046	1.060	1.046	1.056	1.046	1.086	1.060
	1.016	1.056	1.053	1.053	1.053	1.030	1.073	1.033	1.063
	1.070	1.086	1.080	1.043	1.050	1.030	1.056	1.046	1.076
Zn ₀ Fe ₀ B ₀		1.036			1.046			1.066	
S. Em ±		0.017			0.013			0.008	
C.D. at 5%		0.049			N.S.			0.022	

N.S. = Not significant.

Table 12. Effect of three levels of Zn, Fe and B and their interactions on pulp:fruit ratio of mango cv. Fazli.

Treatments	Pulp:fruit ratio		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	1:1.37	1:1.38	1:1.40
Zn ₁ Fe ₁ B ₂	1:1.59	1:1.51	1:1.53
Zn ₁ Fe ₁ B ₃	1:1.33	1:1.47	1:1.36
Zn ₁ Fe ₂ B ₁	1:1.48	1:1.49	1:1.45
Zn ₁ Fe ₂ B ₂	1:1.34	1:1.47	1:1.38
Zn ₁ Fe ₂ B ₃	1:1.40	1:1.42	1:1.43
Zn ₁ Fe ₃ B ₁	1:1.45	1:1.42	1:1.48
Zn ₁ Fe ₃ B ₂	1:1.47	1:1.41	1:1.44
Zn ₁ Fe ₃ B ₃	1:1.34	1:1.50	1:1.42
Zn ₂ Fe ₁ B ₁	1:1.57	1:1.39	1:1.45
Zn ₂ Fe ₁ B ₂	1:1.47	1:1.47	1:1.44
Zn ₂ Fe ₁ B ₃	1:1.53	1:1.44	1:1.52
Zn ₂ Fe ₂ B ₁	1:1.42	1:1.46	1:1.49
Zn ₂ Fe ₂ B ₂	1:1.48	1:1.39	1:1.46
Zn ₂ Fe ₂ B ₃	1:1.41	1:1.46	1:1.43
Zn ₂ Fe ₃ B ₁	1:1.53	1:1.42	1:1.50
Zn ₂ Fe ₃ B ₂	1:1.48	1:1.47	1:1.48
Zn ₂ Fe ₃ B ₃	1:1.48	1:1.42	1:1.51
Zn ₃ Fe ₁ B ₁	1:1.33	1:1.45	1:1.38
Zn ₃ Fe ₁ B ₂	1:1.51	1:1.52	1:1.46
Zn ₃ Fe ₁ B ₃	1:1.42	1:1.50	1:1.48
Zn ₃ Fe ₂ B ₁	1:1.44	1:1.54	1:1.49
Zn ₃ Fe ₂ B ₂	1:1.39	1:1.50	1:1.42
Zn ₃ Fe ₂ B ₃	1:1.44	1:1.47	1:1.45
Zn ₃ Fe ₃ B ₁	1:1.37	1:1.48	1:1.41
Zn ₃ Fe ₃ B ₂	1:1.35	1:1.43	1:1.37
Zn ₃ Fe ₃ B ₃	1:1.46	1:1.46	1:1.48
Zn ₀ Fe ₀ B ₀	1:1.45	1:1.48	1:1.52

influenced by the treatments with micronutrients have been recorded in Table 13. It was observed that among the three micronutrients used in this experiment Zn increased the T.S.S. content significantly as the concentration of Zn was increased in all the years of the study. Fe was found effective only up to Fe₂ (0.2%) level and when the concentration was further increased to Fe₃ (0.4%) the T.S.S. content decreased. The effect of B was not consistent in this respect.

Similar to the individual effect of these nutrients, their various first order interactions were also found effective in bringing about significant variations in T.S.S. contents of fruits. Treatment with Zn₂Fe₂ increased T.S.S. to the maximum extent (22.00%) in 1983, whereas Zn₃Fe₂ resulted in the highest T.S.S. in 1984 and 1985. Among the various combinations of Zn and B, the most effective treatment was Zn₃B₁. As much as 21.86 per cent T.S.S. was obtained under Fe₂B₃ in 1983, however, in the last two years treatment with Fe₂B₁ proved superior to other combinations in this regard.

A number of second order interactions resulted in significant enhancement of total soluble solid contents of fruits over control in all the years. From the results recorded over a period of 3 years, the highest T.S.S. content of 24.40 per cent was noted in 1983 under Zn₂Fe₂B₃ compared to 18.40 per cent under control.

Total sugar :

It was conspicuous from the data recorded in Table 14 that 0.4 per cent concentration of Zn significantly increased the total

Contd....Table 13.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	20.00	19.40	20.33	18.93	18.97	18.88	19.20	19.37	18.60
Fe ₂	20.06	19.80	21.86	19.88	19.44	19.44	19.57	19.28	19.17
Fe ₃	19.40	20.00	18.66	18.24	18.31	18.44	18.60	19.08	18.82
S.Em ±		0.12			0.13			0.06	
C.D.at 5%		0.35			0.36			0.19	
Zn x Fe x B									
Zn ₁									
Fe ₁	19.20	18.80	19.80	17.53	18.60	19.06	19.73	19.11	19.00
Fe ₂	18.00	19.60	20.80	19.26	21.06	18.46	19.80	19.86	18.40
Fe ₃	19.60	18.00	21.00	17.53	17.73	18.53	18.73	19.33	18.40
Zn ₂									
Fe ₁	19.80	20.40	17.60	19.86	18.86	19.00	18.66	19.73	18.00
Fe ₂	21.60	20.00	24.40	19.40	18.13	20.13	18.86	18.93	19.66
Fe ₃	18.60	20.40	17.60	18.40	17.30	19.13	18.06	19.13	18.53
Zn ₃									
Fe ₁	21.00	19.00	23.60	19.40	19.46	18.60	19.20	19.26	18.80
Fe ₂	20.60	19.80	20.40	21.00	19.13	19.73	20.66	19.06	19.46
Fe ₃	20.00	21.60	17.40	18.80	19.40	18.83	19.00	18.80	19.53
Zn ₀ Fe ₀ O		18.40			17.53			18.73	
S.Em ±		0.21			0.22			0.11	
C.D.at 5%		0.61			0.63			0.33	

N.S. = Not significant.

sugar content of fruits in all the three years, whereas Fe showed differential effects in different years. In 1983 the highest value of 13.98 per cent sugar was recorded under 0.1 per cent. On the other hand, maximum content was noted under 0.2 per cent Fe in the subsequent years. Boron at 0.4 per cent enhanced it in the first two years and at 0.2 per cent in the last year.

The highest contents of 16.33, 15.44 and 15.81 per cent total sugar were obtained under $Zn_3Fe_1B_3$ in the first two years and under $Zn_3Fe_2B_1$ in the last year respectively. The corresponding figures under control were 12.42, 11.84 and 13.05 per cent.

Reducing sugar :

It was revealed from the Table 15 that in general, the intermediate concentrations of micronutrients used in the present experiment showed beneficial effect in increasing the reducing sugar content of fruits in all the years. It was also recorded that reducing sugar content of fruits was higher in 1983. In the later years, there had been no conspicuous differences in the values of reducing sugar. In all the years the highest concentration of the micronutrients caused significant reduction in the reducing sugar content of fruits except boron in 1983 and 1984.

Among the first order interactions of the nutrients, the treatment Zn_2Fe_2 resulted increased reducing sugar content to the maximum extent in 1983 (4.84%) and 1984 (4.03%) while in 1985(4.16%) the treatment Zn_3Fe_2 caused maximum enhancement in reducing sugar.

Table 14. Effect of three levels of Zn, Fe and B and their interactions on total sugar content of fruit.

Zn levels	Total sugar content (% fresh weight)			Fe levels	Total sugar content (% fresh weight)			B levels	Total sugar content (% fresh weight)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	13.00	11.92	13.54	Fe ₁	13.98	12.64	13.16	B ₁	12.72	12.27	13.61	
Zn ₂	13.44	12.56	12.62	Fe ₂	13.70	12.91	14.07	B ₂	13.44	11.68	13.69	
Zn ₃	14.07	12.99	13.86	Fe ₃	12.90	11.91	12.80	B ₃	14.41	13.52	12.73	
S. Em ±	0.02	0.24	0.13		0.02	0.24	0.13		0.02	0.24	0.13	
C.D. at 5%	0.06	0.68	0.36		0.06	0.68	0.36		0.06	0.68	0.36	
<u>Zn x Fe</u>												
		1983			1984				1985			
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₂	12.92	13.13	13.13	11.89	12.35	11.51	14.19	13.50	12.95	14.19	13.50	12.95
Zn ₃	14.46	13.68	12.18	13.14	13.57	10.99	12.43	13.90	11.53	12.43	13.90	11.53
S. Em ±	14.55	14.28	13.38	12.89	12.83	13.24	12.88	14.81	13.91	12.88	14.81	13.91
C.D. at 5%		0.03			0.42			0.22			0.22	
		0.10			1.17			0.62			0.62	
<u>Zn x B</u>												
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	11.53	13.39	14.27	10.84	11.55	13.35	14.47	13.74	12.41	14.47	13.74	12.41
Zn ₂	13.39	13.05	13.88	11.71	12.44	13.55	12.04	13.73	12.09	12.04	13.73	12.09
Zn ₃	13.25	13.88	15.09	14.27	11.04	13.65	14.30	13.59	13.70	14.30	13.59	13.70
S. Em ±		0.03			0.42			0.22			0.22	
C.D. at 5%		0.10			1.17			0.62			0.62	

Contd....

Contd....Table 14.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	13.32	13.30	15.32	12.23	11.11	14.58	13.27	13.87	12.35
Fe ₂	13.04	14.27	13.78	12.81	12.86	13.07	14.61	14.64	12.95
Fe ₃	11.81	12.75	14.13	11.78	11.06	12.89	12.94	12.55	12.91
S. Em ±		0.03			0.42			0.22	
C.D. at 5%		0.10			1.17			0.62	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	12.10	12.42	14.25	11.18	11.45	13.05	14.01	13.91	13.64
Fe ₂	11.24	13.85	14.28	11.37	12.03	13.64	14.65	14.28	11.57
Fe ₃	11.22	13.90	14.28	9.98	11.18	13.37	13.78	13.05	12.01
Zn ₂									
Fe ₁	14.45	13.57	15.38	11.84	12.31	15.27	12.04	14.35	10.91
Fe ₂	14.20	14.35	12.50	13.05	13.64	14.01	13.37	15.01	13.33
Fe ₃	11.54	11.24	13.76	10.24	11.37	11.36	10.72	11.84	12.04
Zn ₃									
Fe ₁	13.42	13.92	16.33	13.68	9.56	15.44	12.78	13.37	12.50
Fe ₂	13.65	14.62	14.58	14.01	12.90	11.57	15.81	14.64	13.96
Fe ₃	12.68	13.11	14.37	15.12	10.64	13.96	14.33	12.77	14.65
Zn ₀ Fe ₀ B ₀		12.42			11.84			13.05	
S. Em ±		0.06			0.73			0.38	
C.D. at 5%		0.18			2.04			1.08	

Table 15. Effect of three levels of Zn, Fe and B and their interactions on reducing sugar content of fruit.

Zn levels	Reducing sugar content (% fresh weight)			Fe levels	Reducing sugar content (% fresh weight)			B levels	Reducing sugar content (% fresh weight)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	4.23	3.60	3.93	Fe ₁	4.43	3.57	3.70	B ₁	4.54	3.56	3.78	
Zn ₂	4.76	3.82	3.58	Fe ₂	4.73	3.75	3.90	B ₂	4.54	3.62	3.85	
Zn ₃	4.54	3.22	3.81	Fe ₃	4.37	3.33	3.72	B ₃	4.45	3.48	3.69	
S. Em ±	0.04	0.09	0.03		0.04	0.09	0.03		0.04	0.09	0.03	
C.D. at 5%	0.11	0.27	0.10		0.11	0.27	0.10		N.S.	N.S.	0.10	
<u>Zn x Fe</u>		1983				1984				1985		
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₂	3.94	4.78	3.97	3.82	3.72	3.26	4.01	3.89	4.01	3.89	3.89	3.89
Zn ₃	4.81	4.84	4.62	3.71	4.03	3.73	3.49	3.65	3.49	3.65	3.65	3.60
S. Em ±	4.54	4.56	4.51	3.18	3.51	2.99	3.60	4.16	3.60	4.16	3.67	3.67
C.D. at 5%	0.07	0.19			0.17			0.06		0.06		
<u>Zn x B</u>					N.S.			0.18		0.18		
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₂	4.36	4.37	3.96	3.75	3.89	3.16	4.09	4.13	4.09	4.13	3.57	3.57
Zn ₃	4.81	4.76	4.71	3.87	3.69	3.91	3.21	3.76	3.21	3.76	3.77	3.77
S. Em ±	4.44	4.49	4.69	3.05	3.27	3.35	4.03	3.67	4.03	3.67	3.67	3.73
C.D. at 5%	0.07	0.19			0.17			0.06		0.06		
					0.48			0.18		0.18		

Contd...

Contd...Table 15.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	4.55	4.50	4.25	3.67	3.50	3.54	3.81	3.95	3.33
Fe ₂	4.55	4.43	5.20	3.75	3.80	3.71	4.07	3.82	3.81
Fe ₃	4.51	4.70	3.90	3.26	3.55	3.18	3.44	3.79	3.93
S. Em ±	0.07				0.17			0.06	
C.D. at 5%	0.19				N.S.			0.18	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁									
Fe ₁	4.32	4.41	3.10	4.28	3.81	3.39	4.28	3.93	3.82
Fe ₂	4.61	4.34	5.40	3.56	4.34	3.27	4.17	4.47	3.04
Fe ₃	4.16	4.38	3.37	3.42	3.53	2.84	3.82	4.00	3.86
Zn ₂									
Fe ₁	4.72	4.54	5.18	3.79	3.42	3.93	3.19	4.25	3.05
Fe ₂	4.95	4.37	5.20	4.30	4.03	3.76	3.41	3.16	4.38
Fe ₃	4.76	5.37	3.74	3.51	3.64	4.05	3.03	3.89	3.88
Zn ₃									
Fe ₁	4.61	4.54	4.48	2.94	3.28	3.30	3.98	3.67	3.15
Fe ₂	4.10	4.58	5.00	3.38	3.04	4.12	4.65	3.84	4.00
Fe ₃	4.61	4.35	4.58	2.84	3.49	2.64	3.48	3.50	4.05
Zn ₀ Fe ₀ B ₀		4.53			3.49			3.47	
S. Em ±		0.12			0.29			0.11	
C.D. at 5%		0.33			N.S.			0.32	

N.S. = Not significant.

In 1983 the highest value of 5.40 per cent was obtained under $Zn_1Fe_2B_3$ compared to 4.53 per cent under control.

Non-reducing sugar :

The non-reducing sugar content was also increased significantly as the concentration of Zn was increased in all the years. On the other hand, Fe exhibited a reverse trend in this regard and the effect of B was not consistent. The highest concentration of B resulted in significant increase in non-reducing sugar content in 1983 and 1984, while in 1985 the lowest concentration of it did so.

In all the years a number of treatments brought about significant variations in the values of non-reducing sugar. As much as 10.10, 10.71 and 10.51 per cent non-reducing sugar were recorded under the treatment Zn_3Fe_2 , Zn_3B_1 and Fe_1B_3 in 1985, 1984 and 1983 respectively.

Among the various interactions, $Zn_3Fe_1B_3$, $Zn_3Fe_3B_1$ and $Zn_2Fe_2B_2$ increased the non-reducing sugar content to the maximum extent of 11.25, 11.66 and 11.25 per cent in the year 1983, 1984 and 1985 respectively. The corresponding figures under control were 7.48, 7.93 and 9.10 (Table 16).

Fruit acidity :

From the data in Table 17, it is revealed that fruit acidity as expressed in terms of per cent citric acid was found to increase significantly at the highest level of Zn in the first two years and

Table 16. Effect of three levels of Zn, Fe and B and their interactions on non-reducing sugar content of fruit.

Zn levels	Non-reducing sugar content(% fresh weight)		Fe levels		Non-reducing sugar content(% fresh weight)		B levels		Non-reducing sugar content(% fresh weight)	
	1983	1984	1985	1983	1984	1985	1983	1984	1985	1985
Zn ₁	8.38	7.89	9.15	Fe ₁	8.62	8.98	B ₁	7.77	8.29	9.35
Zn ₂	8.24	8.30	8.58	Fe ₂	8.71	9.69	B ₂	8.45	7.65	9.34
Zn ₃	9.05	9.29	9.55	Fe ₃	8.15	8.62	B ₃	9.45	9.54	8.58
S. Em ±	0.04	0.23	0.13		0.23	0.13		0.04	0.23	0.13
C.D. at 5%	0.12	0.65	0.36		N.S.	0.36		0.12	0.65	0.36
<u>Zn x Fe</u>					1984			1985		
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	
Zn ₂	8.52	7.93	8.70	7.66	8.19	7.83	9.66	9.19	8.60	
Zn ₃	9.16	8.39	7.18	8.95	9.06	6.89	8.48	9.73	7.53	
S. Em ±	9.51	9.23	8.42	9.25	8.88	9.74	8.81	10.10	9.74	
C.D. at 5%	0.07	0.21			0.40			0.22		
<u>Zn x B</u>					1.13			0.63		
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	
Zn ₂	6.80	8.56	9.79	6.74	7.28	9.68	9.94	9.12	8.39	
Zn ₃	8.15	7.87	8.70	7.45	8.31	9.15	8.38	9.46	7.90	
S. Em ±	8.36	8.92	9.88	10.71	7.38	9.78	9.74	9.44	9.46	
C.D. at 5%	0.07	0.21			0.40			0.22		
					1.13			0.63		

Contd...Table 16.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	8.33	8.36	10.51	8.15	7.23	10.49	8.97	9.42	8.55
Fe ₂	8.06	9.35	8.15	8.64	8.60	8.88	10.07	10.27	8.68
Fe ₃	6.93	7.65	9.72	8.09	7.14	9.23	9.02	8.34	8.52
S. Em ±		0.07			0.40			0.22	
C.D. at 5%		0.21			1.13			0.63	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	7.38	7.43	10.59	6.55	7.26	9.17	10.19	9.47	9.33
Fe ₂	6.32	9.03	8.43	7.42	7.31	9.85	10.18	9.31	8.10
Fe ₃	6.70	9.05	10.35	6.24	7.26	10.00	9.45	8.59	7.75
Zn ₂									
Fe ₁	9.24	8.57	9.68	7.64	8.45	10.77	8.39	9.58	7.46
Fe ₂	8.79	9.47	6.93	8.31	9.13	9.73	9.46	11.25	8.50
Fe ₃	6.44	5.58	9.51	6.39	7.35	6.94	7.29	7.55	7.74
Zn ₃									
Fe ₁	8.36	8.90	11.25	10.26	5.96	11.52	8.33	9.21	8.87
Fe ₂	9.06	9.54	9.09	10.20	9.37	7.08	10.58	10.25	9.46
Fe ₃	7.66	8.32	9.29	11.66	6.80	10.75	10.31	8.87	10.06
Zn ₀ Fe ₀ B ₀		7.48			7.93			9.10	
S. Em ±		0.13			0.69			0.39	
C.D. at 5%		0.37			1.95			N.S.	

N.S. = Not significant.

in the last year it was maximum at the intermediate concentration. Fe in the first two years failed to bring about any significant variation, whereas in the last year 0.2 per cent concentration of it reduced the acidity content significantly. Boron however, showed no significant effect in this regard.

In 1983 and 1984, the treatments Zn_2Fe_3 and Zn_1Fe_3 respectively caused significantly the lowest fruit acidity. Similarly, treatment Zn_2B_1 and Zn_3B_1 showed the lowest acidity in 1983 and 1985 respectively. The effect of Fe and B was not very conspicuous.

The treatment combination of Zn+Fe+B also reduced fruit acidity significantly over control in the first two years. In last year treatments showed a reverse effect in this regard.

Sugar/acid ratio :

A perusal of the data recorded in Table 18 revealed that treatments showed wide variation in sugar/acid ratios. In 1983 it was found to vary between 21.20 and 42.65, whereas the ratio varied from 20.07 to 46.27 and 20.61 to 41.82 in 1984 and 1985 respectively. The sugar/acid ratios under control were 24.35, 26.91 and 32.62 in 1983, 1984 and 1985, respectively.

Table 17. Acidity of fruit (expressed in terms of per cent citric acid) as affected by treatments with Zn, Fe and B.

Zn levels	Fruit acidity (% fresh weight)			Fe levels	Fruit acidity (% fresh weight)			B levels	Fruit acidity (% fresh weight)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	0.43	0.39	0.42	Fe ₁	0.43	0.41	0.43	B ₁	0.44	0.43	0.43	
Zn ₂	0.41	0.42	0.46	Fe ₂	0.44	0.42	0.42	B ₂	0.42	0.42	0.44	
Zn ₃	0.46	0.48	0.43	Fe ₃	0.43	0.45	0.46	B ₃	0.44	0.44	0.44	
S. Em ±	0.003	0.011	0.008		0.003	0.011	0.008		0.003	0.011	0.008	
C.D. at 5%	0.011	0.032	0.022		N.S.	N.S.	0.022		N.S.	N.S.	N.S.	
1983												
Zn x Fe	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	0.42	0.43	0.45	0.40	0.43	0.35	0.44	0.41	0.46	0.44	0.41	0.46
Zn ₂	0.42	0.45	0.34	0.39	0.41	0.45	0.45	0.45	0.49	0.45	0.45	0.49
Zn ₃	0.45	0.41	0.51	0.45	0.43	0.55	0.44	0.42	0.45	0.44	0.42	0.45
S. Em ±		0.006			0.020			0.014			0.014	
C.D. at 5%		0.019			0.056			N.S.			N.S.	
1984												
Zn x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	0.46	0.41	0.43	0.38	0.36	0.43	0.43	0.42	0.42	0.43	0.42	0.42
Zn ₂	0.39	0.39	0.44	0.44	0.42	0.40	0.47	0.48	0.48	0.47	0.48	0.44
Zn ₃	0.47	0.45	0.45	0.48	0.48	0.47	0.41	0.42	0.42	0.41	0.42	0.48
S. Em ±		0.006			0.020			0.014			0.014	
C.D. at 5%		0.019			N.S.			0.039			0.039	

Contd....

Contd...Table 17.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	0.45	0.42	0.42	0.42	0.43	0.39	0.44	0.42	0.43
Fe ₂	0.45	0.40	0.46	0.43	0.39	0.45	0.41	0.41	0.45
Fe ₃	0.43	0.43	0.44	0.45	0.45	0.46	0.46	0.48	0.45
S. Em ±		0.006			0.020			0.017	
C.D.at 5%		0.019			N.S.			N.S.	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
	0.43	0.46	0.36	0.36	0.41	0.42	0.42	0.39	0.40
	0.53	0.34	0.43	0.47	0.33	0.49	0.43	0.40	0.41
	0.43	0.42	0.50	0.32	0.35	0.39	0.45	0.48	0.46
Zn ₂	0.38	0.47	0.45	0.41	0.45	0.33	0.49	0.43	0.45
	0.50	0.36	0.50	0.47	0.35	0.41	0.40	0.51	0.44
	0.30	0.38	0.36	0.43	0.47	0.47	0.52	0.52	0.43
Zn ₃	0.55	0.36	0.44	0.50	0.41	0.44	0.41	0.46	0.46
	0.32	0.49	0.43	0.35	0.51	0.45	0.41	0.35	0.51
	0.55	0.50	0.48	0.59	0.53	0.54	0.43	0.45	0.47
Zn ₀ Fe ₀ B ₀		0.51			0.44			0.40	
S. Em ±		0.011			0.035			0.024	
C.D.at 5%		0.033			0.098			0.069	

N.S. = Not significant.

Table 18. Effect of three levels of Zn, Fe and B and their interactions on sugar/acid ratio of fruit.

Treatments	Sugar/acid ratio		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	28.13	31.05	33.35
Zn ₁ Fe ₁ B ₂	27.00	27.92	35.66
Zn ₁ Fe ₁ B ₃	39.58	31.07	34.10
Zn ₁ Fe ₂ B ₁	21.20	24.19	34.06
Zn ₁ Fe ₂ B ₂	40.73	36.45	35.70
Zn ₁ Fe ₂ B ₃	33.21	27.83	28.21
Zn ₁ Fe ₃ B ₁	26.09	31.18	30.62
Zn ₁ Fe ₃ B ₂	33.09	31.94	27.18
Zn ₁ Fe ₃ B ₃	28.56	34.28	26.10
Zn ₂ Fe ₁ B ₁	38.02	28.87	24.57
Zn ₂ Fe ₁ B ₂	28.87	27.35	33.37
Zn ₂ Fe ₁ B ₃	34.17	46.27	24.24
Zn ₂ Fe ₂ B ₁	28.40	27.76	33.42
Zn ₂ Fe ₂ B ₂	39.86	38.97	29.43
Zn ₂ Fe ₂ B ₃	25.00	34.17	30.29
Zn ₂ Fe ₃ B ₁	38.46	23.81	20.61
Zn ₂ Fe ₃ B ₂	29.57	24.19	22.76
Zn ₂ Fe ₃ B ₃	38.22	24.17	28.00
Zn ₃ Fe ₁ B ₁	24.40	27.36	31.18
Zn ₃ Fe ₁ B ₂	25.31	23.31	29.06
Zn ₃ Fe ₁ B ₃	37.11	35.09	27.17
Zn ₃ Fe ₂ B ₁	42.65	40.02	38.56
Zn ₃ Fe ₂ B ₂	29.83	25.29	41.82
Zn ₃ Fe ₂ B ₃	33.91	25.71	27.37
Zn ₃ Fe ₃ B ₁	23.05	25.62	33.32
Zn ₃ Fe ₃ B ₂	26.22	20.07	28.37
Zn ₃ Fe ₃ B ₃	29.93	25.85	31.17
Zn ₀ Fe ₀ B ₀	24.35	26.91	32.62

Experiment Ib : Effect of three levels of Zn, Fe and B and their interactions on flowering, yield and fruit quality of mango cv. Fazli.

Mature trees.

Flowering percentage :

A perusal of the data recorded in Table 19 and Fig.1 indicates that the higher rates of Zn helped in increasing the percentage of flowering shoots in the 'on' years (1983 and 1985), however, in the 'off' year (1984) Zn failed to show any significant effect in this regard. On application of 0.4 per cent Zn 61.03 and 50.36 per cent shoots produced panicle in 1983 and 1985, respectively. In case of Fe significant variation was observed only in the 'off' year and percentage of flowering shoots was found to decrease at the highest concentration (0.4%). The effect of 0.1 and 0.2 per cent was at par. Boron though failed to show any significant result in 1983, yet produced significantly the highest percentage of panicle of 40.38 and 51.43 when applied at 0.4 per cent in 1984 and 1985, respectively.

Like the individual effect, the interaction of nutrients also brought some significant variation on flowering percentage. Interactions of Zn+Fe proved beneficial only in 1983, and 63.64 per cent flowering occurred under the treatment Zn_3Fe_1 . Zn+B resulted significant effect in 1984 and 1985 and treatment with Zn_1B_3 proved beneficial in both the years. Interactions of Fe+B were also found effective in 1983 and 1984. Among the various second order interactions

Table 19. Effect of three levels of Zn, Fe and B and their interactions on percentage of flowering shoots in mango cv. Fazli.

Zn levels	Percentage of flowering shoots			Fe levels	Percentage of flowering shoots			B levels	Percentage of flowering shoots			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	56.49	38.57	49.42	Fe ₁	58.88	39.06	49.14	B ₁	60.11	36.06	48.38	
Zn ₂	59.99	37.48	47.34	Fe ₂	58.82	39.04	48.32	B ₂	59.49	38.25	47.29	
Zn ₃	61.03	38.63	50.36	Fe ₃	59.80	36.58	49.64	B ₃	57.91	40.38	51.43	
S. Em ±	0.81	0.44	0.79		0.81	0.44	0.79		0.81	0.44	0.79	
C.D.at 5%	2.26	N.S.	2.22		N.S.	1.25	N.S.		N.S.	1.25	2.22	
1983												
Zn x Fe	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	55.41	56.43	57.63	40.04	38.89	36.79	49.57	50.48	48.19	49.57	50.48	48.19
Zn ₂	57.58	60.68	61.70	37.34	38.55	36.54	47.37	46.76	47.87	47.37	46.76	47.87
Zn ₃	63.64	59.35	60.08	39.80	39.67	36.42	50.50	47.72	52.85	50.50	47.72	52.85
S. Em ±	1.39				0.77			1.37			1.37	
C.D.at 5%	3.91				N.S.			N.S.			N.S.	
1984												
Zn x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	56.60	58.80	54.06	35.57	38.14	42.02	49.16	45.19	53.90	49.16	45.19	53.90
Zn ₂	60.35	61.19	58.42	34.05	40.69	37.69	48.19	44.56	49.24	48.19	44.56	49.24
Zn ₃	63.37	58.47	61.20	38.55	35.91	41.73	47.79	52.12	51.16	47.79	52.12	51.16
S. Em ±	1.39				0.77			1.37			1.37	
C.D.at 5%	N.S.				2.17			3.86			3.86	

Contd...

Contd...Table 19.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	58.71	59.42	58.51	35.16	41.88	40.16	49.57	46.88	50.98
Fe ₂	59.69	56.07	60.70	36.01	40.52	40.58	47.95	44.81	52.19
Fe ₃	61.93	62.92	54.51	37.01	32.34	40.41	47.61	50.17	51.12
S. Em ±		1.39			0.77			1.37	
C.D. at 5%		3.91			2.17			N.S.	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	53.48	59.18	53.57	33.04	41.12	45.97	56.46	39.19	53.05
Fe ₂	60.40	52.80	56.09	37.50	42.26	36.91	50.89	46.35	54.19
Fe ₃	55.93	64.42	52.54	36.16	31.05	43.17	40.12	50.02	54.45
Zn ₂	Fe ₁	59.34	58.62	54.80	35.55	42.83	40.21	50.58	51.32
Fe ₂	56.83	63.19	62.04	29.84	43.81	42.00	53.76	36.21	50.31
Fe ₃	64.90	61.78	58.43	36.77	35.44	37.42	50.62	46.89	46.10
Zn ₃	Fe ₁	63.31	60.46	67.17	36.89	40.84	52.05	50.88	48.57
Fe ₂	61.85	52.22	63.99	40.68	35.51	42.83	39.22	51.87	52.08
Fe ₃	64.96	62.74	52.56	38.10	30.53	40.64	52.10	53.62	52.83
Zn ₀ Fe ₀ B ₀		54.94			40.79			45.94	
S. Em ±		2.42			1.34			2.38	
C.D. at 5%		6.78			3.77			6.68	

N.S. = Not significant
(Data are angularly transformed)

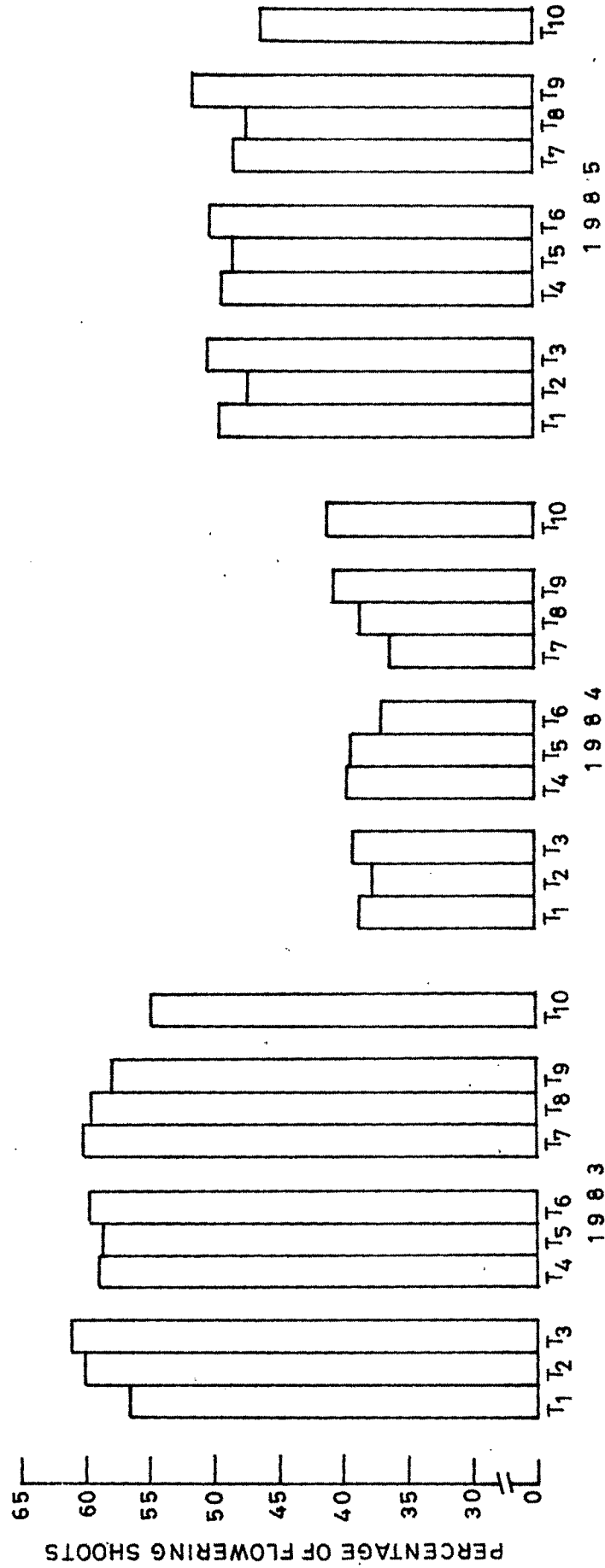


FIG. 1. RESPONSE OF ZN, FE AND B ON FLOWERING,

as much as 67.17, 45.97 and 56.46 per cent panicles were recorded under $Zn_3Fe_1B_3$, $Zn_1Fe_1B_3$ and $Zn_1Fe_1B_1$ compared to 54.94, 40.79 and 45.94 per cent under control in 1983, 1984 and 1985, respectively.

Sex ratio :

It is revealed from the data in Table 20 that treatment with micronutrients showed wide variations in sex expression of flowers on the panicle. In 1983, treatment $Zn_1Fe_2B_3$ promoted the production of hermaphrodite flowers over that under other treatments. Treatment with $Zn_2Fe_1B_3$ promoted production of hermaphrodite flowers in 1984 and 1985 and thereby decreased the ratio of male to hermaphrodite flowers. Trees under control produced higher percentage of male flowers in all the years.

Number of fruits/tree :

It is evident from the data in Table 21 and Fig. 2 that Zn in the first year failed to bring about any significant effect but in the later years it resulted in significant variations. Similar result was also obtained under boron treatments. Spraying with 0.2 and 0.4 per cent Zn produced 202 and 500 fruits in 1984 and 1985 per tree, respectively. The effect of B_1 and B_2 was significant in 1984 and 1985, respectively. The effect of rest of the treatments were at par in this respect. Iron at 0.4 per cent augmented the number of fruits over other treatments in 1983 and 1985. In 1984 no significant difference was noted.

Table 20. Effect of three levels of Zn, Fe and B and their interactions on sex ratio.

Treatments	Distribution of sex (hermaphrodite: male)		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	1:3.22	1:2.75	1:3.16
Zn ₁ Fe ₁ B ₂	1:2.54	1:2.80	1:3.23
Zn ₁ Fe ₁ B ₃	1:2.79	1:3.19	1:2.64
Zn ₁ Fe ₂ B ₁	1:2.34	1:3.53	1:3.92
Zn ₁ Fe ₂ B ₂	1:2.77	1:3.31	1:3.56
Zn ₁ Fe ₂ B ₃	1:1.99	1:3.80	1:2.62
Zn ₁ Fe ₃ B ₁	1:2.08	1:2.82	1:3.19
Zn ₁ Fe ₃ B ₂	1:2.34	1:2.65	1:3.36
Zn ₁ Fe ₃ B ₃	1:2.71	1:3.22	1:3.76
Zn ₂ Fe ₁ B ₁	1:2.21	1:3.05	1:3.81
Zn ₂ Fe ₁ B ₂	1:4.56	1:2.91	1:3.63
Zn ₂ Fe ₁ B ₃	1:3.31	1:1.89	1:2.44
Zn ₂ Fe ₂ B ₁	1:3.01	1:3.12	1:4.35
Zn ₂ Fe ₂ B ₂	1:2.92	1:4.06	1:3.12
Zn ₂ Fe ₂ B ₃	1:2.20	1:3.54	1:3.76
Zn ₂ Fe ₃ B ₁	1:2.44	1:2.91	1:3.37
Zn ₂ Fe ₃ B ₂	1:2.86	1:3.46	1:3.86
Zn ₂ Fe ₃ B ₃	1:3.91	1:2.71	1:3.69
Zn ₃ Fe ₁ B ₁	1:4.15	1:3.19	1:4.85
Zn ₃ Fe ₁ B ₂	1:3.58	1:3.70	1:4.14
Zn ₃ Fe ₁ B ₃	1:3.18	1:2.58	1:3.42
Zn ₃ Fe ₂ B ₁	1:2.87	1:3.23	1:3.53
Zn ₃ Fe ₂ B ₂	1:2.70	1:2.52	1:2.76
Zn ₃ Fe ₂ B ₃	1:2.94	1:3.02	1:3.11
Zn ₃ Fe ₃ B ₁	1:2.92	1:2.08	1:3.05
Zn ₃ Fe ₃ B ₂	1:3.03	1:3.18	1:3.75
Zn ₃ Fe ₃ B ₃	1:2.83	1:2.91	1:4.10
Zn ₀ Fe ₀ B ₀	1:3.84	1:3.76	1:4.42

Production of 509 and 571 fruits per tree were recorded under the treatment Zn_3Fe_3 (each at 0.4%), while 226 fruits were recorded under Zn_3Fe_2 . Likewise 477, 331 and 535 fruits were harvested under the treatments Zn_3B_1 , Zn_2B_1 and Zn_3B_2 in 1983, 1984 and 1985 respectively. The effect of Fe in combination with B was also significant. The highest number of fruits recorded under Fe_3B_1 , Fe_2B_1 and Fe_3B_3 were 479, 242 and 512 per tree in the year 1983, 1984 and 1985, respectively.

Among the various three factor interactions $Zn_2Fe_1B_3$, $Zn_2Fe_1B_1$, and $Zn_3Fe_1B_1$ produced 577, 362 and 621 fruits in 1983, 1984 and 1985, respectively. Plants under control had 434, 129 and 356 fruits in the respective years.

Fruit weight :

Micronutrients used in this experiment were found almost equally effective in producing heavier fruits over control. The various concentrations of Zn and B showed inconsistent variation while Fe showed a similar trend in 1984 and 1985. The intermediate (0.2%) and higher (0.4%) concentrations of Zn showed better effect in 1984 and 1985, respectively. The medium concentration of Fe was found to be the most effective, while the lowest and higher concentrations of B showed beneficial effect during 1984 and 1985.

The various interactions of Zn and Fe did not show any significant result in 1983, however, in 1984 and 1985 treatment with Zn_2Fe_2 and Zn_3Fe_2 increased fruit weight appreciably compared to

Contd...Table 21.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	446	384	453	220	183	121	446	475	460
Fe ₂	402	436	408	242	135	190	334	372	493
Fe ₃	479	476	466	200	175	145	382	506	512
S.Em ±		11.83			14.97			22.71	
C.D. at 5%		33.13			41.93			63.61	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁									
Fe ₁	432	373	455	187	128	137	503	225	599
Fe ₂	385	360	430	165	140	117	582	469	533
Fe ₃	515	416	502	158	179	195	204	458	377
Zn ₂									
Fe ₁	467	345	577	362	164	109	213	592	365
Fe ₂	309	513	427	327	112	160	238	168	469
Fe ₃	443	511	348	303	148	133	345	540	563
Zn ₃									
Fe ₁	440	433	326	112	257	118	621	608	416
Fe ₂	513	433	368	234	152	292	183	478	476
Fe ₃	478	502	548	137	199	109	597	519	596
Zn ₀ Fe ₀ Bo		434			129			356	
S.Em ±		20.49			25.94			39.34	
C.D. at 5%		57.38			72.63			110.17	

N.S. = Not significant.

T₁ - Zinc 0.1% T₄ - Iron 0.1% T₇ Boron 0.1% T₁₀ - Control
 T₂ - Zinc 0.2% T₅ - Iron 0.2% T₈ - Boron 0.2%
 T₃ - Zinc 0.4% T₆ - Iron 0.4% T₉ - Boron 0.4%

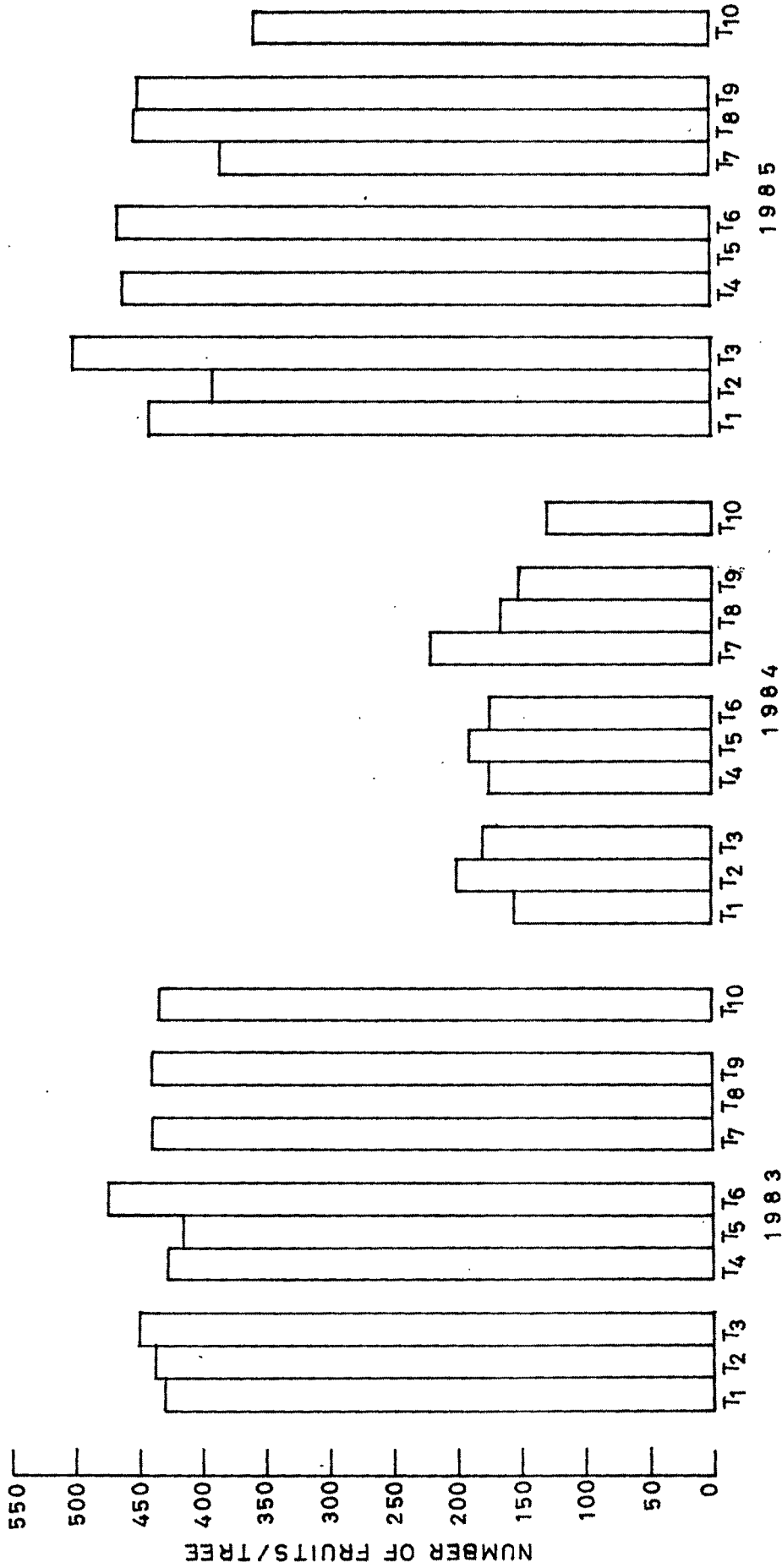


FIG. 2. EFFECT OF THREE LEVELS OF ZN, Fe AND B ON NUMBER OF FRUITS PER TREE.

other treatments. Fruits of 756.11 and 765.33 g were obtained under the treatments Zn_2B_2 and Zn_3B_3 in 1984 and 1985, respectively. The effect of Zn and B was not conspicuous in 1983. An appreciable variation in the weight of fruits was also obtained with the Fe and B.

Due to treatments with Zn+Fe+B weight of fruit varied from 545.00 to 778.33 g in 1983, as compared to 630.66 g under control. In 1984 fruit weight varied between 616.66 and 825.00 g as against 669.33 g under control. In 1985, trees under $Zn_2Fe_2B_3$ treatment had the heaviest fruit (839.33 g) while under control average fruit weight was 645.66 g (Table 22 and Fig.3).

Fruit yield :

The data recorded in Table 23 and Fig.4 showed that the yield of fruit per plant due to treatment with Zn and B did not vary significantly in the first year, however, these micro-nutrients brought about significant variations in 1984 and 1985. Treatments with 0.2 and 0.4 per cent zinc produced 148.92 and 369.27 kg fruits per plant in 1984 and 1985 respectively. On the other hand, Fe at 0.4 per cent resulted in the production of significantly higher yield (304.02 kg) compared to other concentrations. As regards the effect of B it was observed that in 1984 the yield of fruit per plant decreased with the increase in concentration. A reverse trend was noted in 1985, where the highest yield of 358.25 kg fruits per plant was obtained with 0.4 per cent B. Except Zn and B, in 1983, all treatment interactions like Zn+Fe, Zn+B and Fe+B caused significant

Table 22. Variation in average weight of fruit due to treatment with three levels of Zn, Fe and B and their interactions.

Zn levels	Fruit weight (g)			Fe levels	Fruit weight (g)			B levels	Fruit weight (g)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	611.33	687.40	711.96	Fe ₁	633.85	705.37	707.07	B ₁	625.81	735.18	707.44
Zn ₂	640.18	737.96	696.33	Fe ₂	617.81	730.74	738.48	B ₂	627.88	701.29	705.25
Zn ₃	642.88	715.55	741.41	Fe ₃	642.73	704.81	704.14	B ₃	640.70	704.44	736.99
S. Em ±	14.79	5.91	3.62		14.79	5.91	3.62		14.79	5.91	3.62
C.D. at 5%	N.S.	16.55	10.14		N.S.	16.55	10.14		N.S.	16.55	10.14
Zn x Fe											
Zn ₁	634.22	593.33	606.44	Fe ₁	674.44	674.40	713.33	Fe ₃	713.66	687.55	734.66
Zn ₂	624.33	643.88	652.33		752.77	761.11	699.99		683.55	746.66	658.77
Zn ₃	642.99	616.22	669.44		688.88	756.66	701.11		723.99	781.22	718.99
S. Em ±											
C.D. at 5%											
Zn x B											
Zn ₁	612.11	621.33	600.55	B ₁	733.88	643.33	684.99	B ₃	691.77	711.66	732.44
Zn ₂	633.99	649.99	636.55		718.88	756.11	738.88		708.11	667.66	713.22
Zn ₃	631.33	612.33	684.99		752.77	704.44	689.44		722.42	736.44	765.33
S. Em ±											
C.D. at 5%											

Contd...

Contd....Table 22.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	658.88	614.44	628.22	756.11	684.44	675.55	726.77	692.33	702.11
Fe ₂	625.77	635.44	592.22	753.88	686.66	751.66	705.22	745.11	765.11
Fe ₃	592.77	633.77	701.66	695.55	732.77	686.11	690.33	678.33	743.77
S. Em ±		25.63			10.24			6.27	
C.D. at 5%		71.76			28.68			17.56	
Zn x Fe x B									
Zn ₁									
Fe ₁	625.00	626.00	651.66	761.66	616.66	645.00	674.33	761.33	705.33
Fe ₂	645.00	590.00	545.00	678.33	658.33	686.66	713.66	685.33	663.66
Fe ₃	566.33	648.00	605.00	761.66	655.00	723.33	687.33	688.33	828.33
Zn ₂									
Fe ₁	705.00	591.66	576.33	756.66	783.33	718.33	762.66	633.33	654.66
Fe ₂	611.66	708.33	611.66	758.33	703.33	821.66	667.33	733.33	839.33
Fe ₃	585.33	650.00	721.66	641.66	781.66	676.66	694.33	636.33	645.66
Zn ₃									
Fe ₁	646.66	625.66	656.66	750.00	653.33	663.33	743.33	682.33	746.33
Fe ₂	620.66	608.00	620.00	825.00	698.33	746.66	734.66	816.66	792.33
Fe ₃	626.66	603.33	778.33	683.33	761.66	658.33	689.33	710.33	757.33
Zn ₀ Fe ₀ B ₀		630.66			669.33			645.66	
S. Em ±		44.39			17.74			10.86	
C.D. at 5%		N.S.			49.67			30.42	

N.S. = Not significant.

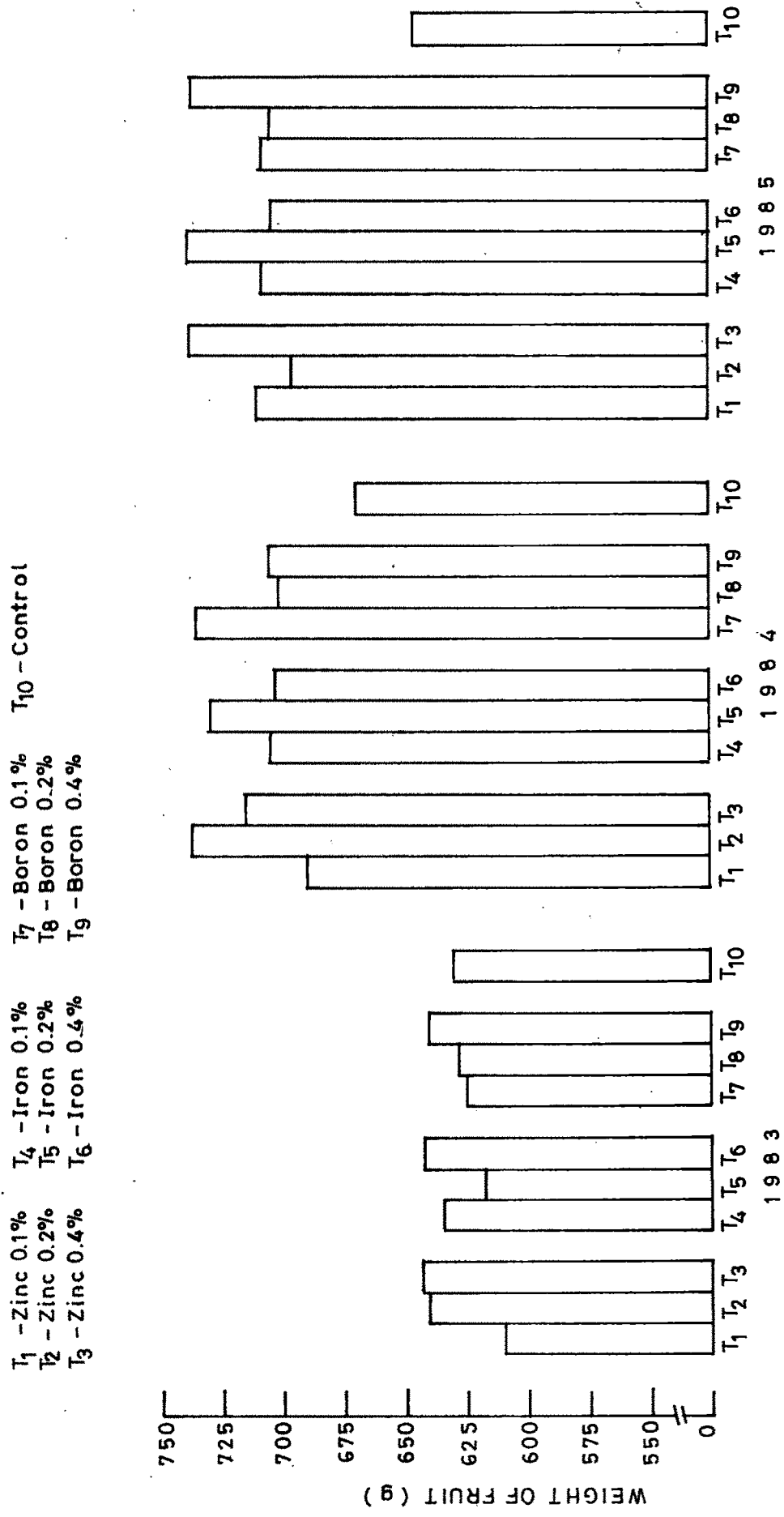


FIG.3. EFFECT OF DIFFERENT LEVELS OF ZN, FE AND B ON WEIGHT OF FRUIT.

variation in fruit yield in all the years of the experiment. In the 'on' years (1983 and 1985) treatment with Zn_3Fe_3 gave the highest production while in 1984 ('off' year) treatment with Zn_3Fe_2 did so. As much as 239.04 and 391.33 kg of fruits were obtained under Zn_2B_1 and Zn_3B_2 in 1984 and 1985, respectively. A yield of 327.02 and 375.81 kg of fruits were obtained respectively in 1983 and 1985 with Zn_3B_3 treatment. In 1984, treatment with Zn_2B_1 recorded the highest yield (184.05 kg).

Among the interactions of Zn+Fe+B, $Zn_3Fe_3B_3$, $Zn_2Fe_1B_1$ and $Zn_3Fe_1B_1$ enhanced the yield of fruits to 426.74, 273.56 and 462.08 kg per plant as compared to 273.90, 86.89 and 230.01 kg per plant under control in 1983, 1984 and 1985, respectively.

Fruit size (length and breadth) :

It is apparent from the data summarized in Table 24.1 and 24.2 that Zn, Fe and B proved beneficial in increasing the length of fruits in the 'on' years only, whereas due to treatment with Fe and B fruit breadth varied appreciably only in 1985. Among the significant effects, the maximum fruit length of 15.54, 15.52 and 15.38 cm were obtained respectively with 0.4 per cent Zn, 0.2 per cent Fe and 0.4 per cent B in 1985. The highest fruit breadth of 9.70 and 9.71 cm were recorded respectively under treatment Fe_2 and B_3 in 1985.

In general, the first order interaction of various nutrients resulted in significant effect in this regard only in 'on' years. In 'off' year the treatments were comparatively less effective. In 1985,

Table 23. Effect of three levels of Zn, Fe and B and their interactions on yield of fruit.

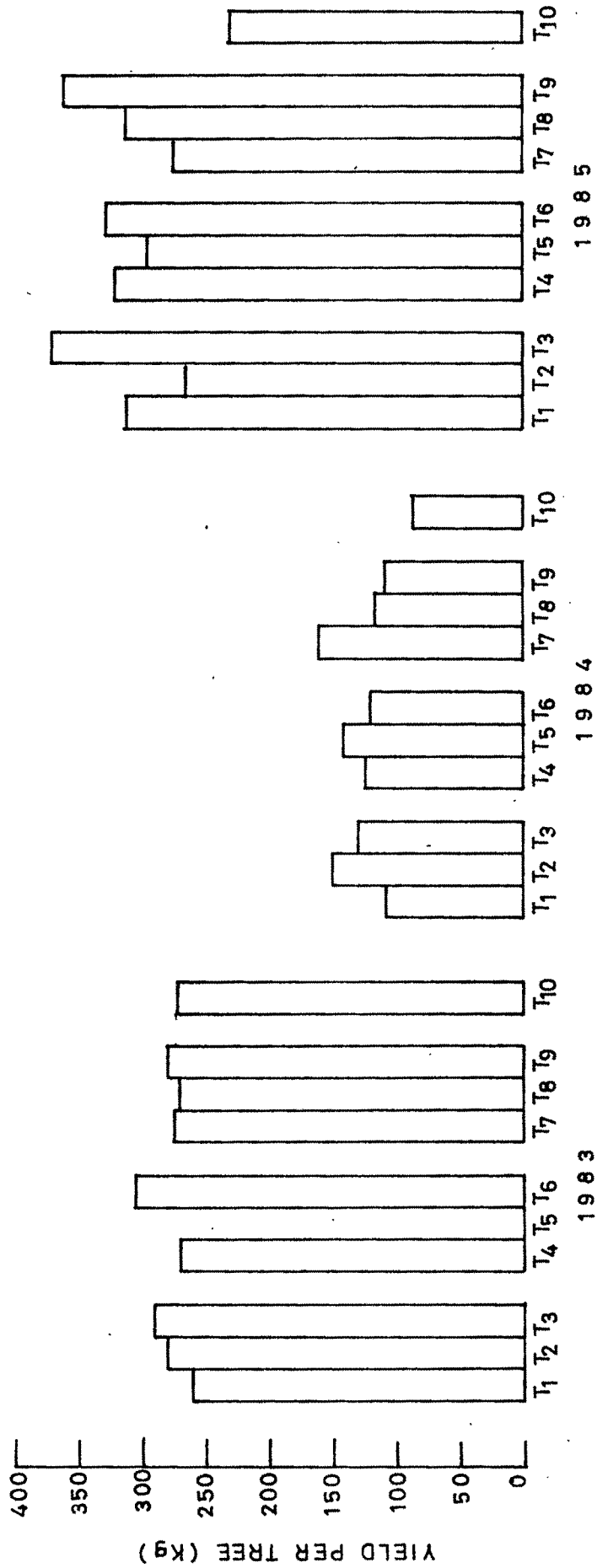
Zn levels	Yield/plant (kg)			Fe levels	Yield/plant (kg)			B levels	Yield/plant (kg)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	262.52	108.17	310.19	Fe ₁	270.58	124.55	321.95	B ₁	276.94	162.49	273.99
Zn ₂	280.10	148.92	266.41	Fe ₂	257.72	139.72	296.48	B ₂	272.45	115.29	313.63
Zn ₃	289.70	129.05	369.27	Fe ₃	304.02	121.86	327.44	B ₃	282.93	108.36	358.25
S. Em ±	7.89	6.43	9.77		7.89	6.43	9.77		7.89	6.43	9.77
C.D. at 5%	N.S.	18.02	27.36		22.11	N.S.	N.S.		N.S.	18.02	27.36
Zn x Fe											
Zn ₁	266.42	232.62	288.52	Fe ₁	103.13	94.76	126.62	Fe ₃	311.00	363.43	256.15
Zn ₂	288.97	270.77	280.56		160.75	152.85	133.16		258.89	225.29	315.04
Zn ₃	256.34	269.79	342.97		109.76	171.56	105.82		395.95	300.73	411.14
S. Em ±		13.67				11.14				16.93	
C.D. at 5%		38.30				31.21				47.40	
Zn x B											
Zn ₁	270.82	238.70	278.04	B ₁	125.27	95.92	103.31	B ₃	298.44	269.14	362.99
Zn ₂	259.26	299.47	281.57		239.04	108.50	99.22		187.30	280.42	331.50
Zn ₃	300.73	279.19	289.18		123.15	141.44	122.56		336.23	391.33	380.25
S. Em ±		13.67				11.14				16.93	
C.D. at 5%		N.S.				31.21				47.40	

Contd...

Contd... Table 23.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	294.75	235.70	281.28	166.44	125.50	81.71	321.40	320.31	324.13
Fe ₂	252.65	280.01	240.50	184.05	92.36	142.75	236.47	278.17	374.79
Fe ₃	283.40	301.64	327.02	136.97	128.00	100.62	264.10	342.41	375.81
S. Em ±		13.67			11.14			16.93	
C.D. at 5%		38.30			31.21			47.40	
Zn x Fe x B									
Zn ₁									
Fe ₁	269.92	233.47	295.88	142.04	78.69	88.67	339.62	170.79	422.58
Fe ₂	250.27	213.33	234.25	111.79	92.51	79.97	415.45	321.36	353.47
Fe ₃	292.28	269.29	304.01	122.00	116.57	141.30	140.26	315.27	312.92
Zn ₂									
Fe ₁	330.08	203.35	333.48	273.56	130.86	77.83	162.50	374.95	239.24
Fe ₂	188.36	363.02	260.92	248.79	78.76	131.01	159.60	123.54	392.72
Fe ₃	259.33	332.05	250.31	194.77	115.88	88.82	239.82	342.78	362.54
Zn ₃									
Fe ₁	284.26	270.29	214.48	83.71	166.95	78.64	462.08	415.21	310.56
Fe ₂	319.33	263.70	226.33	191.59	105.81	217.29	134.38	389.62	378.19
Fe ₃	298.60	303.58	426.74	94.14	151.56	71.76	412.24	369.18	451.99
Zn ₀ Fe ₀ B ₀		273.90			86.89			230.01	
S. Em ±		23.69			19.31			29.32	
C.D. at 5%		66.34			54.06			82.10	

N.S. = Not significant.



T₁ - Zinc 0.1% T₄ - Iron 0.1% T₇ - Boron 0.1% T₁₀ - Control
 T₂ - Zinc 0.2% T₅ - Iron 0.2% T₈ - Boron 0.2%
 T₃ - Zinc 0.4% T₆ - Iron 0.4% T₉ - Boron 0.4%

FIG. 4. EFFECT OF DIFFERENT LEVELS OF ZN, FE AND B ON YIELD OF FRUIT.

the maximum length of 16.04 cm was accompanied by 9.90 cm breadth under Zn_3Fe_2 treatment. Fruit size was indicated by length and breadth was comparatively less in 1983 than that in 1984 and 1985.

Likewise, the various three factor interactions also proved effective in increasing the length and breadth of fruits significantly over control in 1983 and 1985. In 1984, the treatments were at par and failed to bring about any significant variation over control. In 1983 and 1985 the highest length and breadth of fruits were 16.66 and 10.63 cm under $Zn_3Fe_3B_2$ and 16.76 and 10.33 cm under $Zn_2Fe_2B_3$, respectively. The corresponding figures under control were 13.26 and 9.06 and 15.16 and 9.57 in 1983 and 1985.

Specific gravity :

The data on the role of micronutrients on the specific gravity of fruits have been summarized in Table 25. Zinc and Fe failed to bring about any statistically measurable differences in the values of specific gravity of fruits in 1983 and 1984, however, these nutrients proved effective in this regard in 1985, while B in all the years failed to recorded any significant effect. In 1985, a significant response was obtained when Zn and B were applied each at 0.2 per cent. It was also noted that specific gravity of fruits increased upto 0.2 per cent concentration of the micronutrients and declined when concentration was increased further.

Among the various first order interactions, significant variation was observed only in 1984 under the Zn and B treatments.

Table 24.1. Effect of three levels of Zn, Fe and B and their interactions on length of fruit.

Zn levels	Fruit length(cm)			Fe levels	Fruit length(cm)			B levels	Fruit length(cm)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	13.86	15.27	15.12	Fe ₁	14.00	15.80	15.11	B ₁	13.70	15.41	15.19	
Zn ₂	13.82	15.42	15.04	Fe ₂	13.73	15.02	15.52	B ₂	14.42	15.42	15.12	
Zn ₃	14.42	15.61	15.54	Fe ₃	14.37	15.47	15.07	B ₃	13.98	15.47	15.38	
S.Em ±	0.14	0.22	0.05		0.14	0.22	0.05		0.14	0.22	0.05	
C.D. at 5%	0.40	N.S.	0.15		0.40	N.S.	0.15		0.40	N.S.	0.15	
					1983	1984			1985			
Zn x Fe												
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₂	13.98	14.02	13.58	16.02	14.81	14.98	15.27	14.77	15.30	15.27	14.77	15.30
Zn ₃	13.20	13.98	14.28	15.84	14.60	15.83	14.78	15.75	14.58	14.78	15.75	14.58
S.Em ±	14.80	13.20	15.24	15.55	15.66	15.61	15.26	16.04	15.32	15.26	16.04	15.32
C.D. at 5%	0.24	0.69			0.39			0.09		0.09	0.27	
Zn x B					N.S.					0.27		
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₂	12.92	14.43	14.24	15.21	15.01	15.60	15.13	14.98	15.23	15.13	14.98	15.23
Zn ₃	13.57	13.48	14.41	15.63	15.65	14.98	14.96	14.83	15.33	14.96	14.83	15.33
S.Em ±	14.62	15.34	13.30	15.40	15.60	15.83	15.48	15.54	15.60	15.48	15.54	15.60
C.D. at 5%	0.24	0.69			0.39			0.09		0.09	N.S.	
					N.S.			N.S.		N.S.		

Contd...

Contd...Table 24.1.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	14.45	13.82	14.06	15.74	15.73	15.94	15.58	14.70	15.04
Fe ₂	13.52	14.36	13.32	15.53	14.57	14.96	15.11	15.70	15.76
Fe ₃	13.14	15.07	14.90	14.96	15.95	15.51	14.88	14.96	15.35
S. Em ±		0.24			0.39			0.09	
C.D. at 5%		0.69			N.S.			0.27	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	14.06	13.50	14.40	15.20	16.20	16.66	15.30	15.43	15.10
Fe ₂	13.46	15.23	13.36	15.83	14.16	14.43	15.20	14.76	14.36
Fe ₃	11.23	14.56	14.96	14.60	14.66	15.70	14.90	14.76	16.23
Zn ₂									
Fe ₁	13.20	13.23	13.16	15.66	16.26	15.60	15.63	14.20	14.53
Fe ₂	14.06	13.23	14.66	15.40	13.93	14.46	14.73	15.76	16.76
Fe ₃	13.46	14.00	15.40	15.83	16.76	14.90	14.53	14.53	14.70
Zn ₃									
Fe ₁	16.10	14.73	13.63	16.36	14.73	15.56	15.83	14.46	15.50
Fe ₂	13.03	14.63	11.93	15.36	15.63	16.00	15.40	16.56	16.16
Fe ₃	14.73	16.66	14.33	14.46	16.43	15.93	15.23	15.60	15.13
Zn ₀ Fe ₀ B ₀		13.26			15.00			15.16	
S. Em ±		0.43			0.68			0.16	
C.D. at 5%		1.21			N.S.			0.47	

N.S. = Not significant.

Table 24.2. Effect of three levels of Zn, Fe and B and their interactions on breadth of fruit.

Zn levels	Breadth of fruit(cm)			Fe levels	Breadth of fruit(cm)			B levels	Breadth of fruit(cm)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	9.26	9.71	9.57	Fe ₁	9.25	9.78	9.51	B ₁	9.18	9.72	9.53
Zn ₂	9.25	9.72	9.54	Fe ₂	9.37	9.61	9.70	B ₂	9.41	9.88	9.48
Zn ₃	9.51	9.88	9.61	Fe ₃	9.40	9.92	9.51	B ₃	9.42	9.71	9.71
S. Em ±	0.09	0.11	0.04		0.09	0.11	0.04		0.09	0.11	0.04
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	0.11		N.S.	N.S.	0.11
<u>Zn x Fe</u>		1983			1984				1985		
Zn ₁	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₃	Fe ₁	Fe ₂	Fe ₃	
Zn ₂	9.33	9.53	8.93	9.84	9.63	9.67	9.67	9.62	9.28	9.81	
Zn ₃	8.98	9.17	9.60	9.68	9.50	9.98	9.98	9.37	9.92	9.32	
S. Em ±	9.45	9.40	9.67	9.82	9.71	10.11	10.11	9.54	9.90	9.40	
C.D. at 5%	0.16	0.16		0.19	0.19			0.06	0.06		
<u>Zn x B</u>		1983			1984				1985		
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₃	B ₁	B ₂	B ₃	
Zn ₂	8.84	9.31	9.64	9.67	9.77	9.70	9.70	9.48	9.41	9.82	
Zn ₃	9.15	9.17	9.43	9.68	10.05	9.43	9.43	9.54	9.36	9.71	
S. Em ±	9.56	9.76	9.20	9.82	9.82	10.00	10.00	9.57	9.66	9.60	
C.D. at 5%	0.16	0.16		0.19	0.19			0.06	0.06		
	0.45	0.45		0.53	0.53			0.19	0.19		

Contd...

Contd... Table 24.2.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	9.60	8.85	9.32	10.05	9.73	9.56	9.61	9.40	9.53
Fe ₂	9.32	9.42	9.36	9.73	9.63	9.47	9.65	9.72	9.73
Fe ₃	8.64	9.37	9.58	9.40	10.28	10.08	9.34	9.32	9.86
S. Em ±	0.16			0.19				0.06	
C.D. at 5%	0.45			N.S.				0.19	
Zn x Fe x B									
Zn ₁									
Fe ₁	9.43	8.70	9.86	10.20	9.83	9.50	9.40	9.83	9.36
Fe ₂	9.70	9.73	9.16	9.73	9.50	9.66	9.83	8.83	9.20
Fe ₃	7.40	9.50	9.90	9.10	10.00	9.93	9.23	9.56	10.63
Zn ₂									
Fe ₁	8.83	9.10	9.03	9.83	9.60	9.63	9.70	9.06	9.36
Fe ₂	9.43	8.63	9.46	9.83	9.76	8.90	9.57	9.86	10.33
Fe ₃	9.20	9.80	9.80	9.40	10.80	9.76	9.37	9.16	9.43
Zn ₃									
Fe ₁	10.53	8.76	9.06	10.13	9.76	9.56	9.73	9.30	9.60
Fe ₂	8.83	9.90	9.46	9.63	9.63	9.86	9.56	10.46	9.66
Fe ₃	9.33	10.63	9.06	9.70	10.06	10.56	9.43	9.23	9.53
Zn ₀ Fe ₀ B ₀									
S. Em ±		9.06			10.26			9.57	
C.D. at 5%		0.27			0.33			0.12	
		0.78			N.S.			0.33	

N.S. = Not significant.

Table 25. Effect of three levels of Zn, Fe and B and their interactions on specific gravity of fruit at ripening.

Zn levels	Specific gravity			Fe levels	Specific gravity			B levels	Specific gravity		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	1.040	1.058	1.051	Fe ₁	1.048	1.057	1.042	B ₁	1.047	1.071	1.064
Zn ₂	1.055	1.067	1.077	Fe ₂	1.047	1.078	1.076	B ₂	1.040	1.069	1.056
Zn ₃	1.044	1.078	1.056	Fe ₃	1.044	1.069	1.066	B ₃	1.052	1.064	1.064
S. Em ±	0.005	0.010	0.005		0.005	0.010	0.005		0.005	0.010	0.005
C.D. at 5%	N.S.	N.S.	0.015		N.S.	N.S.	0.015		N.S.	N.S.	N.S.
1983											
1984											
Zn x Fe				Fe ₁					Fe ₁		Fe ₃
Zn ₁	1.034	1.054	1.033		1.046	1.054	1.074		1.040	1.065	1.048
Zn ₂	1.061	1.042	1.062		1.078	1.076	1.046		1.061	1.086	1.085
Zn ₃	1.050	1.045	1.037		1.045	1.103	1.086		1.025	1.077	1.065
S. Em ±		0.009				0.017				0.009	
C.D. at 5%		N.S.				N.S.				N.S.	
1985											
Zn x B				B ₁					B ₁		B ₃
Zn ₁	1.047	1.030	1.044		1.048	1.083	1.043		1.061	1.037	1.055
Zn ₂	1.045	1.064	1.055		1.048	1.061	1.092		1.082	1.072	1.078
Zn ₃	1.047	1.027	1.057		1.115	1.063	1.056		1.050	1.058	1.060
S. Em ±		0.009				0.017				0.009	
C.D. at 5%		N.S.				0.048				N.S.	

Contd...

Contd...Table 25.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	1.040	1.038	1.066	1.038	1.070	1.062	1.044	1.038	1.043
Fe ₂	1.052	1.041	1.048	1.078	1.078	1.076	1.087	1.063	1.078
Fe ₃	1.048	1.042	1.042	1.095	1.058	1.053	1.061	1.066	1.072
S. Em ±		0.009			0.017			0.009	
C.D. at 5%		N.S.			N.S.			N.S.	
Zn x Fe x B									
Zn ₁	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
	1.033	1.030	1.040	1.046	1.053	1.040	1.046	1.030	1.043
	1.060	1.046	1.056	1.037	1.083	1.043	1.076	1.056	1.063
	1.050	1.013	1.036	1.063	1.113	1.046	1.060	1.026	1.060
Zn ₂									
	1.060	1.063	1.060	1.053	1.086	1.096	1.073	1.050	1.060
	1.036	1.050	1.040	1.043	1.060	1.126	1.103	1.056	1.100
	1.040	1.080	1.066	1.050	1.036	1.053	1.070	1.110	1.076
Zn ₃									
	1.026	1.023	1.100	1.016	1.070	1.050	1.013	1.036	1.026
	1.060	1.026	1.050	1.156	1.093	1.060	1.083	1.076	1.073
	1.056	1.033	1.023	1.173	1.026	1.060	1.053	1.063	1.080
Zn ₀ Fe ₀ B ₀		1.050			1.036			1.036	
S. Em ±		0.016			0.030			0.016	
C.D. at 5%		N.S.			N.S.			N.S.	

N.S. = Not significant.

The highest specific gravity of 1.115 was noted under Zn_3B_1 treatment. The interactions of Zn+Fe+B were also found to be less efficacious in this respect.

Pulp:fruit ratio :

A perusal of the data on pulp:fruit recorded in Table 26 indicates that pulp content of fruits increased with a number of treatments and thereby pulp:fruit ratio increased over control in all the years. In 1983, the highest pulp content was obtained under $Zn_1Fe_1B_2$ (1:1.22). The lowest fruit/pulp ratios of 1:1.34 and 1:1.28 were obtained under the treatments $Zn_3Fe_3B_3$ and $Zn_2Fe_2B_2$ in 1984 and 1985, respectively. These values under control were 1:1.38, 1:1.43 and 1:1.41 in 1983, 1984 and 1985, respectively. The treatments, however, showed no consistent effect in this regard during the period of observation. In general, the 'on' year fruits had comparatively high pulp content than 'off' year fruits.

Total soluble solid (T.S.S.) :

It is apparent from the data in Table 27 and Fig.5 that in all the years the concentration of total soluble solids increased as the concentration of Zn increased and the highest T.S.S. of 19.54, 19.49 and 19.42 per cent occurred under 0.4 per cent Zn in 1983, 1984 and 1985 respectively. The concentration effect of Fe was not consistent but the increased rate of B proved effective in this regard in 1983 and 1984 and at 0.4% it caused significantly higher concentration of T.S.S., while in 1985 B failed to show any significant result. in

Table 26. Effect of three levels of Zn, Fe and B and their interactions on pulp:fruit ratio of mango.

Treatments	Pulp:fruit ratio		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	1:1.37	1:1.47	1:1.39
Zn ₁ Fe ₁ B ₂	1:1.22	1:1.41	1:1.36
Zn ₁ Fe ₁ B ₃	1:1.23	1:1.46	1:1.37
Zn ₁ Fe ₂ B ₁	1:1.32	1:1.34	1:1.41
Zn ₁ Fe ₂ B ₂	1:1.23	1:1.49	1:1.35
Zn ₁ Fe ₂ B ₃	1:1.34	1:1.43	1:1.38
Zn ₁ Fe ₃ B ₁	1:1.39	1:1.46	1:1.42
Zn ₁ Fe ₃ B ₂	1:1.42	1:1.40	1:1.41
Zn ₁ Fe ₃ B ₃	1:1.36	1:1.38	1:1.32
Zn ₂ Fe ₁ B ₁	1:1.38	1:1.40	1:1.42
Zn ₂ Fe ₁ B ₂	1:1.31	1:1.41	1:1.37
Zn ₂ Fe ₁ B ₃	1:1.38	1:1.43	1:1.40
Zn ₂ Fe ₂ B ₁	1:1.34	1:1.44	1:1.36
Zn ₂ Fe ₂ B ₂	1:1.29	1:1.42	1:1.28
Zn ₂ Fe ₂ B ₃	1:1.30	1:1.43	1:1.34
Zn ₂ Fe ₃ B ₁	1:1.36	1:1.36	1:1.37
Zn ₂ Fe ₃ B ₂	1:1.33	1:1.45	1:1.42
Zn ₂ Fe ₃ B ₃	1:1.34	1:1.39	1:1.36
Zn ₃ Fe ₁ B ₁	1:1.38	1:1.45	1:1.41
Zn ₃ Fe ₁ B ₂	1:1.30	1:1.42	1:1.35
Zn ₃ Fe ₁ B ₃	1:1.41	1:1.43	1:1.39
Zn ₃ Fe ₂ B ₁	1:1.39	1:1.36	1:1.37
Zn ₃ Fe ₂ B ₂	1:1.41	1:1.41	1:1.42
Zn ₃ Fe ₂ B ₃	1:1.32	1:1.39	1:1.34
Zn ₃ Fe ₃ B ₁	1:1.28	1:1.44	1:1.33
Zn ₃ Fe ₃ B ₂	1:1.37	1:1.43	1:1.38
Zn ₃ Fe ₃ B ₃	1:1.37	1:1.34	1:1.36
Zn ₀ Fe ₀ B ₀	1:1.38	1:1.43	1:1.41

1983 and 1984, 19.42 and 19.20 per cent total soluble solids were noted under B_3 .

Interaction treatments of Zn+Fe and Zn+B caused significant effect on T.S.S. content in all the years of the experiments, whereas Zn+B did so only in the 'on' years. The highest percentage of T.S.S. under Zn_2Fe_1 was 20.15 and highest values obtained under Zn_3B_3 and Fe_3B_3 were 20.04 and 19.86 per cent. These values were obtained in 1983.

Among the interactions of Zn+Fe+B, it was observed that a number of treatments caused significant increase in T.S.S. contents of fruits compared to the fruits under control in all the years. The maximum concentrations recorded were 21.06, 20.33 and 20.06 per cent under the treatments $Zn_2Fe_1B_2$, $Zn_3Fe_2B_2$ and $Zn_3Fe_1B_2$ in 1983, 1984 and 1985 respectively. The corresponding values under control were 18.13, 17.46 and 18.53.

Total sugar :

The data on the effect of micronutrients on total sugar content of fruits recorded in Table 28 and Fig.6 clearly indicate that Zn and B at all concentrations proved effective in increasing the sugar content of fruit in all the three years, whereas such effect of Fe was noted only in 1985. The total sugar content increased as the concentrations of Zn and B increased and the highest values were attained with Zn_3 and B_3 . The concentration effect of iron was not consistent.

Table 27. Effect of three levels of Zn, Fe and B and their interactions on total soluble solid content of fruit.

Zn levels	T.S.S.(0°Brix)			Fe levels	T.S.S.(0°Brix)			B levels	T.S.S.(0°Brix)		
	1983	1984	1985		1983	1984	1985		1983	1984	1985
Zn ₁	18.91	18.25	18.68	Fe ₁	19.41	18.77	19.22	B ₁	18.98	18.33	19.09
Zn ₂	19.09	18.66	18.95	Fe ₂	19.01	18.71	18.75	B ₂	19.15	18.87	18.97
Zn ₃	19.54	19.49	19.42	Fe ₃	19.13	18.92	19.08	B ₃	19.42	19.20	18.99
S.Em ±	0.09	0.12	0.05		0.09	0.12	0.05		0.09	0.12	0.05
C.D.at 5%	0.27	0.33	0.15		0.27	N.S.	0.15		0.27	0.33	N.S.
					1984				1985		
Zn x Fe				Fe ₁		Fe ₂	Fe ₃		Fe ₁	Fe ₂	Fe ₃
Zn ₁	18.68	19.17	18.88		18.04	18.08	18.62		18.66	18.37	19.02
Zn ₂	20.15	18.60	18.53		19.08	17.95	18.95		19.37	18.48	19.00
Zn ₃	19.40	19.26	19.97		19.17	20.11	19.20		19.62	19.40	19.24
S.Em ±		0.16				0.21				0.09	
C.D.at 5%		0.47				0.58				0.26	
Zn x B				B ₁	B ₂	B ₃			B ₁	B ₂	B ₃
Zn ₁	18.57	19.13	19.04		17.44	18.40	18.91		18.60	18.88	18.57
Zn ₂	18.84	19.26	19.17		18.08	18.77	19.13		19.24	18.55	19.06
Zn ₃	19.53	19.06	20.04		19.46	19.44	19.57		19.44	19.48	19.33
S.Em ±		0.16				0.21				0.09	
C.D. at 5%		0.47				N.S.				0.26	

Contd...

Contd...Table 27.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	19.31	19.22	19.71	18.93	18.75	18.62	19.04	19.55	19.06
Fe ₂	19.53	18.88	18.68	18.13	18.44	19.57	18.97	18.31	18.97
Fe ₃	18.11	19.42	19.86	17.93	19.42	19.42	19.26	19.06	18.93
S. Em ±	0.16			0.21				0.09	
C.D. at 5%	0.47			0.58				0.26	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	19.73	18.13	18.20	17.06	18.53	18.53	18.93	19.06	18.00
Fe ₁	19.26	19.86	18.40	17.26	17.73	19.26	17.86	18.46	18.80
Fe ₂	16.73	19.40	20.53	18.00	18.93	18.93	19.00	19.13	18.93
Fe ₃	19.26	21.06	20.13	19.66	19.46	18.13	18.73	19.53	19.86
Zn ₂	19.80	17.20	18.80	17.06	17.26	19.53	19.60	17.26	18.60
Fe ₁	17.46	19.53	18.60	17.53	19.60	19.73	19.40	18.86	18.73
Fe ₂	18.93	18.46	20.80	20.06	18.26	19.20	19.46	20.06	19.33
Fe ₃	19.53	19.40	18.86	20.06	20.33	19.93	19.46	19.20	19.53
Zn ₃	20.13	19.33	20.46	18.26	19.73	19.60	19.40	19.20	19.13
Zn ₀ Fe ₀ B ₀	18.13			17.46				18.53	
S. Em ±	0.29			0.36				0.16	
C.D. at 5%	0.82			1.01				0.45	

N.S. = Not significant.

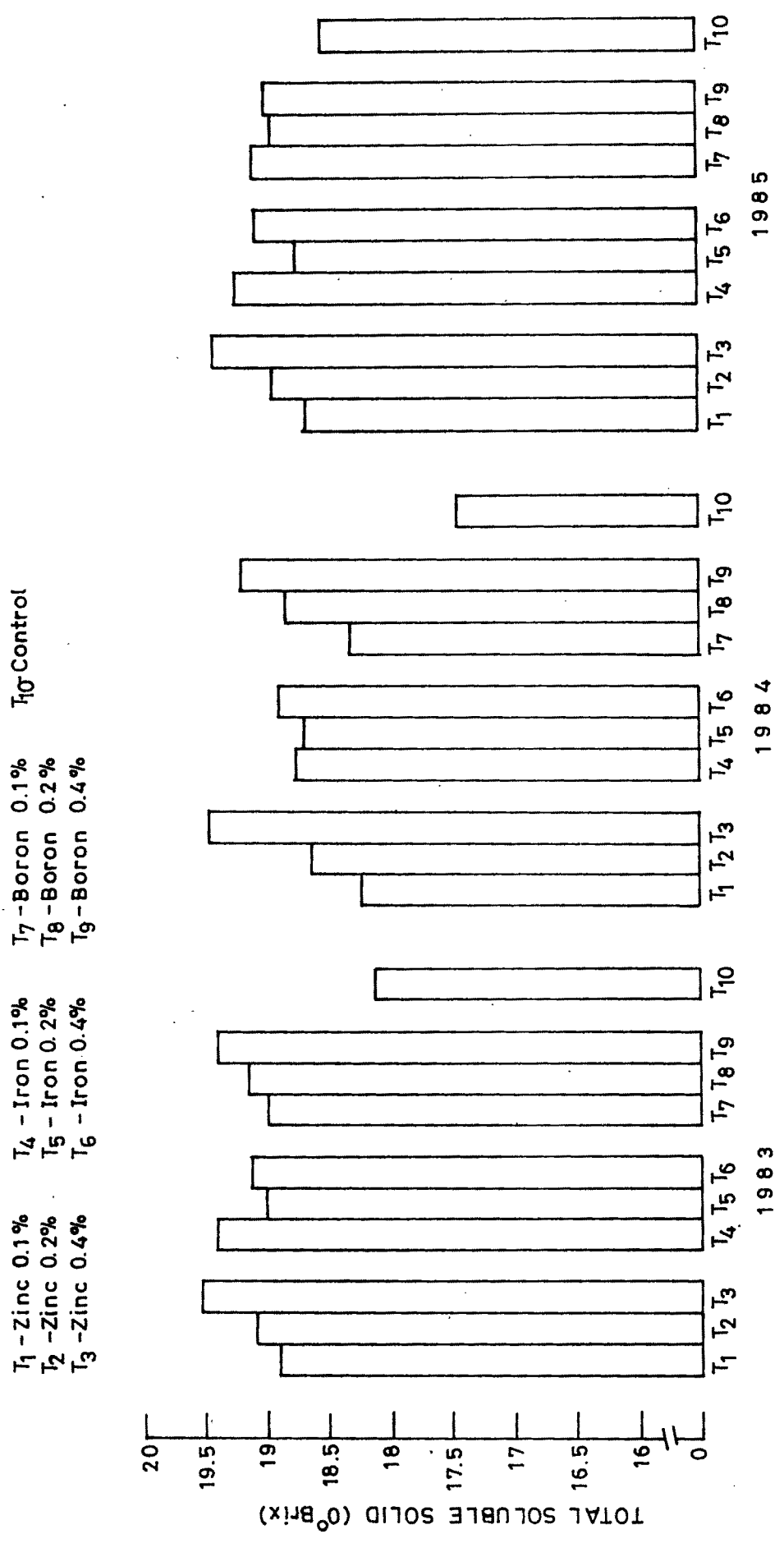


FIG.5. TOTAL SOLUBLE SOLID CONTENT OF FRUIT DUE TO DIFFERENT LEVELS OF ZN, FE AND B.

Like the individual effect of micronutrients, their various first order interactions also proved effective in this respect. As much as 13.93, 16.10 and 15.26 per cent total sugar were recorded with Zn_3Fe_3 , Zn_3Fe_2 and Zn_3Fe_1 in 1983, 1984 and 1985, respectively. Similarly, 14.15, 15.54 and 14.77 per cent total sugar were obtained under Zn_3B_3 in the first two years (1983 and 1984) and under Zn_3B_1 in the last year (1985). Likewise, the interaction of Fe+B at higher levels resulted in increased total sugar content.

Treatment with Zn+Fe+B also resulted in significant variations over control in all the years. Total sugar content varied between 8.58 and 15.44 in 1983, between 11.77 and 16.22 in 1984 and between 11.28 and 15.87 in 1985. These values under control were 10.04, 12.14 and 12.40 in the respective years.

Reducing sugar :

It was observed from the data in Table 29 that reducing sugar content of fruit increased significantly as the concentration of zinc was increased, in all the years under observation. Treatment with iron caused increase in reducing sugar content only in 1985. In 1983 and 1984 treatment with B_3 proved effective in this respect, while no such effect was obtained under B_2 in 1984.

In accordance with the individual effect of Zn, Fe and B, their various first order interactions also enhanced the reducing sugar contents of fruits particularly when combined at their higher levels. The effect of Zn+B was however, less conspicuous in 1984. The

Table 28. Effect of three levels of Zn, Fe and B and their interactions on total sugar content of fruit.

Zn levels	Total sugar (% fresh weight)			B Levels	Total sugar (% fresh weight)							
	1983	1984	1985		1983	1984	1985					
Zn ₁	11.43	12.94	13.85	Fe ₁	12.56	14.17	14.47	B ₁	12.22	13.31	14.21	
Zn ₂	12.17	13.76	13.96	Fe ₂	11.99	13.84	13.63	B ₂	11.71	14.34	14.01	
Zn ₃	13.0	15.31	14.61	Fe ₃	12.04	14.00	14.31	B ₃	12.67	14.36	14.21	
S. Em ±	0.19	0.17	0.04		0.19	0.17	0.04		0.19	0.17	0.04	
C.D. at 5%	0.55	0.48	0.12		N.S.	N.S.	0.12		0.55	0.48	0.12	
1983												
Zn x Fe	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	11.47	11.93	10.89	12.97	12.70	13.17	13.83	13.33	14.39	13.83	13.03	14.53
Zn ₂	13.90	11.30	11.31	14.47	12.73	14.09	14.31	13.03	14.53	14.31	13.03	14.53
Zn ₃	12.31	12.75	13.93	15.08	16.10	14.74	15.26	14.53	14.03	15.26	14.53	14.03
S. Em ±	0.34	0.34		0.30	0.30		0.07	0.07		0.07	0.07	
C.D. at 5%	0.96	0.96		0.84	0.84		0.21	0.21		0.21	0.21	
Zn x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	11.89	11.02	11.38	12.01	13.42	13.40	14.24	13.75	13.56	14.24	13.75	13.56
Zn ₂	11.83	12.19	12.48	12.90	14.25	14.14	13.59	13.57	14.71	13.59	13.57	14.71
Zn ₃	12.94	11.90	14.15	15.02	15.36	15.54	14.77	14.70	14.35	14.77	14.70	14.35
S. Em ±	0.34	0.34		0.30	0.30		0.07	0.07		0.07	0.07	
C.D. at 5%	0.96	0.96		N.S.	N.S.		0.21	0.21		0.21	0.21	

Contd...

Contd... Table 28.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	12.45	11.84	13.39	14.13	14.45	13.93	14.30	15.21	13.91
Fe ₂	13.17	11.59	11.22	13.30	13.66	14.57	13.57	12.82	14.49
Fe ₃	11.05	11.68	13.39	12.50	14.92	14.57	14.74	13.98	14.23
S. Em ±	0.34				0.30			0.07	
C.D. at 5%	0.96				0.84			0.21	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁ Fe ₁	14.33	10.04	10.04	11.77	13.50	13.30	14.39	14.84	12.28
Fe ₂	12.77	12.31	10.71	12.11	12.77	13.22	12.85	12.86	14.29
Fe ₃	8.58	10.71	13.37	12.18	13.99	13.34	15.49	13.54	14.12
Zn ₂ Fe ₁	11.57	15.44	14.69	14.89	15.48	13.05	13.04	14.91	15.01
Fe ₂	13.70	8.83	11.37	11.79	11.99	14.42	13.42	11.28	14.38
Fe ₃	10.24	12.31	11.37	12.30	15.28	14.96	14.34	14.53	14.74
Zn ₃ Fe ₁	11.45	10.04	15.44	15.74	14.39	15.12	15.47	15.87	14.44
Fe ₂	13.05	13.64	11.57	16.02	16.22	16.07	14.46	14.34	14.81
Fe ₃	14.33	12.03	15.44	13.32	15.49	15.44	14.40	13.88	13.82
Zn ₀ Fe ₀ Bo		10.04			12.14			12.40	
S. Em ±		0.59			0.52			0.13	
C.D. at 5%		1.66			1.45			0.36	

N.S. = Not significant.

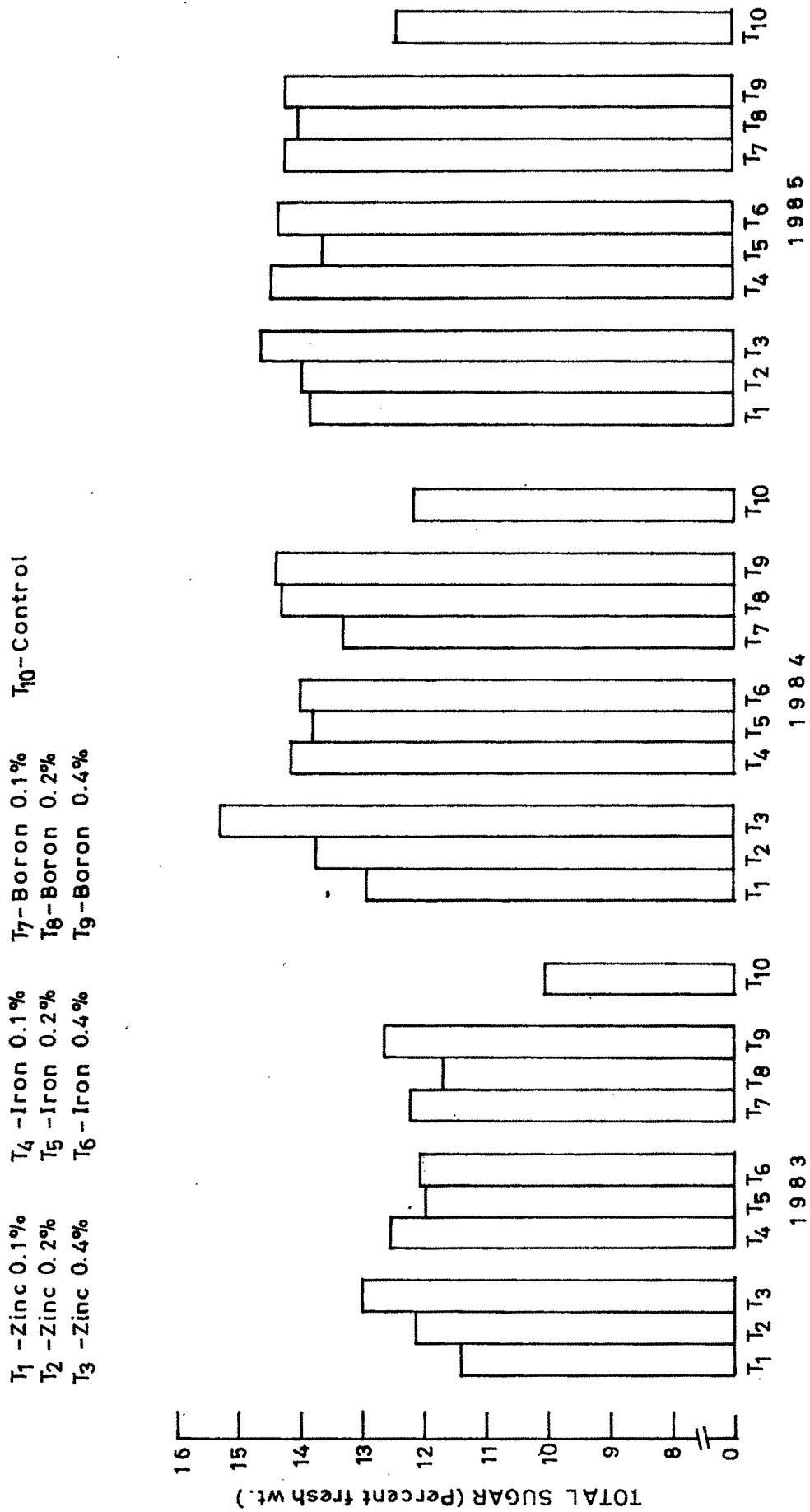


FIG.6. TOTAL SUGAR CONTENT OF FRUIT AS AFFECTED BY DIFFERENT LEVELS OF ZN, Fe AND B.

Contd... Table 29.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	4.19	3.94	4.15	4.06	3.77	3.86	3.89	4.33	4.23
Fe ₂	4.13	3.92	3.87	3.41	3.63	4.62	4.04	4.09	4.15
Fe ₃	3.56	3.95	4.31	3.25	4.62	4.52	4.39	4.18	4.08
S. Em ±		0.09			0.19			0.04	
C.D. at 5%		0.27			0.53			0.12	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁ Fe ₁	4.17	3.26	3.23	2.65	3.51	3.99	4.45	4.66	3.79
Fe ₂	3.49	4.39	3.74	2.72	3.03	4.48	3.57	4.00	3.91
Fe ₃	3.10	3.84	4.72	3.41	4.21	3.89	4.19	4.22	4.06
Zn ₂ Fe ₁	4.12	4.76	4.51	4.68	4.54	3.54	3.92	4.08	5.05
Fe ₂	4.43	3.04	3.70	2.61	2.68	4.45	4.39	3.74	3.87
Fe ₃	3.25	4.41	3.73	3.04	4.85	4.95	4.44	4.04	4.08
Zn ₃ Fe ₁	4.29	3.82	4.72	4.86	3.25	4.04	3.31	4.24	3.86
Fe ₂	4.48	4.34	4.17	4.90	5.19	4.92	4.17	4.54	4.66
Fe ₃	4.32	3.62	4.49	3.31	4.81	4.73	4.55	4.30	4.11
Zn ₀ Fe ₀ B ₀		3.14			3.20			3.84	
S. Em ±		0.17			0.33			0.07	
C.D. at 5%		0.48			0.92			0.21	

N.S = Not significant.

treatments $Zn_2Fe_1B_2$, $Zn_3Fe_2B_2$ and $Zn_3Fe_1B_3$ caused maximum increase in the reducing sugar content respectively in 1983, 1984 and 1985. Apart from these, a number of other treatments also enhanced the reducing sugar content significantly over control.

Non-reducing sugar :

Like the total and reducing sugar contents of fruits, the non-reducing sugar contents of fruits increased as the concentration of Zn increased and significant beneficial effect was obtained both in 1984 and 1985. The effect of various concentrations of Fe differed significantly in this respect in all the years and the effective concentration was 0.1 per cent. At higher levels the non-reducing sugar content declined. Concentrations of B exhibited differential response in different years, though in all the years it showed significant effect.

In general, the non-reducing sugar content of fruit was also found to vary significantly among the various treatment interaction of Zn+Fe, Zn+B and Fe+B in all the years. Treatment with Zn_3Fe_1 caused marked increase in non-reducing sugar content in 1984 and 1985. Interactions of Zn + B at higher levels enhanced it appreciably. The beneficial effect of Fe_1B_2 was also noted in the last two years.

Non-reducing sugar contents ranged from 5.20 to 10.40, 8.29 to 10.59 and 8.06 to 11.55 per cent due to the different treatment respectively in 1983, 1984 and 1985. Fruits obtained from control trees had 6.55, 8.48 and 8.13 per cent non-reducing sugar in the respective years under study (Table 30).

Contd... Table 30.

<u>Fe x B</u>	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	7.83	7.49	8.77	9.56	10.15	9.57	9.88	10.33	9.19
Fe ₂	8.58	7.28	6.97	9.39	9.51	9.44	9.05	8.29	9.82
Fe ₃	7.11	7.34	8.62	8.78	9.79	9.54	9.82	9.31	9.63
S. Em ±		0.26			0.14			0.07	
C.D.at 5%		0.75			0.41			0.21	
<u>Zn x Fe x B</u>									
Zn ₁									
Fe ₁	9.64	6.43	6.46	8.65	9.49	9.17	9.44	9.66	8.06
Fe ₂	8.81	7.52	6.61	8.91	9.24	8.29	8.81	8.42	9.85
Fe ₃	5.20	6.52	8.21	8.32	9.32	8.97	10.73	8.85	9.55
Zn ₂									
Fe ₁	7.07	10.14	9.67	9.69	10.38	9.03	8.65	10.27	9.45
Fe ₂	8.80	5.49	7.28	8.71	8.84	9.46	8.57	7.15	9.97
Fe ₃	6.63	7.50	7.25	8.52	9.90	9.50	9.39	9.96	10.12
Zn ₃									
Fe ₁	6.80	5.91	10.17	10.33	10.57	10.51	11.55	11.05	10.06
Fe ₂	8.13	8.83	7.02	10.56	10.49	10.59	9.77	9.30	9.63
Fe ₃	9.49	7.99	10.40	9.50	10.14	10.16	9.35	9.10	9.23
Zn ₀ Fe ₀ B ₀		6.55			8.48			8.13	
S. Em ±		0.46			0.25			0.13	
C.D.at 5%		1.30			0.71			0.36	

N.S. = Not significant.

Fruit acidity :

Fruit acidity expressed as the percentage of citric acid was significantly lower when the trees were treated with 0.1 per cent Zn in all the years. Higher concentration of zinc promoted acidity. The effect of Fe and B were however, less pronounced in this regard. Treatment with Fe₂ resulted in lower fruit acidity in 1983.

Among the combinations of Zn+Fe, Zn₃Fe₂ and Zn₁Fe₂ recorded the lowest acidity. Fe₂B₁ and Fe₃B₂ also recorded lower values in 1983 and 1984 respectively. The effect of Zn and B was not apparent in all the years of the experiment.

Of the various interactions, the treatment Zn₁Fe₂B₂ proved most effective in reducing the fruit acidity in all the years. Besides the said treatments, a number of other treatments also proved effective in this regard (Table 31).

Sugar:acid ratio :

It is revealed from the data (Table 32) on sugar/acid ratio that treatment with Zn, Fe and B caused variable results with respect to sugar:acid ratio of fruits. The treatments Zn₂Fe₂B₁, Zn₂Fe₃B₂ and Zn₁Fe₃B₃ enhanced the sugar content markedly over other treatments including control and thereby increased the proportion of sugar to acid causing increased sweetness of fruits in 1983, 1984 and 1985 respectively. In general, the magnitude of variation of sugar/acid ratio was less apparent in 1985 than in 1984 and 1983.

Table 31. Effect of three levels of Zn, Fe and B and their interactions on fruit acidity (interms of citric acid).

Zn levels	Fruit acidity (% fresh weight)			Fe levels	Fruit acidity (% fresh weight)			B levels	Fruit acidity (% fresh weight)			
	1983	1984	1985		1983	1984	1985		1983	1984	1985	
Zn ₁	0.42	0.38	0.40	Fe ₁	0.46	0.44	0.44	B ₁	0.43	0.42	0.45	
Zn ₂	0.46	0.42	0.45	Fe ₂	0.41	0.41	0.43	B ₂	0.46	0.41	0.43	
Zn ₃	0.48	0.44	0.44	Fe ₃	0.49	0.40	0.43	B ₃	0.47	0.42	0.43	
S. Em ±	0.014	0.01	0.006		0.014	0.01	0.006		0.014	0.01	0.006	
C.D. at 5%	0.040	0.03	0.016		0.040	N.S.	N.S.		N.S.	N.S.	0.016	
1983												
Zn x Fe	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃	Fe ₁	Fe ₂	Fe ₃
Zn ₁	0.42	0.40	0.44	0.43	0.32	0.39	0.41	0.39	0.41	0.39	0.41	0.41
Zn ₂	0.47	0.46	0.46	0.40	0.45	0.42	0.46	0.46	0.46	0.46	0.45	0.45
Zn ₃	0.49	0.37	0.58	0.47	0.46	0.40	0.44	0.44	0.44	0.45	0.44	0.44
S. Em ±		0.024			0.02					0.010		
C.D. at 5%		0.069			0.05					N.S.		
1984												
Zn x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁	0.42	0.43	0.43	0.38	0.40	0.37	0.42	0.39	0.39	0.42	0.39	0.39
Zn ₂	0.41	0.48	0.51	0.44	0.40	0.44	0.48	0.45	0.44	0.48	0.45	0.44
Zn ₃	0.45	0.51	0.48	0.46	0.43	0.44	0.46	0.43	0.44	0.46	0.43	0.44
S. Em ±		0.024			0.02					0.010		
C.D. at 5%		N.S.			N.S.					N.S.		

Contd...

Contd... Table 31.

Fe x B	1983			1984			1985		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Fe ₁	0.42	0.45	0.51	0.40	0.44	0.47	0.44	0.43	0.43
Fe ₂	0.37	0.38	0.48	0.43	0.41	0.39	0.44	0.44	0.42
Fe ₃	0.49	0.55	0.43	0.45	0.37	0.39	0.47	0.41	0.42
S. Em ±		0.024			0.02			0.010	
C.D. at 5%		0.069			0.05			0.029	
Zn x Fe x B	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Zn ₁									
Fe ₁	0.41	0.35	0.50	0.36	0.51	0.44	0.38	0.43	0.42
Fe ₂	0.41	0.33	0.45	0.32	0.32	0.32	0.44	0.37	0.40
Fe ₃	0.43	0.53	0.36	0.46	0.38	0.35	0.47	0.39	0.36
Zn ₂									
Fe ₁	0.40	0.55	0.45	0.36	0.37	0.50	0.46	0.43	0.48
Fe ₂	0.33	0.42	0.65	0.47	0.48	0.42	0.45	0.43	0.41
Fe ₃	0.50	0.47	0.42	0.49	0.36	0.41	0.52	0.40	0.44
Zn ₃									
Fe ₁	0.45	0.44	0.59	0.49	0.46	0.47	0.47	0.44	0.41
Fe ₂	0.36	0.41	0.35	0.51	0.46	0.42	0.49	0.42	0.45
Fe ₃	0.55	0.67	0.51	0.39	0.39	0.43	0.41	0.44	0.46
Zn ₀ Fe ₀ B ₀		0.49			0.41			0.42	
S. Em ±		0.042			0.030			0.018	
C.D. at 5%		0.120			0.08			0.050	

N.S. = Not significant.

Table 32. Effect of three levels of Zn, Fe and B and their interactions on sugar/acid ratio of fruit.

Treatments	Sugar/acid ratio		
	1983	1984	1985
Zn ₁ Fe ₁ B ₁	34.95	32.69	37.86
Zn ₁ Fe ₁ B ₂	28.68	26.47	34.51
Zn ₁ Fe ₁ B ₃	20.08	30.22	29.23
Zn ₁ Fe ₂ B ₁	31.14	37.84	29.20
Zn ₁ Fe ₂ B ₂	37.30	39.90	34.75
Zn ₁ Fe ₂ B ₃	23.80	41.31	35.72
Zn ₁ Fe ₃ B ₁	19.95	26.47	32.95
Zn ₁ Fe ₃ B ₂	20.20	36.81	34.71
Zn ₁ Fe ₃ B ₃	37.13	38.11	39.22
Zn ₂ Fe ₁ B ₁	29.92	41.36	28.34
Zn ₂ Fe ₁ B ₂	28.07	41.83	34.67
Zn ₂ Fe ₁ B ₃	32.64	26.10	31.27
Zn ₂ Fe ₂ B ₁	41.51	25.08	29.82
Zn ₂ Fe ₂ B ₂	21.02	24.97	26.23
Zn ₂ Fe ₂ B ₃	17.49	34.33	35.07
Zn ₂ Fe ₃ B ₁	20.48	25.10	27.57
Zn ₂ Fe ₃ B ₂	26.19	42.44	36.32
Zn ₂ Fe ₃ B ₃	27.07	36.48	33.50
Zn ₃ Fe ₁ B ₁	25.44	32.12	32.91
Zn ₃ Fe ₁ B ₂	22.81	31.28	36.06
Zn ₃ Fe ₁ B ₃	26.16	32.17	35.22
Zn ₃ Fe ₂ B ₁	36.25	31.41	29.51
Zn ₃ Fe ₂ B ₂	33.26	35.26	34.14
Zn ₃ Fe ₂ B ₃	33.05	38.26	32.91
Zn ₃ Fe ₃ B ₁	26.05	34.15	35.12
Zn ₃ Fe ₃ B ₂	17.95	39.71	31.54
Zn ₃ Fe ₃ B ₃	30.27	35.90	30.04
Zn ₀ Fe ₀ B ₀	20.48	29.61	29.52

Effect of three levels of Zn, Fe, B and their interactions on N, P and K content of leaf and shoot of mango tree.

Nitrogen :

Leaf - The effect of application of micronutrients on leaf N content of mangoes as presented in the data in Table 33 indicated that application of zinc, iron and boron caused increase in the nitrogen content in leaf. The maximum nitrogen contents of 1.59 and 1.42 per cent were recorded in the leaves from the plants treated with $Zn_3Fe_3B_3$, in the vegetative and preharvest stages respectively; while in the full-bloom stage nitrogen content of 1.34 per cent was obtained under $Zn_3Fe_3B_2$. It is also evident from the data that the leaf nitrogen content was comparatively higher at the vegetative stage, which declined at the full-bloom stage and again showed an increasing trend at the preharvest stage.

Shoot - The data presented in Table 33 revealed that the N content in shoot was less than that in leaf and the maximum nitrogen contents in shoot at the vegetative and full-bloom stages were recorded by treatment with $Zn_3Fe_3B_3$ but at the preharvest stage the highest N content in shoot was recorded under $Zn_3Fe_2B_3$ treatment. The effect of micronutrients sprays particularly at higher levels were more effective in increasing the N content in shoot.

Phosphorus :

Leaf - The data presented in Table 34 reveal that as the level of zinc, iron and boron increased the phosphorus content in leaf also increased up to height level. The highest P content in

Table 33. Effect of three levels of Zn, Fe, B and their interactions on the nitrogen content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight)

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn ₁ Fe ₁ B ₁	1.42	1.17	1.26	0.78	0.58	0.75
Zn ₁ Fe ₁ B ₂	1.45	1.17	1.30	0.78	0.56	0.75
Zn ₁ Fe ₁ B ₃	1.45	1.14	1.26	0.81	0.61	0.78
Zn ₁ Fe ₂ B ₁	1.45	1.17	1.30	0.81	0.61	0.78
Zn ₁ Fe ₂ B ₂	1.42	1.20	1.34	0.81	0.58	0.75
Zn ₁ Fe ₂ B ₃	1.45	1.17	1.30	0.89	0.61	0.84
Zn ₁ Fe ₃ B ₁	1.48	1.20	1.26	0.81	0.67	0.81
Zn ₁ Fe ₃ B ₂	1.45	1.23	1.37	0.84	0.61	0.84
Zn ₁ Fe ₃ B ₃	1.48	1.23	1.30	0.84	0.67	0.86
Zn ₂ Fe ₁ B ₁	1.48	1.20	1.26	0.92	0.81	0.84
Zn ₂ Fe ₁ B ₂	1.51	1.20	1.34	0.95	0.75	0.78
Zn ₂ Fe ₁ B ₃	1.48	1.23	1.34	0.95	0.72	0.89
Zn ₂ Fe ₂ B ₁	1.51	1.26	1.37	0.81	0.81	0.81
Zn ₂ Fe ₂ B ₂	1.51	1.26	1.40	0.78	0.75	0.75
Zn ₂ Fe ₂ B ₃	1.48	1.26	1.37	0.81	0.61	0.95
Zn ₂ Fe ₃ B ₁	1.45	1.23	1.34	0.84	0.67	0.81
Zn ₂ Fe ₃ B ₂	1.48	1.26	1.37	0.92	0.72	0.78
Zn ₂ Fe ₃ B ₃	1.53	1.26	1.40	0.84	0.81	0.95
Zn ₃ Fe ₁ B ₁	1.51	1.23	1.40	0.92	0.75	0.86
Zn ₃ Fe ₁ B ₂	1.54	1.26	1.37	0.78	0.72	0.75
Zn ₃ Fe ₁ B ₃	1.54	1.31	1.42	0.95	0.84	0.92
Zn ₃ Fe ₂ B ₁	1.53	1.31	1.40	0.92	0.78	0.75
Zn ₃ Fe ₂ B ₂	1.48	1.26	1.37	0.81	0.67	0.86
Zn ₃ Fe ₂ B ₃	1.53	1.31	1.40	0.92	0.84	0.95
Zn ₃ Fe ₃ B ₁	1.54	1.31	1.34	0.95	0.78	0.84
Zn ₃ Fe ₃ B ₂	1.56	1.34	1.42	0.81	0.81	0.81
Zn ₃ Fe ₃ B ₃	1.59	1.31	1.42	0.95	0.92	0.92
Zn ₀ Fe ₀ B ₀	1.42	1.14	1.24	0.75	0.58	0.72

V.S. = Vegetative stage
 F.B.S. = Full bloom stage
 P.S. = Preharvest stage.

leaf (0.110%) was recorded at the vegetative stage when the plants were treated with $Zn_3Fe_3B_3$. The maximum P content of 0.085 per cent was noted at the full-bloom stage by treatment with $Zn_3Fe_3B_2$.

Shoot - Like leaf, the phosphorus content in shoot increased with the higher concentration of zinc, iron and boron. Irrespective of the treatment the P content in shoot was lower than that of leaf at different stage of sampling. The highest P content of 0.075 per cent in shoot was noted under $Zn_3Fe_3B_3$, at the vegetative stage and thereafter phosphorus content declined in the full bloom and perharvest stages.

Potassium :

Leaf - The data on the leaf and shoot K content presented in Table 35 reveal variations in the percentage of K content in leaf with the application of zinc, iron and boron. The highest potassium content of 1.03% in leaf was found under $Zn_3Fe_3B_3$, at the vegetative stage and it declined at full bloom and preharvest stages.

Shoot - In shoot the potassium content was lower than that of leaf. Sprays with the increased levels of zinc, iron and boron caused higher concentrations of potassium in shoot. As in the case of leaf, potassium content in shoot also declined at full-bloom stage but again increased in preharvest stage.

Table 34. Effect of three levels of Zn, Fe, B and their interactions on the phosphorus content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight).

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn ₁ Fe ₁ B ₁	0.070	0.060	0.065	0.045	0.025	0.040
Zn ₁ Fe ₁ B ₂	0.070	0.060	0.060	0.040	0.030	0.040
Zn ₁ Fe ₁ B ₃	0.075	0.065	0.065	0.045	0.030	0.035
Zn ₁ Fe ₂ B ₁	0.070	0.060	0.060	0.045	0.025	0.040
Zn ₁ Fe ₂ B ₂	0.075	0.065	0.065	0.045	0.035	0.040
Zn ₁ Fe ₂ B ₃	0.075	0.070	0.065	0.040	0.035	0.045
Zn ₁ Fe ₃ B ₁	0.080	0.075	0.065	0.045	0.040	0.040
Zn ₁ Fe ₃ B ₂	0.070	0.065	0.060	0.050	0.040	0.045
Zn ₁ Fe ₃ B ₃	0.085	0.075	0.065	0.055	0.040	0.045
Zn ₂ Fe ₁ B ₁	0.075	0.070	0.065	0.050	0.045	0.050
Zn ₂ Fe ₁ B ₂	0.080	0.070	0.060	0.055	0.045	0.050
Zn ₂ Fe ₁ B ₃	0.080	0.065	0.060	0.055	0.050	0.050
Zn ₂ Fe ₂ B ₁	0.085	0.075	0.065	0.060	0.045	0.055
Zn ₂ Fe ₂ B ₂	0.085	0.080	0.070	0.065	0.055	0.055
Zn ₂ Fe ₂ B ₃	0.090	0.080	0.075	0.060	0.050	0.060
Zn ₂ Fe ₃ B ₁	0.085	0.075	0.070	0.065	0.060	0.065
Zn ₂ Fe ₃ B ₂	0.090	0.085	0.075	0.065	0.055	0.055
Zn ₂ Fe ₃ B ₃	0.095	0.085	0.075	0.060	0.050	0.065
Zn ₃ Fe ₁ B ₁	0.085	0.075	0.070	0.065	0.055	0.065
Zn ₃ Fe ₁ B ₂	0.090	0.075	0.075	0.065	0.060	0.070
Zn ₃ Fe ₁ B ₃	0.095	0.080	0.070	0.065	0.055	0.065
Zn ₃ Fe ₂ B ₁	0.095	0.080	0.075	0.070	0.065	0.060
Zn ₃ Fe ₂ B ₂	0.100	0.085	0.075	0.070	0.065	0.065
Zn ₃ Fe ₂ B ₃	0.105	0.080	0.070	0.065	0.060	0.065
Zn ₃ Fe ₃ B ₁	0.100	0.085	0.075	0.065	0.060	0.060
Zn ₃ Fe ₃ B ₂	0.105	0.085	0.075	0.070	0.065	0.065
Zn ₃ Fe ₃ B ₃	0.110	0.080	0.080	0.075	0.060	0.065
Zn ₀ Fe ₀ B ₀	0.075	0.060	0.065	0.045	0.030	0.035

V.S. = Vegetative stage
 F.B.S. = Full bloom stage
 P.S. = Preharvest stage.

Table 35. Effect of three levels of Zn, Fe, B and their interactions on the potassium content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight).

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn ₁ Fe ₁ B ₁	0.90	0.74	0.78	0.40	0.33	0.36
Zn ₁ Fe ₁ B ₂	0.90	0.76	0.78	0.40	0.33	0.36
Zn ₁ Fe ₁ B ₃	0.91	0.76	0.74	0.43	0.34	0.39
Zn ₁ Fe ₂ B ₁	0.91	0.74	0.81	0.43	0.33	0.36
Zn ₁ Fe ₂ B ₂	0.90	0.78	0.81	0.44	0.36	0.39
Zn ₁ Fe ₂ B ₃	0.93	0.78	0.84	0.44	0.36	0.39
Zn ₁ Fe ₃ B ₁	0.93	0.78	0.84	0.47	0.34	0.36
Zn ₁ Fe ₃ B ₂	0.91	0.81	0.87	0.44	0.36	0.36
Zn ₁ Fe ₃ B ₃	0.93	0.84	0.87	0.47	0.39	0.41
Zn ₂ Fe ₁ B ₁	0.91	0.78	0.87	0.47	0.39	0.39
Zn ₂ Fe ₁ B ₂	0.93	0.81	0.90	0.49	0.36	0.49
Zn ₂ Fe ₁ B ₃	0.96	0.81	0.90	0.49	0.41	0.47
Zn ₂ Fe ₂ B ₁	0.93	0.81	0.90	0.47	0.41	0.47
Zn ₂ Fe ₂ B ₂	0.93	0.84	0.93	0.49	0.44	0.47
Zn ₂ Fe ₂ B ₃	0.96	0.84	0.93	0.49	0.44	0.49
Zn ₂ Fe ₃ B ₁	0.96	0.87	0.96	0.51	0.46	0.49
Zn ₂ Fe ₃ B ₂	0.96	0.87	0.96	0.51	0.44	0.47
Zn ₂ Fe ₃ B ₃	0.98	0.90	0.93	0.54	0.47	0.51
Zn ₃ Fe ₁ B ₁	0.98	0.90	0.96	0.51	0.47	0.51
Zn ₃ Fe ₁ B ₂	0.98	0.91	0.93	0.54	0.49	0.49
Zn ₃ Fe ₁ B ₃	0.98	0.91	0.96	0.51	0.47	0.51
Zn ₃ Fe ₂ B ₁	0.98	0.91	0.96	0.54	0.47	0.51
Zn ₃ Fe ₂ B ₂	1.01	0.93	0.98	0.56	0.49	0.54
Zn ₃ Fe ₂ B ₃	0.98	0.93	0.96	0.56	0.49	0.49
Zn ₃ Fe ₃ B ₁	1.03	0.93	0.96	0.54	0.47	0.54
Zn ₃ Fe ₃ B ₂	1.01	0.91	0.98	0.56	0.51	0.51
Zn ₃ Fe ₃ B ₃	1.03	0.93	0.96	0.56	0.49	0.54
Zn ₀ Fe ₀ B ₀	0.91	0.70	0.74	0.36	0.30	0.34

V.S. = Vegetative stage
 F.B.S. = Full bloom stage
 P.S. = Preharvest stage.

Discussion :

Results presented in the foregoing pages reveal that micro-nutrients were effective in promoting vegetative growth as indicated by plant height, trunk girth and spread of the canopy in young Fazli mango. Of the nutrients, the effect of zinc was most promising. The favourable effect of zinc can be explained from the fact that zinc is a constituent of several enzymes. It is also essential in carbohydrate and nitrogen metabolism and probably in turnover of organic phosphorus compounds (Asana et al., 1971). Zinc increases the synthesis of tryptophan which is a precursor of auxin that promotes vegetative growth. Zinc also plays a positive role in photosynthesis (Agerwala and Sharma, 1978). The present findings appear to be in conformity with the results of Singh and Rajput (1976), Rajput et al. (1976), Oppenheimer and Gazit (1961) in mango and Arora and Singh (1970) in guava.

Similar to zinc, iron also plays a distinct role in the growth and development of plant. Iron is essential in the formation of chlorophyll and absorption of other elements in plant. It is a constituent of enzyme systems which bring about oxidation reduction reaction in the plant, It is also regulates respiration, photosynthesis and reduction of nitrates and sulphates which are essential for plant development. Besides these it is also essential for the synthesis of protein contained in the chloroplast (Kunte and Yawalkar, 1970). Being a constituent of ferredoxin, iron is involved in nitrogen fixation by diverse groups of micro-organism (Agerwala and Sharma, 1978). In the present study the lower level of iron exhibited beneficial effect

in augmenting the vegetative growth of plants possibly due to the reasons described earlier. Similar observation was also made by Arora and Singh (1970) in guava.

From the results of the investigation it is revealed that boron application had a significant role in increasing growth of the plant. It is known that boron plays a vital role in proper development and differentiation of tissues, particularly the vascular elements and its function in cell maturation by regulating the formation and lignification of the cellwall (Agarwal and Sharma, 1978). It helps in absorption of nitrogen, metabolism of carbohydrates, water and pectic substances, absorption of salt and hormone movement in the plant. It is also necessary in the translocation of sugar in the plant (Kunte and Yawalkar, 1970). From the present experiments it was found that highest level of boron proved highly beneficial in enhancing the vegetative growth of mango. The present findings are in agreement with the observations of Rajput et al. (1976) who recorded the maximum length of terminal shoot and number of leaves per shoot with the application of highest dose (0.8%) of this chemical.

The results of the present investigation, however, showed that treatments with various concentration of zinc, iron and boron were less effective in augmenting the flowering percentage significantly in juvenile mango plants, whereas in case of bearing trees iron and boron proved beneficial in bringing about significant variations particularly in the 'off' year (1984) whereas zinc played effective role in the 'on' year. Similar to the individual effect their

various interactions were also found effective in this respect. Minessy et al. (1974) also observed increased flowering with soil application of the iron in mature mango trees. Flowering in plant is largely dependent on shoot maturity, Application of zinc resulted in better vegetative growth. Besides this, application of zinc increased flowering perhaps by increasing the auxin content. Under condition of zinc deficiency, flowering was reported to have been considerably reduced (Agarwala and Sharma, 1978). Rajput and Chand (1975) also noted better flowering with zinc treatment in guava.

It is well established that boron is associated with the flowering process (Kunte and Yawalkar, 1970). Increased flowering obtained in the present study with boron application supports the observations reported by Rajput et al. (1976) in mango, Rajput and Chand (1975) in guava.

The result of the present experiment clearly show beneficial effect of iron and zinc in increasing fruit number. Similar effect of zinc application has also been reported by Daulta et al. (1981) and Minessy et al. (1974). This increase in fruit number was mainly due to better growth and flowering of the plant. Boron was found effective in improving the fruit number upto highest level, but the variation was not very conspicuous. Similar results were also reported by Rajput et al. (1976).

As regards the effect of zinc on fruit weight it was revealed that maximum fruit weight was recorded with the highest level of

zinc. Increase in fruit weight with the application of zinc has been reported by Rath et al. (1980). Similarly, iron and boron increased the fruit weight markedly but the effect was not consistent. The increase in fresh fruit weight with the treatment of boron was also reported by Rath et al. (1980).

Application of zinc, iron and boron was found to increase the fruit yield in bearing trees. Among the three nutrients, zinc and boron improved the fruit yield as compared to iron and the increased yield was obtained with the higher levels of the nutrients. The improvement in yield, obtained in the present investigation was primarily due to production of larger number of fruits and also due to higher weight of individual fruits. Improvement in yield of mango fruit with the application of zinc was also reported by Singh and Rajput (1977).

It is evident from the results mentioned in the foregoing pages that spraying with zinc, iron and boron at higher concentrations in general, showed a tendency to increase the fruit size (length and breadth). Trees sprayed with intermediate concentration of zinc produced larger fruits than that obtained with the lowest concentration. Observation made by Singh and Rajput (1976), Rath et al. (1980) are in line with the present findings. The favourable effect may be attributed to the fact that zinc is essential in nitrogen metabolism (Asana et al., 1971) and it also increases the synthesis of auxin which promotes the cell size (Agarwala and Sharma, 1978). Likewise the beneficial effect of boron in increasing the fruit size is perhaps

due to increased cell division and elongation (Rajput *et al.*, 1976). The effect of iron was not very conspicuous and the increased fruit size is likely due to better vigour of the plant.

As regards the effect of micronutrients on fruit quality, it was found that foliar application of zinc caused increase in the total soluble solids, total sugar, reducing sugar, non-reducing sugar and acidity and the best fruit quality was observed with the higher dose of zinc as compared to the other level of this nutrient. Similar results were obtained by Arora and Singh (1970), Singh and Rajput (1976), Rajput and Chand (1976). The favourable effects of zinc was possibly due to various enzymatic reactions like transformation of carbohydrate, activity of hexokinase and changes in sugar due to its action on zymohexose, a metal protein is blocked by formation of complex cystein. The blocked enzyme is reactivated by zinc and its presence was perhaps of great importance in the sugar metabolism thereby causing the improvement in fruit quality (Singh and Rajput, 1976). Iron had little effect on T.S.S., total sugar, reducing and non-reducing sugars and acidity.

The chemical composition of mango fruit was also improved greatly by boron application. The highest T.S.S. content of fruit was obtained with the application of higher rate (0.4%) of this nutrient. B also increased the acidity content of fruit upto the highest level (0.4%). Alvarrez-Rosario (1965), Bultovic and Javanovic (1970) reported increased T.S.S. and acidity in apple with increased

level of B. Foliar spray of B also increased the total reducing and non-reducing sugar contents of fruits. The maximum total sugar content was obtained with the highest level of B. These results are in agreement with those of Rajput et al. (1976) and Rajput and Chand (1976). Zn in combination with B at higher level also caused increase in the total sugar content of fruit. Similar results were also reported by Rath et al. (1980). The highest total sugar content of fruit was obtained by treatment with 0.4 per cent Zn, 0.1 per cent Fe and 0.4 per cent B.

The nitrogen percentage in the leaf and shoot showed marked variation with application of zinc, iron and boron. An increase in the level of boron caused maximum accumulation of nitrogen in the leaf and shoot, irrespective of the stage of sampling. Singh (1977) also reported that the nitrogen content increased in leaf by application of 0.2 per cent boron.

The phosphorus content in leaf and shoot also increased with the higher levels of micronutrient and variations were noted at the different stages of sampling. Phosphorus content in leaf increased at the vegetative stage and decreased at the later stages. Bopalah et al. (1985) reported that phosphorus content in leaf at the bearing stage was less than that in leaf at the non-bearing stage.

Like phosphorus, potassium content in leaf and shoot also increased with the application of the higher doses of micronutrient, at the vegetative stage and declined at the full bloom stage. Rao and Mukherjee (1985) also reported that potassium content in leaves decreased during full-bloom and preharvest stages.

Experiment II : Effect of Zn, Fe and B in combination with urea on vegetative growth, flowering, yield and fruit quality of mango cv. Fazli.

Plant height :

The data on plant height presented in Table 36 show significant difference due to application of micronutrients in combination with urea. In the year 1983 spraying of zinc at 0.4 per cent with 1 per cent urea was found most effective in increasing the plant height (60.25 cm) over previous year and the growth was 35.75 cm more over control. All the concentrations of boron in combination with urea at 1 per cent exhibited a retarding effect, whereas in the next two years the highest level of iron and boron was found highly effective in promoting growth than control. The maximum increase in height of 79.50 cm was recorded under Fe at 0.4 per cent in combination with 1 per cent urea in 1984, while it was 62.5 cm under B at 0.4 per cent in combination with 1 per cent urea in 1985 as against 53.25 and 30.75 cm under control.

Trunk girth :

It was apparent from the data in Table 36 that spraying of micronutrients were beneficial in enhancing the trunk girth. The maximum increase in trunk girth of 3.0 cm was found when plants were treated with Zn at 0.2 per cent and 1 per cent urea, followed by 2.8 cm under B at 0.2 per cent and 1 per cent urea, while in control it was only 1.41 cm in 1983. The maximum increase in trunk girth of

Table 36. Effect of Zn, Fe and B with urea on plant height and girth of the trunk (expressed as increase over last year)

Treatments	Plant height (cm)			Trunk girth (cm)		
	1983	1984	1985	1983	1984	1985
Zn 0.2%+urea 1%	38.25	60.25	42.25	3.00	4.21	4.79
Zn 0.4%+urea 1%	60.25	71.25	51.75	1.38	3.86	6.03
Fe 0.2%+urea 1%	33.50	45.50	37.75	0.41	3.42	5.17
Fe 0.4%+urea 1%	40.25	79.50	48.50	2.26	7.18	6.30
B 0.2%+urea 1%	20.25	59.50	54.25	2.80	4.18	5.27
B 0.4%+urea 1%	22.25	74.50	62.50	2.12	5.49	7.21
Control	24.50	53.25	30.75	1.41	3.76	4.57
S. Em \pm	2.68	4.17	3.35	0.18	0.32	0.09
C.D. at 5%	7.98	12.41	9.95	0.54	0.95	0.29

7.18 cm occurred in 1984 when plants were sprayed with Fe at 0.4 per cent and 1 per cent urea. Sprays of B at 0.4 per cent and urea caused the maximum increase in trunk girth of 7.21 cm in 1985 followed by 6.3 cm with the application of Fe (0.4 per cent) and urea. The increase in trunk girth under control in 1985 was 4.57 cm.

Spread of the canopy :

As regards the spread of canopy in East-West and North-South direction it is evident from the data in Table 37 that the maximum increase in spread of the canopy in East-West direction (53.25 cm) was recorded when the plants were treated with Fe at 0.2 per cent together with urea at 1 per cent while in the North-South direction the maximum increase of 43.75 cm was noted under Fe at 0.4 per cent with urea in 1983 and this was significantly higher over control. In 1984 the maximum spread of 84.25 cm was observed under B at 0.2 per cent in the East-West direction and 74.50 cm spread occurred at higher level of B in North-South direction. In 1985 the highest spread (69.25 cm) of the canopy in East-West direction was obtained when plants were sprayed with B at 0.4 per cent with 1 per cent urea and in the North-South direction the maximum spread of 66.75 cm was observed under Fe at 0.2 per cent+urea. In control spread was only 47.0 cm in the North-South direction.

Percentage of flowering :

It is seen from the presented data in Table 38 that micro-nutrients were effective in augmenting the flowering percentage. In

Table 37. Effect of Zn, Fe and B with urea on spread of plants (expressed as increase over last year).

Treatments	East-west (cm)			North-south (cm)		
	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	12.25	68.25	52.25	12.00	71.25	65.25
Zn 0.4% + urea 1%	10.50	46.75	54.75	13.25	31.25	62.75
Fe 0.2% + urea 1%	53.25	71.75	61.75	30.50	60.25	66.75
Fe 0.4% + urea 1%	51.25	63.50	47.75	43.75	71.75	49.25
B 0.2% + urea 1%	14.75	84.25	57.75	9.75	66.25	58.50
B 0.4% + urea 1%	22.25	77.50	69.25	21.50	74.50	39.50
Control	30.25	26.25	45.25	33.50	56.75	47.00
S. Em ±	2.51	5.32	2.74	1.87	6.08	3.83
C.D. at 5%	7.48	15.81	8.14	5.57	18.08	11.38

the 'on' year of 1983 the highest of 79 per cent shoots produced panicles when treated with boron at 0.4 per cent along with 1 per cent urea, followed by 77.93 per cent under Fe at 0.2 per cent and urea. In control trees, only 64.34 per cent shoots produced panicles. In the 'off' year of 1984 and the 'on' year of 1985 as much as 42.63 and 71.26 per cent of shoots, respectively bore panicles when treated with 0.4 per cent Zn in combination with urea, as compared to 16.26 and 58.23 per cent under control.

Sex ratio :

It is revealed from the data presented in Table 38 that spraying of micronutrients showed variation in the proportion of perfect flowers to male flowers in all the years of experiment. It was observed that in 1983 and 1985 ('on' years) spraying of Fe at 0.4 per cent with urea (1 per cent) caused the development of maximum number of perfect flowers and thereby decreased the ratio compared to other treatments. On the other hand, in 1984 ('off' year) boron at higher concentration (0.4 per cent) enhanced the number of perfect flowers. In general, the higher rate of micronutrients promoted number of hermaphrodite flowers in all the years of the experiment. Control plants generally showed a tendency to produce more number of male flowers, however, the highest proportion of male flowers was obtained under boron at 0.2 per cent along with 1 per cent urea in all the years of the investigation.

Number of fruits/plant :

The data on the number of fruits harvested as given in the Table 38 and Fig.7 indicate that in 1985 the highest number of fruits (48) were harvested from the plants treated with Zn at 0.4 per cent along with 1 per cent urea resulting thereby 50 per cent more fruits over control. Boron at higher rate also proved effective in increasing the fruit production by 34.4 per cent over the control (32 fruits). It was also clear from the table that zinc and boron each at 0.4 per cent in combination with urea produced more number of fruits as compared to control throughout the period of the investigation.

Fruit weight :

The data on effect of different micronutrients on weight of individual fruits have been presented in Table 39 and Fig. 8. Foliar application of all the micronutrients at their highest levels caused significant improvement on fruit weight in 1983 and 1984. But in the third year (1985) lower levels of Fe and B were found more effective whereas a reverse trend was noted in case of Zn.

Plants receiving 0.4 per cent Fe+1 per cent urea, 0.4 per cent B+1 per cent urea and 0.2 per cent Fe+1 per cent urea produced fruits of 623.50, 724.50 and 747.50 g respectively, in 1983, 1984 and 1985 as compared to 463.75, 612.0 and 637.0 g under control in the respective years.

Table 38. Effect of Zn, Fe and B in combination with urea on flowering, sex ratio and number of fruits per tree.

Treatments	Panicle percentage			Sex ratio of flowers			Number of fruits harvested		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	75.06 (61.51)	26.95 (31.22)	63.04 (52.55)	1:4.84	1:6.72	1:4.53	23	4	39
Zn 0.4% + urea 1%	76.06 (63.13)	42.63 (40.78)	71.26 (57.86)	1:2.89	1:3.46	1:3.73	24	6	48
Fe 0.2% + urea 1%	77.93 (63.89)	15.97 (23.45)	54.97 (47.84)	1:5.15	1:4.79	1:4.31	20	2	37
Fe 0.4% urea 1%	69.45 (57.39)	24.82 (29.72)	65.29 (53.94)	1:1.31	1:2.58	1:2.45	17	5	42
B 0.2% + urea 1%	73.75 (61.41)	32.87 (34.50)	59.31 (50.37)	1:7.09	1:6.84	1:7.79	21	4	38
B 0.4% + urea 1%	79.00 (64.02)	28.66 (31.90)	66.11 (54.38)	1:2.67	1:2.44	1:3.25	24	5	43
Control	64.34 (54.07)	16.26 (23.41)	58.23 (49.73)	1:5.13	1:5.67	1:4.97	14	4	32
S. Em \pm	7.23	5.03	1.84				3.65	1.47	2.73
C.D. at 5%	N.S.	N.S.	5.47				N.S.	N.S.	3.12

N.S. = Not significant.

Yield of fruit :

The data recorded in Table 39 show that the highest yield of 14.17 kg was obtained when the plants were treated with 0.4 per cent B plus 1 per cent urea, followed by Zn at 0.4 per cent and urea (13.15 kg). The minimum yield of 6.65 kg fruit was recorded in control in the year 1983 while in the 'off' year (1984) Zn at 0.4 per cent was found effective in increasing the yield to 3.78 kg followed by 3.77 kg under B at 0.4 per cent. In 1985, Zn at 0.4 per cent plus 1 per cent urea caused the highest yield of 32.53 kg fruits which was 59.6 per cent more than that of control (20.38 kg). Boron at the same level also significantly enhanced the yield by 48.2 per cent over control. Foliar sprays of iron was also found beneficial in increasing the yield during 1985.

The data also indicated that the highest levels of Zn, B and Fe were effective in increasing the fruit yield per plant (by weight) over the control throughout the period of investigation.

Fruit size (length and breadth) :

All the micronutrients were found to be beneficial in increasing the fruit size (length and breadth) in all the years of experiment. The maximum fruit length (15.45 cm) was recorded when the plants were treated with Fe at 0.4 per cent and urea in 1983, while the highest breadth was obtained with B at 0.4 per cent concentration. In 1984 and 1985, the maximum length as well as breadth were noted when plants were sprayed with B at 0.4 per cent and Fe at

Table 39. Effect of Zn, Fe and B in combination with urea on weight and yield of mango cv. Fazli.

Treatments	Weight of fruit (g)			Yield per plant(kg)		
	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	542.75	610.00	645.50	12.30	2.14	25.33
Zn 0.4% + urea 1%	555.25	642.50	684.25	13.15	3.78	32.53
Fe 0.2% + urea 1%	485.50	675.50	747.50	9.34	1.34	27.64
Fe 0.4% + urea 1%	623.50	678.25	653.25	10.31	3.35	27.59
B 0.2% + urea 1%	523.25	587.00	718.25	11.06	2.22	27.32
B 0.4% + urea 1%	583.25	724.50	698.75	14.17	3.77	30.21
Control	463.75	612.00	637.00	6.65	2.45	20.38
S. En \pm	20.34	10.25	6.35	2.20	0.93	1.89
C.D. at 5%	60.43	30.47	18.86	N.S.	N.S.	5.61

N.S. = Not significant.

Table 40. Effect of Zn, Fe and B in combination with urea on size of fruit.

Treatments	Length of fruit (cm)			Breadth of fruit (cm)		
	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	14.65	15.85	15.25	9.25	9.55	9.47
Zn 0.4% + urea 1%	14.67	15.60	15.33	9.45	9.75	9.42
Fe 0.2% + urea 1%	13.80	15.95	16.13	8.95	10.42	9.85
Fe 0.4% + urea 1%	15.45	15.90	15.43	9.60	9.80	9.75
B 0.2% + urea 1%	14.05	14.75	15.97	9.77	9.37	9.60
B 0.4% + urea 1%	14.70	16.92	15.60	9.87	10.42	9.43
Control	12.95	15.50	15.82	9.37	9.70	9.10
S. Em \pm	0.35	0.26	0.20	0.18	0.12	0.16
C.D. at 5%	1.05	0.78	0.60	0.52	0.38	N.S.

N.S. = Not significant.

0.2 per cent each with 1 per cent urea respectively (Table 40).

Specific gravity :

It is seen from the data presented in the Table 41 that the application of different rates of micronutrients failed to bring about any significant effect on specific gravity of fruits in all the years of experiments. Specific gravity of fruit attained maximum value of 1.047 in 1983 and 1.062 in 1985 under B at 0.4 per cent with 1 per cent urea. Zn at 0.2 per cent in combination with urea caused maximum specific gravity of fruits in 1984 (1.097). These values under control were 1.027, 1.052 and 1.035 in the year 1983, 1984 and 1985 respectively.

Pulp:fruit ratio :

The data on pulp:fruit ratio noted in Table 41 revealed that micronutrients had beneficial effect in increasing the pulp:fruit ratio irrespective of the years. Treatment with Fe at 0.2 per cent in combination with 1 per cent urea caused increased pulp:fruit ratio of 1:1.37 and 1:1.36 in 1983 and 1985 respectively while in 1984 highest pulp:fruit ratio of 1:1.47 was obtained in fruits from the plants treated with B at 0.2 per cent along with 1 per cent urea.

Total soluble solids (T.S.S.) :

Foliar sprays of the micronutrients were found to cause significant improvement in the total soluble solids content (Table 41 and Fig.9). Treatment with B at 0.4 per cent with urea 1 per cent

caused the maximum T.S.S. of 20.7, 20.5 and 20.4 per cent in 1983, 1984 and 1985 respectively whereas 18.45, 18.15 and 18.20 per cent T.S.S. were noted under control in the respective year. It was clearly observed that except Zn at 0.2 per cent in 1985 all the micronutrients caused increase in the total soluble solid contents of fruits throughout the period of investigation. Other treatments in order to efficacy were Fe at 0.2 per cent (20.20%), Zn at 0.4 per cent (20.05%) and B at 0.2 per cent (19.80%) each with 1 per cent urea in 1983, 1984 and 1985 respectively.

Total sugar :

The data presented in Table 42 and Fig. 10 indicate that all the micronutrients significantly increased the total sugar contents of fruit. The highest total sugar contents i.e., 14.94, 15.21 and 14.92 per cent were observed in fruits from plants treated with B at 0.4% in combination with 1 per cent urea in 1983, 1984 and 1985 respectively. Fe at 0.2 per cent and Zn at 0.4 per cent each in combination with 1 per cent urea also appreciably increased the total sugar contents of fruits in all the years of the investigation. The total sugar contents under control were 12.84 per cent in 1983, 13.18 per cent in 1984 and 13.76 per cent in 1985.

Reducing sugar :

Some of the micronutrient sprays were found to increase the reducing sugar content of fruit significantly over control in all the three years (Table 42). The highest reducing sugar content of

Table 41. Effect of Zn, Fe and B in combination with urea on specific gravity, pulp:fruit ratio and total soluble solid content of fruit.

Treatments	Specific gravity			Pulp:fruit ratio			T.S.S. (°Brix)		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	1.012	1.097	1.030	1:1.50	1:1.53	1:1.44	18.55	18.75	17.95
Zn 0.4% + urea 1%	1.030	1.062	1.035	1:1.41	1:1.52	1:1.48	19.40	20.05	18.40
Fe 0.2% + urea 1%	1.022	1.095	1.042	1:1.37	1:1.48	1:1.36	20.20	19.25	18.85
Fe 0.4% + urea 1%	1.037	1.092	1.045	1:1.40	1:1.52	1:1.44	19.55	19.80	19.55
B 0.2% + urea 1%	1.042	1.055	1.037	1:1.45	1:1.47	1:1.41	18.95	19.55	19.80
B 0.4% + urea 1%	1.047	1.035	1.062	1:1.48	1:1.50	1:1.42	20.70	20.50	20.40
Control	1.027	1.052	1.035	1:1.53	1:1.54	1:1.47	18.45	18.15	18.20
S. Em ±	0.012	0.031	0.007				0.21	0.09	0.134
C.D. at 5%	N.S.	N.S.	N.S.				0.63	0.28	0.401

N.S. = Not significant.

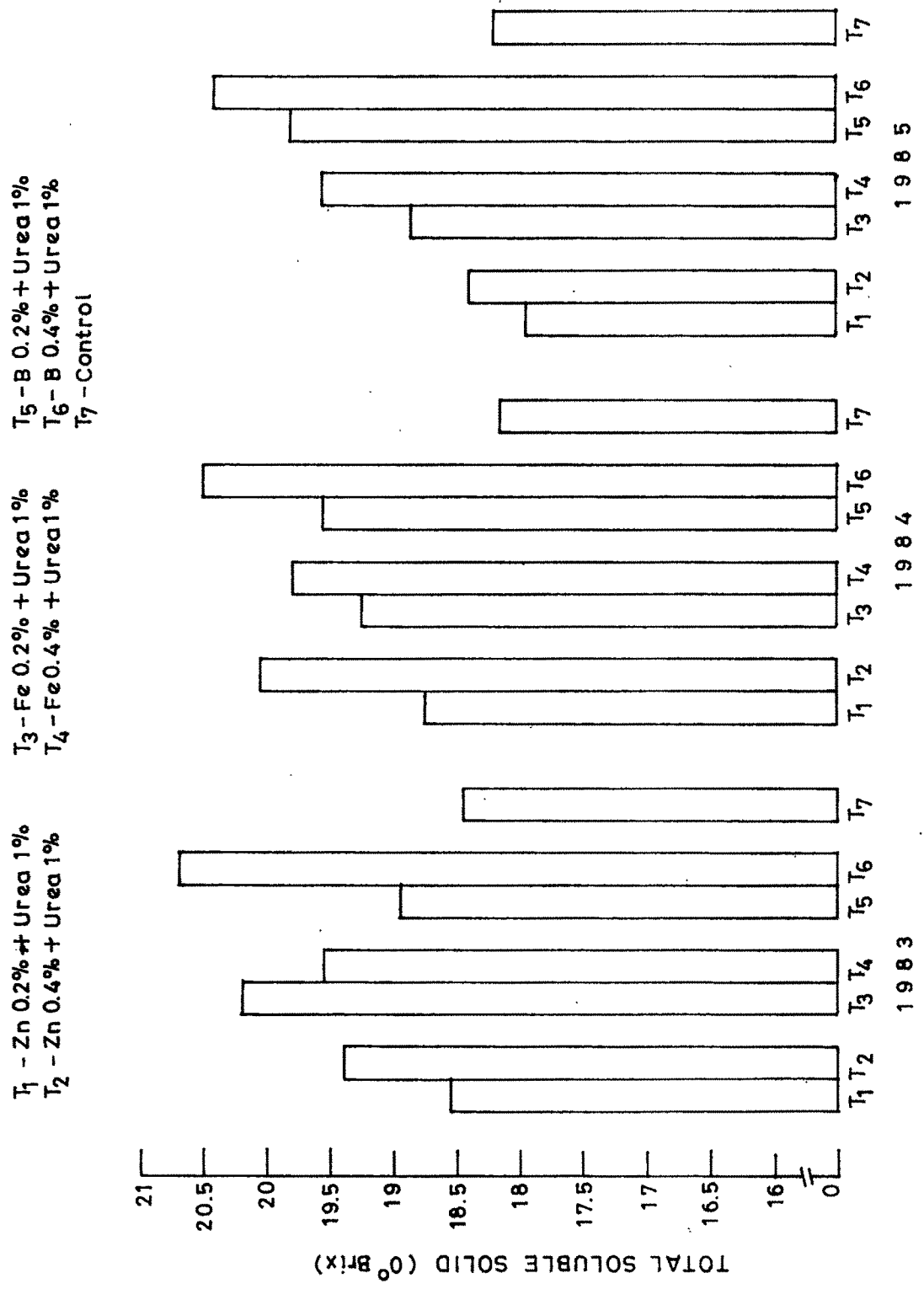


FIG. 9. TOTAL SOLUBLE SOLID CONTENT OF FRUIT DUE TO APPLICATION OF Zn, Fe AND B WITH UREA.

4.35 per cent was found when the plants were treated with B at 0.4 per cent and this was followed by Fe at 0.2 per cent (4.22%), while in control reducing sugar content was 3.75 per cent in 1983. In 1984, the reducing sugar content was maximum in fruits from plants treated with Zn at 0.4 per cent with urea (4.41%) followed by B at 0.4 per cent and urea (4.38%). The lowest reducing sugar content was obtained in fruits from the control plants throughout the period of experiment.

Non-reducing sugar :

It is revealed from the data in Table 42 that all the micro-nutrients viz. Zn, Fe and B significantly increased the non-reducing sugar contents of fruits. Spraying of Fe at 0.2 per cent gave the highest non-reducing sugar content (10.11%) followed by B at 0.2 per cent (10.08%) in 1983. In 1984 and 1985, the highest non-reducing sugar contents of 10.32 and 10.07 per cent were recorded when the plants were treated with B at 0.2 and 0.4 per cent respectively. Non-reducing sugar content of fruits under control was much less.

Fruit acidity :

A perusal of the data recorded in Table 43 revealed that in general the fruit acidity (expressed in terms of per cent citric acid) decreased appreciably when the plants were treated with micro-nutrients in 1983 and 1985 ('on' years) as compared to control. The lowest fruit acidity of 0.28 and 0.32 per cent were obtained by treatment with Zn at 0.2 and B at 0.2 per cent and 1 per cent urea

Table 42. Effect of Zn, Fe and B in combination with urea on total, reducing and non-reducing sugar content of fruit.

Treatments	Total sugar (% fresh weight)			Reducing sugar (% fresh weight)			Non-reducing sugar (% fresh weight)		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	13.46	13.19	13.90	3.76	4.03	4.14	9.21	8.70	9.26
Zn 0.4% + urea 1%	14.23	14.53	14.10	3.94	4.41	4.24	9.77	9.61	9.37
Fe 0.2% + urea 1%	14.88	14.39	14.43	4.22	3.95	4.26	10.11	9.91	9.67
Fe 0.4% + urea 1%	13.28	13.62	14.72	3.79	4.02	4.38	9.01	9.11	9.81
B 0.2% + urea 1%	14.82	14.97	13.91	4.20	4.09	4.11	10.08	10.32	9.31
B 0.4% + urea 1%	14.94	15.21	14.92	4.35	4.38	4.33	10.05	10.28	10.07
Control	12.84	13.18	13.76	3.75	3.63	4.08	8.63	9.07	9.21
S. Em ±	0.02	0.12	0.12	0.14	0.11	0.04	0.14	0.19	0.12
C.D. at 5%	0.06	0.38	0.35	0.42	0.33	0.11	0.42	0.59	0.34

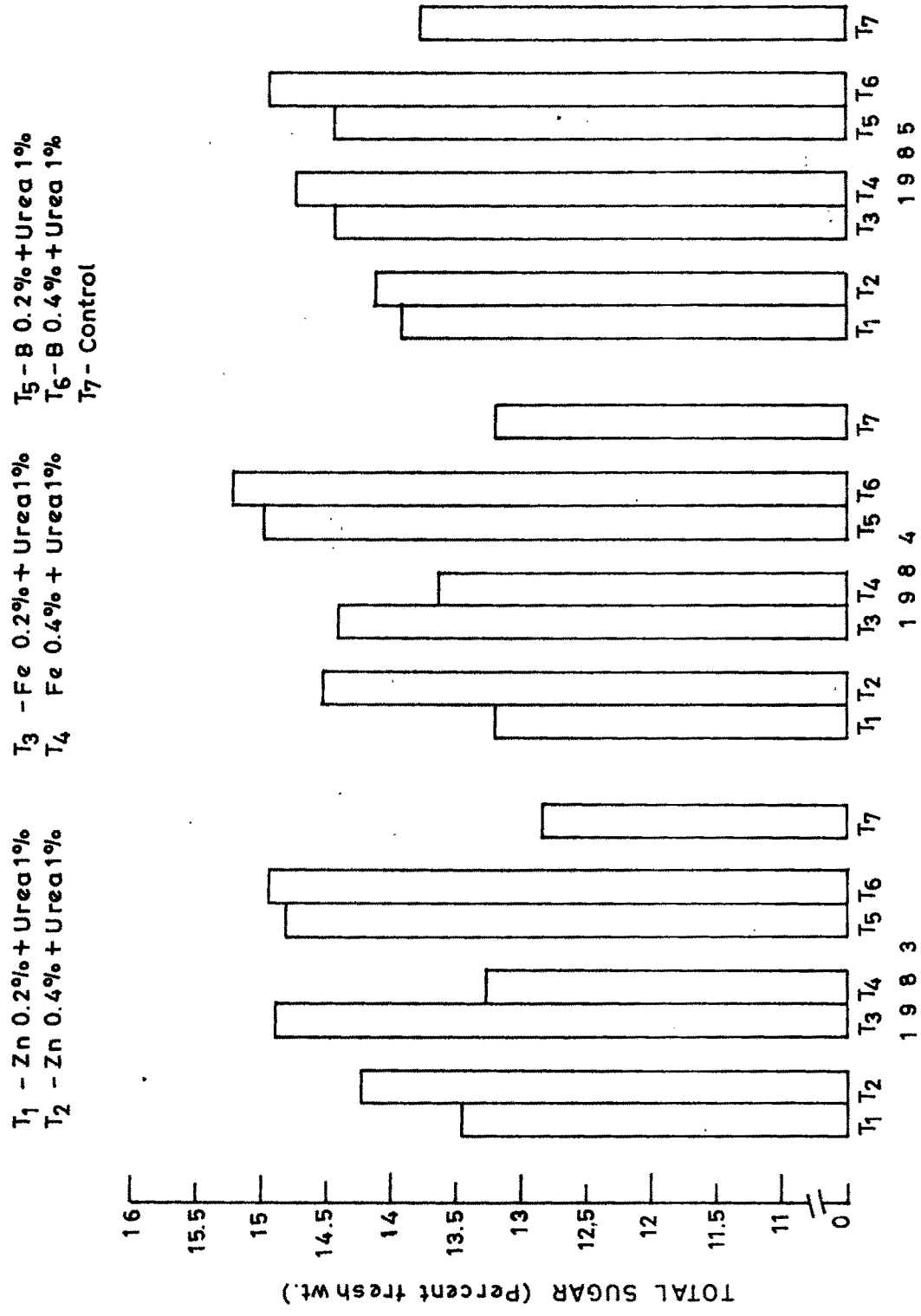


FIG. 10. TOTAL SUGAR CONTENT OF FRUIT DUE TO TREATMENT WITH Zn, Fe AND B WITH UREA.

in 1983 and 1985 respectively. The corresponding figures under control were 0.38 and 0.41.

It was also noted that the higher concentrations of all the micronutrients promoted acidity and fruit acidity was the maximum under B at 0.4 per cent in combination with 1 per cent urea in all the years.

Sugar/acid ratio :

The data summarized in Table 43 indicate that micronutrients exhibited differential effect on acid to sugar ratio of the fruits in different years of the experiment. The sugar/acid ratio varied between 30.18 and 48.07 in 1983, between 28.69 and 43.61 in 1984 and between 34.69 and 43.46 in 1985 under the different treatments. The highest sugar/acid ratios of 48.07 under Zn 0.2 per cent, 43.61 under Fe 0.2 per cent and 43.46 under B 0.2 per cent were observed in the year 1983, 1984 and 1985 respectively. Fruits obtained from the control trees recorded 33.78, 41.18 and 33.56 sugar/acid ratios in 1983, 1984 and 1985 respectively.

Effect of Zn, Fe and B along with urea on the nitrogen content in leaf and shoot of mango cv. Fazli.

Nitrogen :

Leaf - The effect of micronutrient applications on the leaf and shoot nitrogen are presented in Table 44. Application of zinc, iron and boron also increased the N content in leaf. The highest N content in leaf (1.70%) was recorded when the plants were treated

Table 43. Effect of Zn, Fe and B in combination with urea on acidity and sugar/acid ratio of fruit.

Treatments	Acidity (% fresh weight)			Sugar/acid ratio		
	1983	1984	1985	1983	1984	1985
Zn 0.2% + urea 1%	0.28	0.36	0.34	48.07	36.63	40.88
Zn 0.4% + urea 1%	0.39	0.48	0.40	36.48	30.27	35.25
Fe 0.2% + urea 1%	0.33	0.33	0.34	45.09	43.61	42.44
Fe 0.4% + urea 1%	0.44	0.39	0.36	30.18	34.92	40.88
B 0.2% + urea 1%	0.34	0.38	0.32	43.58	39.39	43.46
B 0.4% + urea 1%	0.47	0.53	0.43	31.78	28.69	34.69
Control	0.38	0.32	0.41	33.78	41.18	33.56
S. Em \pm	0.02	0.01	0.01			
C.D. at 5%	0.06	0.04	0.04			

with B at 0.4 per cent with 1 per cent urea, at the vegetative stage and preharvest stage. In the vegetative stage the leaf N content was generally higher and it declined in the full bloom stage and again increased in the preharvest stage.

Shoot - It was observed that the nitrogen content in shoot increased with the application of higher levels of zinc and boron with urea at the vegetative stage. The nitrogen content in shoot was lower than that in the leaf, irrespective of treatments and stage of sampling. The maximum accumulation of nitrogen in shoot (0.98%) was noted when the plants were treated with 0.4 per cent zinc or boron in combination with 1 per cent urea. It was also noted that shoot N content decreased at the full-bloom stage.

Phosphorus :

Leaf - It was revealed from the data summarized in the Table 45 that application of zinc, iron and boron increased the leaf P content irrespective of stages of observations. The highest P content in leaf (0.110%) was observed from plant treated the highest level of B with urea (B 0.4% + urea 1%), at the vegetative stage and preharvest stage and it declined at the full bloom stage.

Shoot - Application of different levels of zinc, iron and boron resulted in increase in P content of shoot and the highest P content (0.085%) was noted when the plants were sprayed with B at 0.4 per cent in combination with 1 per cent urea. At the full-bloom stage it decreased but again increased at the preharvest stage.

Table 44. Effect of Zn, Fe and B with urea on the nitrogen content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight).

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn 0.2% + urea 1%	1.56	1.42	1.48	0.95	0.67	0.86
Zn 0.4% + urea 1%	1.56	1.45	1.56	0.98	0.72	0.86
Fe 0.2% + urea 1%	1.65	1.34	1.56	0.92	0.72	0.92
Fe 0.4% + urea 1%	1.68	1.37	1.59	0.95	0.75	0.95
B 0.2% + urea 1%	1.68	1.40	1.68	0.92	0.78	0.89
B 0.4% + urea 1%	1.70	1.45	1.70	0.98	0.78	0.92
Control	1.48	1.17	1.42	0.84	0.64	0.81

V.S. = Vegetative stage

F.B.S. = Full bloom stage

P.S. = Preharvest stage.

Table 45. Effect of Zn, Fe and B with urea on the phosphorus content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight).

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn 0.2% + urea 1%	0.080	0.065	0.095	0.060	0.035	0.065
Zn 0.4% + urea 1%	0.095	0.075	0.110	0.065	0.040	0.070
Fe 0.2% + urea 1%	0.080	0.065	0.080	0.055	0.045	0.055
Fe 0.4% + urea 1%	0.090	0.080	0.095	0.065	0.050	0.055
B 0.2% + urea 1%	0.105	0.070	0.095	0.080	0.035	0.060
B 0.4% + urea 1%	0.110	0.075	0.110	0.085	0.040	0.065
Control	0.070	0.060	0.070	0.035	0.025	0.040

V.S. = Vegetative stage

F.B.S. = Full bloom stage

P.S. = Preharvest stage.

Table 46. Effect of Zn, Fe and B with urea on the potassium content in leaf and shoot of mango cv. Fazli (expressed as per cent dry weight).

Treatments	Leaf			Shoot		
	V.S.	F.B.S.	P.S.	V.S.	F.B.S.	P.S.
Zn 0.2% + urea 1%	1.08	0.81	0.91	0.54	0.43	0.56
Zn 0.4% + urea 1%	1.10	0.84	0.93	0.56	0.46	0.58
Fe 0.2% + urea 1%	1.03	0.84	0.91	0.54	0.46	0.51
Fe 0.4% + urea 1%	1.08	0.88	0.96	0.60	0.48	0.56
B 0.2% + urea 1%	1.10	0.81	0.96	0.58	0.43	0.56
B 0.4% + urea 1%	1.15	0.84	0.98	0.60	0.48	0.60
Control	0.98	0.78	0.87	0.49	0.41	0.48

V.S. = Vegetative stage

F.B.S. = Full bloom stage

P.S. = Preharvest stage.

Potassium :

Leaf - Data on the effect of application of micronutrients on potassium content of leaf and shoot are presented in Table 46. Potassium content was found to increase with the application of zinc, iron and boron and the maximum concentration of leaf-K (1.15%) was found under 0.4 per cent B with urea 1 per cent, at the vegetative stage and it declined at the full-bloom and preharvest stage.

Shoot - Potassium content in shoot also increased with the application of zinc, iron and boron and the concentration of K in shoot was less than in leaf irrespective of the treatment and stages of sampling. The highest concentration of potassium in shoot was obtained with higher level of boron, at the vegetative and preharvest stages and it declined in the full-bloom stage.

Discussion :

It is revealed from the data presented in the previous pages that application of micronutrients viz. zinc, iron and boron each in combination with 1 per cent urea markedly promoted the vegetative growth of young mango plants cv. Fazli during all the years of the experiment. In general, the effect of micronutrients was more pronounced when applied at higher rates. The effect of zinc can be possibly explained in the light of the fact that it is essential in carbohydrate and nitrogen metabolism and probably in turnover of organic phosphorus compounds (Asana et al., 1971). It is considered

essential for the formation of chlorophyll and hence essential for photosynthetic activity. Zinc is also a constituent of some enzymes and it possibly taken part in the synthesis of indole acetic acid in plants (Singh, 1980). It increases the synthesis of tryptophan which is a precursor of auxin, that promotes vegetative growth (Agarwala and Sharma, 1978). The beneficial effect of zinc in improving vegetative growth has also been observed by Singh and Rajput (1976), Rajput et al. (1976) in mango.

Like zinc, iron also played an important role in augmenting vegetative growth of young mango plants. It is well established that iron is essential for chlorophyll synthesis. In association with enzymes like catalase, peroxidase, cytochrome oxidase and the cytochromes iron compounds play important role in cellular metabolism of plants (Singh, 1980). Boron at higher rate proved highly effective in enhancing the plant height, trunk girth and spread of crown during 1984 and 1985. An increased growth with boron application has been recorded by Rajput et al. (1976) and Singh (1977). The effectiveness of boron in augmenting the vegetative growth is conceivable in view of the fact that boron is considered necessary for the meristematic activities and also for the normal development of the conducting tissue (Singh, 1980). Kunte and Yawalkar (1970) have reported that boron helps in the formation and lignification of cell wall, absorption of nitrogen and metabolism of carbohydrates.

The effect of micronutrients was further enhanced by

accelerating effect of urea applied along with micronutrients. The favourable effect of urea, a nitrogenous fertilizer possibly needs no further explanation as nitrogen is the major constituent of many compounds of great physiological importance in the metabolism, such as amino acid, protein, nucleic acid, porphyrins, purine, enzymes and co-enzymes (Agarwala and Sharma, 1978). Protein and chlorophyll synthesis are markedly accelerated by the application of nitrogen (Wadleigh, 1957).

A perusal of the results stated in the foregoing pages clearly indicates that besides increasing the vegetative growth, micronutrients in combination with urea also caused better flowering in the young mango plants regardless the existence 'on' and 'off' year rhythm. By application of micronutrients and urea better flowering have been reported by many workers. It has been reported that zinc, iron (Minessy et al., 1974); boron (Rajput et al., 1976) and urea (Rajput and Tiwari, 1975) when applied to mango and other fruit plants caused better flowering. Zinc increased the percentage of flowering shoots possibly by increasing the auxin content. According to Agarwala and Sharma (1978), under conditions of zinc deficiency flower setting was considerably reduced. Kunte and Yawalkar (1970) explained the beneficial effect of iron in increasing the percentage of shoot producing panicle through regulation of some physiological activities like respiration, photosynthesis and reduction of nitrates and sulphates and these reactions are necessary for plant reproduction. They also stated that boron is associated with the flowering

processes. Flowering in plant is largely dependent on vegetative growth. The application of micronutrients and urea provide favourable conditions to induce good vegetative growth. This might have caused enhanced emergence of panicle in mango. Besides increasing the flowering percentage, micronutrient treatments also increased the proportion of hermaphrodite to male flowers over control. Iron in combination with urea was most effective as compared to the other nutrient combinations in all the years. Rajput and Tiwari (1975) also obtained more number of hermaphrodite flowers by treatment with urea. Results of the experiment showed that micronutrients in combination with urea proved highly beneficial in augmenting the yield of fruit both in number and weight significantly over control in all the years of the investigation. Among the micronutrients the effect of zinc was most pronounced followed by boron and iron. Further, the higher dose of all the nutrients proved more effective than the lower ones. The beneficial effect of zinc was also recorded by Daulta et al. (1981) and Minessy et al. (1974). Rajput et al. (1976) reported higher yield by treatment with boron.

Treatments also proved effective in producing heavier fruits of bigger size in all the years. The effect of zinc was, however, less pronounced but was significantly superior to controls. Fruits of increased size and weight were also obtained by Rath et al. (1980) with micronutrient application. Higher fruit weight by application of N was recorded by Singh et al. (1977) and Tiwari and Rajput (1975). The effect of nitrogen in increasing the fruit size may be due to the fact

that it increases the size and total number of cells (Njoku, 1957). The increased yield obtained in the present study was due to the production of larger number of fruits with increased weight.

As regards fruit quality it was observed that the application of zinc, iron and boron in combination with urea resulted in significant enhancement of T.S.S., sugar contents of ripe edible fruits. Among the micronutrients, the best result was obtained with boron, followed by iron and zinc. Besides increasing the total soluble solid and sugar contents, boron at higher rate also influenced the fruit acidity. With the application of boron at higher rates, Alverrez-Rosario (1965) and Biltovic and Jovanovic (1970) noted higher T.S.S. and acidity in apple. In the present investigation, the maximum total soluble solids and total sugar contents and increased reducing and non-reducing sugar contents were obtained when boron was applied at higher concentration. This is perhaps attributed to the fact that boron is considered to be essential in the metabolism of carbohydrate (Kunte and Yawalkar, 1970). Boron is also necessary in the translocation of sugar in the plant. Iron regulates photosynthesis (Kunte and Yawalkar, 1970). Higher photosynthesis means more carbohydrate formation which perhaps helped in increasing the T.S.S. and total sugar contents of fruits with iron application. The favourable effects of zinc is due to various enzymatic reactions like transformation of carbohydrates, activity of hexokinase and changes in sugar which is to be due to action of zinc on zymohexose (Singh and Rajput, 1976). Rath et al. (1980) also reported that zinc acted as a catalyst

in the oxidation and reduction process and was also of great importance in the sugar metabolism which might have improved the fruit quality.

The nitrogen content in leaf and shoot increased when zinc, iron or boron was sprayed with urea 1 per cent and the highest N content in leaf was observed when the plant was sprayed with boron 0.4+ urea 1 per cent. Increase in the leaf N content with the increasing supply of boron was also observed by Singh (1977). The nitrogen content in the leaf and shoot attained maximum values at the vegetative stage and declined at the full bloom stage. The leaf nitrogen content again showed a rising trend at the preharvest stage. Avilan (1971) also noted that N level attained highest value before flowering, declined during flowering and fruit formation and again increased during ripening.

Like nitrogen, phosphorus content in leaf and shoot showed marked variations at the different stages of sampling and lowest phosphorus content in both leaf and shoot was noted at the full-bloom stage. The phosphorus content in leaf and shoot decreased due to its translocation from the adjacent leaves and stems to the panicles. The translocation of phosphorus from leaves and stem to swelling buds and developing fruits has been reported by Burstrom (1948).

Treatment with micronutrients increased the potassium content in leaf and shoot at the vegetative stage and the increase was more with the higher level of boron. The potassium content in leaf

and shoot decreased at the full bloom stage probably due to translocation of potassium from the adjacent leaves and stems to the panicles. Similar results were also obtained by Avilan (1971).

Experiment III : Effect of different chemicals on fruit retention, yield and fruit quality of mango cv. Fazli.

Fruit retention :

Basic data recorded before spraying and subsequent data collected till harvest in 1983 ('on' year) have been presented in Table 47.1. It is revealed from the data that chemicals used in this experiment at all concentrations were very effective in fruit retention at early stage of development and therefore caused increase in the percentage of harvestable fruits significantly over control. Amongst the various chemicals used, 2,4-D at 20 ppm and NAA at 40 ppm were found to retain the maximum number of fruits at harvest stage, followed by 2,4,5-T, GA₃ and Almon.

Among the different concentrations of chemicals it was found that 2,4-D, NAA and 2,4,5-T at higher levels increased the fruit retention at harvest stage while fruit retention decreased at lower concentrations. The maximum retention of 15.67 per cent fruits were obtained up to harvest when sprayed with NAA at 40 ppm, while the retention of fruits was 15.46 per cent at 20 ppm of 2,4-D. GA₃ and Almon at lower concentration increased fruit retention but the efficacy dropped at higher concentration. The percentage of fruit retained

in the control plants was only 8.45 per cent. It is evident from the data presented in Table 47.2 that spraying with chemicals reduced the premature fruit drop in Fazli mango and thereby increased the percentage of fruit retention significantly over control in 1984 ('off' year). Best result with respect to fruit retention was obtained with 2,4-D followed by 2,4,5-T, NAA, Almon and GA₃. The maximum fruit retention of 19.28 per cent occurred when the fruits were sprayed with 2,4-D at 20 ppm as compared to 8.41 per cent under control (i.e., 129.25 per cent more over control). Treatment with 2,4-D at lower concentration of 10 ppm was also effective in retaining 18.88 per cent fruits at harvest indicating 124.49 per cent more retention over control. Spray application of 2,4,5-T at both the concentrations reduced premature drop of fruits, as compared to control. NAA at 40 and 20 ppm also reduced the drop of immature fruits and resulted in significantly increased retention of fruits to the tune of 16.26 and 13.33 per cent thereby showing respectively 93.34 and 58.50 per cent higher fruit retention over control. In case of GA₃ and Almon, treatments with 20 ppm GA₃ and 500 ppm Almon indicated beneficial effect and retention of fruits were 10.76 and 11.65 per cent, respectively, while 40 ppm GA₃ and 1000 ppm Almon had a little effect over control.

Spraying with different chemicals in general checked the early drop of fruits and caused higher retention of fruits significantly at harvest over control in 1985 as evident from the data summarized in Table 47.3. Application of 2,4-D at 20 ppm concentration was found very effective in fruit retention at different stages

of observation followed by 2,4,5-T, NAA, Almon and GA₃.

Application of 2,4-D at 20 ppm increased the percentage of fruit at harvest and the maximum retention was 17.24 per cent i.e., 70.52 per cent more over control. The higher concentration of NAA (40 ppm) improved the fruit retention (17.06%) compared to lower concentration of 20 ppm where the percentage of retention was 15.34. 2,4,5-T at 10 and 20 ppm concentration caused 16.13 and 16.53 per cent retention of fruits respectively (59.54 and 63.50 per cent higher over control). GA₃ and Almon treatments reduced the drop of immature fruits which ultimately caused increase in the fruit retention at harvest over control but the increase was not significant.

Number of fruits per tree :

The data on the number of fruits harvested per tree presented in Table 48 indicate that spraying with different chemicals at various concentrations had dissimilar effect in 'on' and 'off' years. The maximum number of fruits/tree (307) were harvested when sprayed with NAA at 20 ppm concentration in 1983 ('on' year). The same chemical at 40 ppm also gave markedly higher harvest yield (289), followed by 2,4-D and GA₃ each at 20 ppm concentration. 2,4,5-T at both the concentrations only slightly increased fruit retention over control. In the 'off' year (1984), however, application of 2,4-D at 10 and 20 ppm resulted in high retention of 238 and 225 fruits respectively as compared to 85 in control and these were followed by NAA at 20 ppm.

As regards the effect of chemicals on the number of fruits

Table 47.1. Effect of different chemicals on fruit retention (1983).

Treatments	Percentage of fruits retained		Percentage of fruits harvested
	After 15 days of 1st spraying	After 35 days of 1st spraying and 20 days of 2nd spraying	
GA ₃ 20 ppm	24.28 (29.44)	19.37 (26.02)	12.44 (20.59)
GA ₃ 40 ppm	28.81 (32.41)	22.88 (28.52)	9.50 (17.94)
2,4-D 10 ppm	31.13 (33.88)	14.95 (22.72)	9.66 (18.09)
2,4-D 20 ppm	32.93 (34.95)	23.32 (28.77)	15.46 (23.06)
NAA 20 ppm	22.47 (28.03)	15.90 (23.41)	12.11 (20.26)
NAA 40 ppm	27.24 (31.34)	22.07 (27.94)	15.67 (23.20)
2,4,5-T 10 ppm	28.29 (31.82)	19.77 (26.35)	10.37 (18.67)
2,4,5-T 20 ppm	29.89 (33.01)	21.25 (27.13)	13.78 (21.28)
Almon 500 ppm	24.31 (29.43)	18.89 (25.71)	9.78 (18.00)
Almon 1000 ppm	25.76 (30.47)	14.34 (22.19)	8.85 (17.20)
Control	21.53 (27.57)	12.46 (20.52)	8.45 (16.72)
S. Em ±	1.92	1.47	1.48
C.D. at 5%	N.S.	4.26	4.30

(Angular transformed values are presented in the parentheses)

N.S. = Not significant.

Table 47.2. Effect of different chemicals on fruit retention(1984).

Treatments	Percentage of fruits retained		Percentage of fruits harvested
	After 15 days of Ist spraying	After 35 days of Ist spraying and 20 days of 2nd spraying	
GA ₃ 20 ppm	30.77 (33.63)	19.03 (25.79)	10.76 (19.11)
GA ₃ 40 ppm	32.36 (34.64)	15.05 (22.72)	8.64 (17.07)
2,4-D 10 ppm	34.28 (35.83)	24.95 (29.95)	18.88 (25.69)
2,4-D 20 ppm	38.47 (38.33)	28.08 (31.96)	19.28 (26.04)
NAA 20 ppm	36.09 (36.90)	16.89 (24.26)	13.33 (21.40)
NAA 40 ppm	36.05 (36.88)	21.41 (27.53)	16.26 (23.79)
2,4,5-T 10 ppm	34.59 (36.00)	18.71 (25.61)	17.13 (24.47)
2,4,5-T 20 ppm	28.92 (32.21)	18.63 (25.54)	17.49 (24.69)
Almon 500 ppm	31.07 (33.86)	17.02 (24.35)	11.65 (19.76)
Almon 1000 ppm	32.80 (34.92)	14.88 (22.64)	9.04 (17.44)
Control	21.19 (27.30)	11.96 (20.01)	8.41 (16.81)
S. Em ±	1.01	1.02	0.67
C.D. at 5%	2.94	2.96	1.95

(Angular transformed values are presented in the parentheses)

Table 47.3. Effect of different chemicals on fruit retention(1985).

Treatments	Percentage of fruits retained		Percentage of fruits harvested
	After 15 days of Ist spraying	After 35 days of Ist spraying and 20 days of 2nd spraying	
GA ₃ 20 ppm	27.58 (31.64)	19.86 (26.44)	12.56 (20.70)
GA ₃ 40 ppm	28.51 (32.23)	21.11 (27.32)	12.44 (20.62)
2,4-D 10 ppm	31.69 (34.18)	23.42 (28.83)	13.08 (21.11)
2,4-D 20 ppm	38.17 (38.14)	28.48 (32.23)	17.24 (24.47)
NAA 20 ppm	34.82 (36.14)	24.32 (29.53)	15.34 (23.0)
NAA 40 ppm	34.88 (36.16)	25.55 (30.33)	17.06 (24.36)
2,4,5-T 10 ppm	37.16 (37.45)	26.36 (30.73)	16.13 (23.56)
2,4,5-T 20 ppm	36.94 (37.39)	26.45 (30.91)	16.53 (23.88)
Almon 500 ppm	28.68 (32.29)	18.99 (25.78)	12.19 (20.38)
Almon 1000 ppm	31.12 (33.88)	21.47 (27.57)	13.29 (21.31)
Control	24.40 (29.56)	16.06 (23.56)	10.11 (18.51)
S. Em ±	1.45	1.20	0.96
C.D. at 5%	4.18	3.47	2.78

(Angular transformed values are presented in the parentheses)

attaining harvest maturity in 1985 ('on' year) it was observed from the data that except 2,4-D at 10 ppm, NAA at 20 ppm and Almon at 500 ppm all other treatments augmented harvest yield significantly over control (216). NAA at 40 ppm produced the largest number of fruits per tree (386). Other treatments in order to efficacy were 40 ppm GA₃ (372), 10 ppm (335) and 20 ppm 2,4,5-T (321) and 2,4-D at 20 ppm (292).

Fruit weight :

As regards to fruit weight it is revealed from the data presented in Table 48 and Fig. 11 that chemicals had beneficial effect in increasing the individual fruit weight irrespective of 'on' and 'off' years. 2,4-D and Almon at all concentrations, GA₃ at 20 ppm, and 2,4,5-T at 10 ppm caused increase in fruit weight as compared to control (636.25 g) in 1983 ('on' year) and the highest fruit weight of 804 g was recorded by the application of 2,4-D at 10 ppm. In the 'off' year (1984), all concentrations of GA₃ and Almon and NAA at 20 ppm recorded significant increase in individual fruit weight over control (650 g) and the maximum fruit weight was obtained when the trees were treated with 500 ppm of Almon followed by 40 ppm of GA₃. In the year 1985, all the treatments except Almon at 1000 ppm was found to be effective in enhancing fruit weight over control (611.25g) and the heaviest fruit (782.25 g) was recorded when the trees were sprayed with 10 ppm 2,4-D.

Fruit yield :

It is evident from the data on fruit yield (weight per plant) presented in Table 48 and Fig.12 that different chemicals used in this experiment increased the fruit yield significantly and the maximum yield of 193.78 kg was obtained with NAA at 20 ppm as compared to 121.27 kg under control. GA₃ at 20 ppm, NAA at 40 ppm and 2,4-D at 20 ppm also caused higher yield over control. Treatment with 2,4,5-T and Almon also showed marked improvement in fruit yield in 1983 ('on' year). In the next year ('off' year) it was found that both the concentrations of 2,4-D, 20 ppm NAA and 2,4,5-T at 10 ppm increased yield significantly over control (55.25 kg/tree) and the highest yield (169.71 kg/tree) was obtained when the trees were treated with 2,4-D at 10 ppm. In 1985 ('on' year) all the concentrations of GA₃ and 2,4,5-T, 20 ppm 2,4-D, NAA at 40 ppm and 500 ppm of Almon increased yield significantly over control (132.34 kg/tree). NAA at 40 ppm concentration caused the maximum yield (267.07 kg/tree).

Fruit size (length and breadth) :

The data on fruit size under the different treatments have been presented in Table 49. It was found that spray application of 2,4-D at 10 ppm resulted in the maximum fruit size i.e., 17.1 cm in length and 10.9 cm in breadth as compared to control (14 cm in length and 9.2 cm in breadth), in 1983. All the concentrations of 2,4-D and Almon significantly increased the fruit size.

In the 'off' year (1984) also, the size of the fruit

Table 48. Effect of different chemicals on fruit number, weight and yield of mango cv. Fazli.

Treatments	Number of fruits per plant			Average weight of fruit (g)			Yield (kg)		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
GA ₃ 20 ppm	269	105	285	711.25	777.50	714.50	190.79	81.88	203.75
GA ₃ 40 ppm	231	67	372	682.25	800.00	686.50	157.35	53.16	255.54
2,4-D 10 ppm	181	238	204	804.00	708.75	782.25	146.26	169.71	160.02
2,4-D 20 ppm	270	225	292	686.50	598.75	694.25	185.92	134.34	202.84
NAA 20 ppm	307	217	244	621.75	731.25	715.25	193.78	158.44	174.85
NAA 40 ppm	289	123	386	655.25	640.00	691.50	187.46	78.94	267.07
2,4,5-T 10ppm	232	185	335	783.50	628.75	645.5	180.99	116.21	216.04
2,4,5-T 20ppm	200	123	321	644.25	598.75	687.5	128.11	73.69	220.33
Almon 500 ppm	219	70	257	765.00	821.25	743.75	166.63	57.45	191.23
Almon 1000ppm	177	84	285	704.00	738.75	595.50	124.69	62.40	169.85
Control	192	85	216	636.25	650.00	611.25	121.27	55.25	132.34
S. Em ±	29.62	19.65	22.35	17.00	26.49	6.36	21.60	14.14	15.29
C.D. at 5%	85.56	57.74	64.54	49.09	76.51	18.39	62.40	40.85	44.17

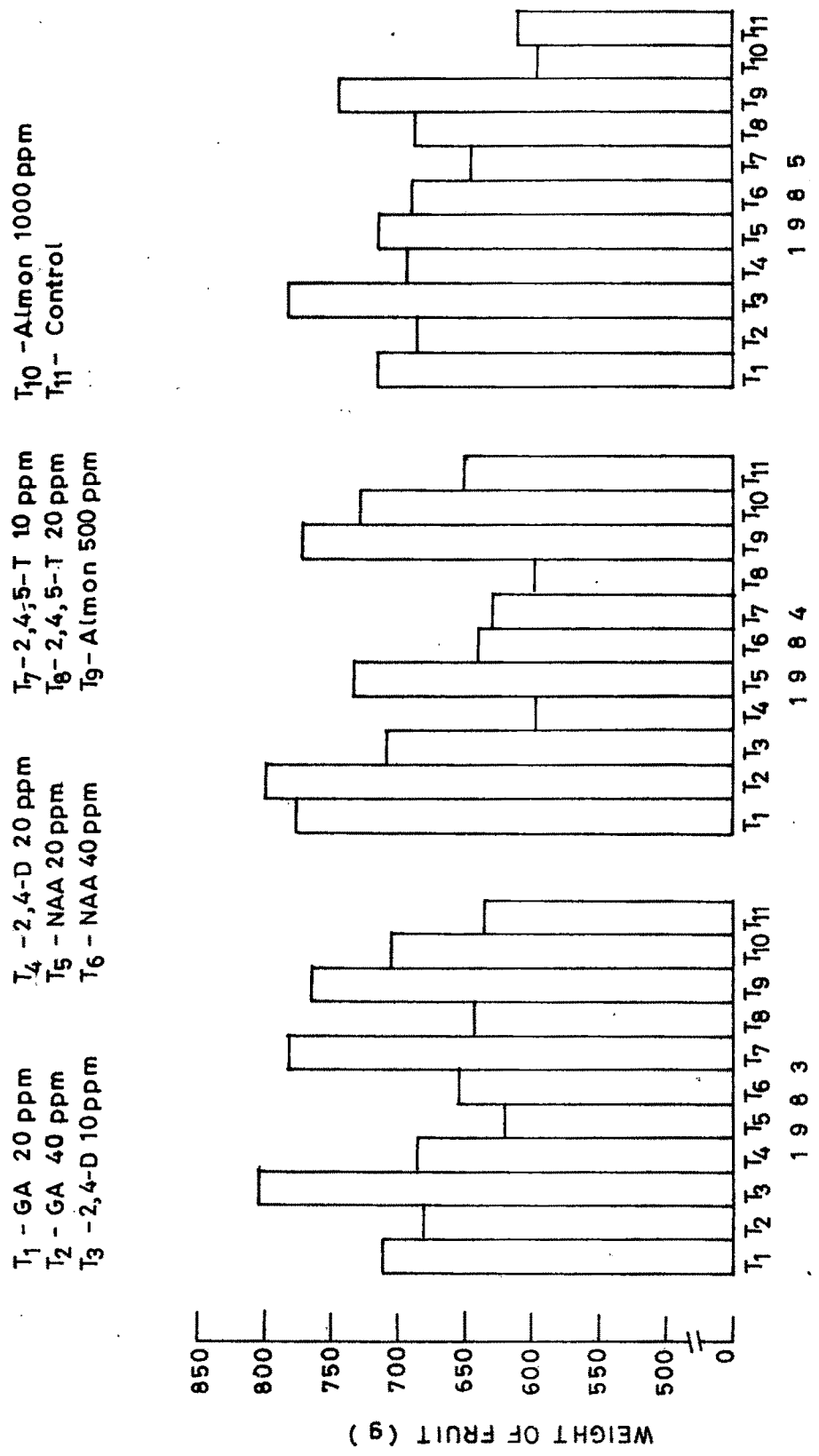


FIG.11. WEIGHT OF FRUIT DUE TO TREATMENT WITH DIFFERENT CHEMICALS.

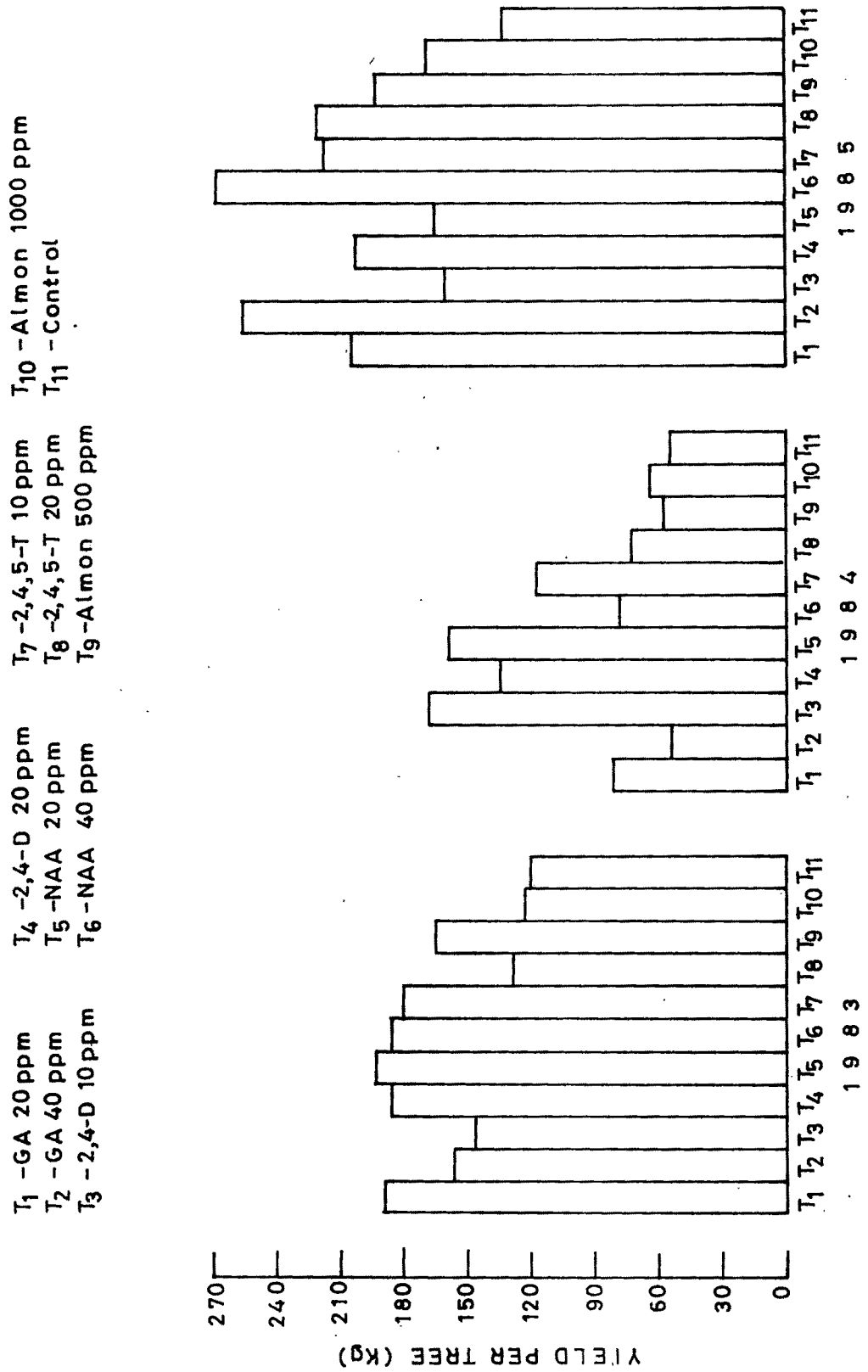


FIG.12. EFFECT OF DIFFERENT CHEMICALS ON YIELD OF FRUIT.

increased with the application of chemicals and the highest fruit size was recorded (16.9 and 11.5 cm in length and breadth, respectively) with Almon at 500 ppm as compared to 15.4 and 9.0 cm in length and breadth under control.

It was observed that in 1985 ('on' year), application of 20 ppm GA₃, 10 ppm 2,4-D and 20 ppm NAA and 500 ppm Almon significantly increased the fruit size over control (15.5 cm length and 9.6 cm breadth) and NAA at 20 ppm showed the maximum improvement in fruit size i.e. 16.5 and 10.8 cm length and breadth, respectively.

Specific gravity :

Chemicals did not affect the specific gravity of ripe edible fruits (Table 49). However, GA₃ at 40 ppm concentration was found to cause production of fruits with the highest specific gravity (1.11) in the first year (1983) while it was reverse in the next two years.

Pulp:fruit ratio :

It is seen from the Table 50 that spraying with chemicals caused marked variation in the pulp content of fruits irrespective of 'on' and 'off' years. In 1983 ('on' year) pulp content of fruits increased when the plants were treated with 2,4,5-T at 10 ppm. NAA at 20 ppm increased the pulp to fruit ratio over control in 1984 ('off' year). Lower concentration of 2,4,5-T (10 ppm) increased the pulp content of fruits in 1985. It was also noted that in 1983 and 1985 ('on' years), 2,4,5-T at 10 ppm increased the pulp content of fruits compared to other treatments including control.

Table 49. Effect of different chemicals on size and specific gravity of fruit cv. Fazli.

Treatments	Length of fruit (cm)			Breadth of fruit (cm)			Specific gravity		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
GA ₃ 20 ppm	13.7	15.8	15.9	9.7	11.2	10.6	1.060	1.045	1.055
GA ₃ 40 ppm	12.5	16.5	15.5	8.5	10.5	10.2	1.110	1.047	1.045
2,4-D 10 ppm	17.1	16.7	16.4	10.9	10.5	10.6	1.047	1.045	1.060
2,4-D 20 ppm	15.8	14.5	15.9	10.1	8.3	9.9	1.055	1.055	1.050
NAA 20 ppm	15.0	16.6	16.5	9.9	10.2	10.8	1.047	1.072	1.045
NAA 40 ppm	16.3	15.0	15.5	10.1	10.5	10.4	1.057	1.045	1.067
2,4,5-T 10ppm	15.7	15.2	15.5	9.8	9.8	9.5	1.050	1.080	1.037
2,4,5-T 20ppm	15.1	16.2	16.0	9.8	8.5	9.8	1.052	1.057	1.057
Almon 500 ppm	16.6	16.9	16.4	10.2	11.5	10.4	1.052	1.047	1.052
Almon 1000ppm	15.5	16.5	15.3	10.4	9.5	9.0	1.057	1.062	1.030
Control	14.0	15.4	15.5	9.2	9.0	9.6	1.047	1.055	1.047
S. Em ±	0.351	0.460	0.109	0.314	0.159	0.151	0.018	0.015	0.009
C.D. at 5%	1.328	1.328	0.316	0.907	0.460	0.436	N.S.	N.S.	N.S.

N.S. = Not significant.

Total soluble solid (T.S.S.):

A perusal of the data presented in Table 50 and Fig. 13 indicates that in general, T.S.S. content of fruits under different treatments increased significantly over control in all the three years of investigation. The highest T.S.S. content of fruits were 20.00, 20.35 and 19.85 per cent under NAA at 40 ppm in 1983, 1984 and 1985, respectively. The corresponding figures under control were 17.25, 18.00 and 18.35 per cent. Other treatments in order of efficacy were 2,4-D 20 ppm GA₃ 20 ppm and 2,4,5-T at 10 ppm in 1983; GA₃ 40 ppm, 2,4,5-T in 1984 and 2,4-D at 20 ppm, 2,4,5-T at 10 ppm, GA₃ 40 ppm and Almon 1000 ppm in 1985.

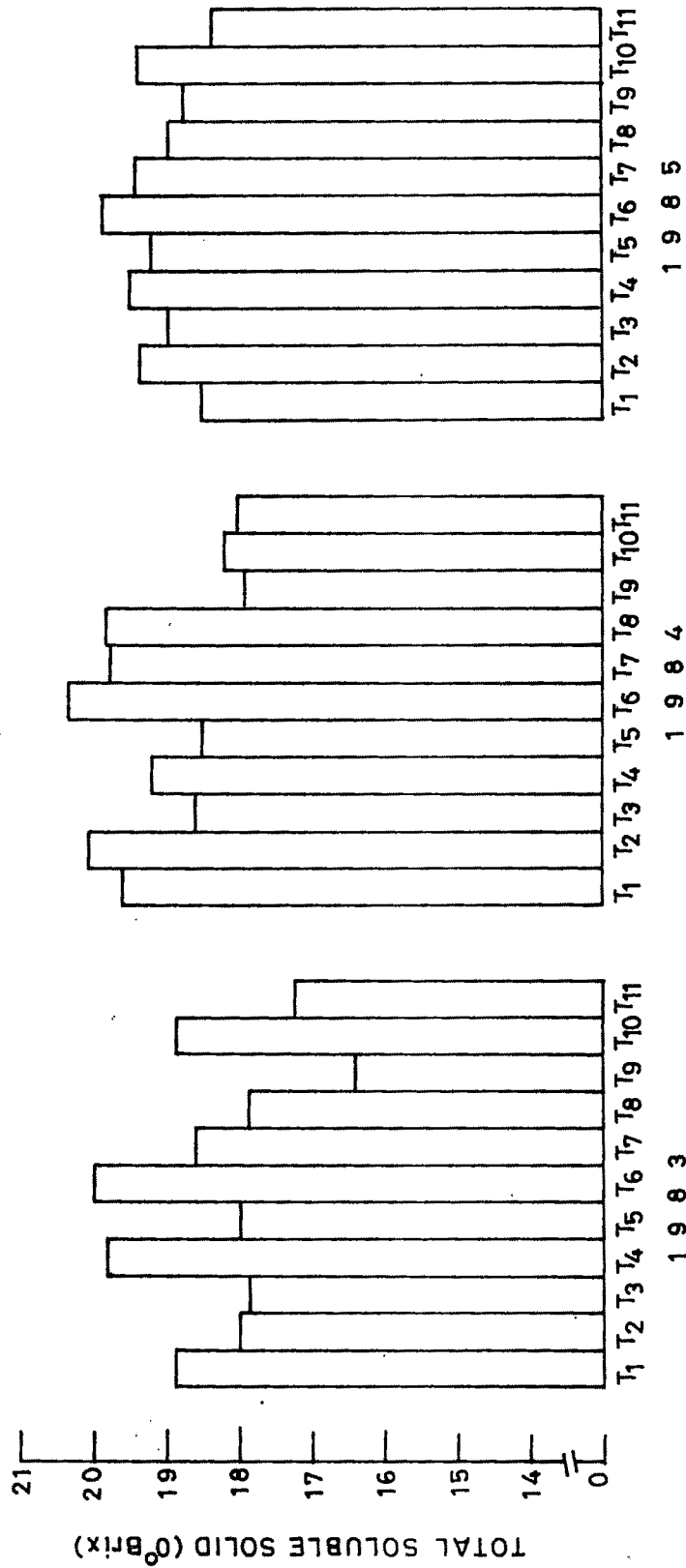
Total sugar :

It is clear from the data presented in Table 51 and Fig. 14 that application of chemicals improved the total sugar content of fruits as compared to control. In 1983 and 1984 ('on' and 'off' years) all the treatments except Almon at both concentrations and 10 ppm of 2,4-D increased the total sugar contents significantly over control and NAA at 40 ppm showed the highest percentage of total sugar of 15.85 and 16.00 per cent in 1983 and 1984, respectively followed by 2,4-D at 20 ppm (15.62%) and GA₃ at 40 ppm (15.90%) and the corresponding figures under control were 11.8 and 12.44 per cent.

In 1985 ('on' year), the total sugar contents also increased significantly over control due to the treatments. The maximum percentage of total sugar (15.82%) was obtained when the trees were sprayed with 2,4,5-T at 20 ppm followed by NAA at 40 ppm. In control it was only 12.99 per cent.

Table 50. Effect of different chemicals on fruit quality of mango cv. Fazli.

Treatments	Pulp:fruit ratio			Total soluble solids (°Brix)		
	1983	1984	1985	1983	1984	1985
GA ₃ 20 ppm	1:1.36	1:1.44	1:1.39	18.85	19.60	18.50
GA ₃ 40 ppm	1:1.38	1:1.43	1:1.41	18.00	20.05	19.35
2,4-D 10 ppm	1:1.42	1:1.46	1:1.45	17.85	18.60	18.95
2,4-D 20 ppm	1:1.30	1:1.47	1:1.38	19.85	19.20	19.50
NAA 20 ppm	1:1.34	1:1.34	1:1.36	18.00	18.55	19.20
NAA 40 ppm	1:1.40	1:1.42	1:1.47	20.00	20.35	19.85
2,4,5-T 10 ppm	1:1.29	1:1.44	1:1.34	18.60	19.75	19.40
2,4,5-T 20 ppm	1:1.35	1:1.55	1:1.43	17.85	19.80	18.95
Almon 500 ppm	1:1.33	1:1.37	1:1.39	16.40	17.95	18.75
Almon 1000 ppm	1:1.42	1:1.46	1:1.40	18.85	18.20	19.35
Control	1:1.39	1:1.46	1:1.42	17.25	18.00	18.35
S. Em ±				0.305	0.190	0.120
C.D. at 5%				0.882	0.549	0.347



T₁ - GA 20 ppm T₄ - 2,4-D 20 ppm T₇ - 2,4,5-T 10 ppm T₁₀ - Almon 1000 ppm
 T₂ - GA 40 ppm T₅ - NAA 20 ppm T₈ - 2,4,5-T 20 ppm T₁₁ - Control
 T₃ - 2,4-D 10 ppm T₆ - NAA 40 ppm T₉ - Almon 500 ppm

FIG.13. TOTAL SOLUBLE SOLID CONTENT OF FRUIT DUE TO TREATMENT WITH CHEMICALS.

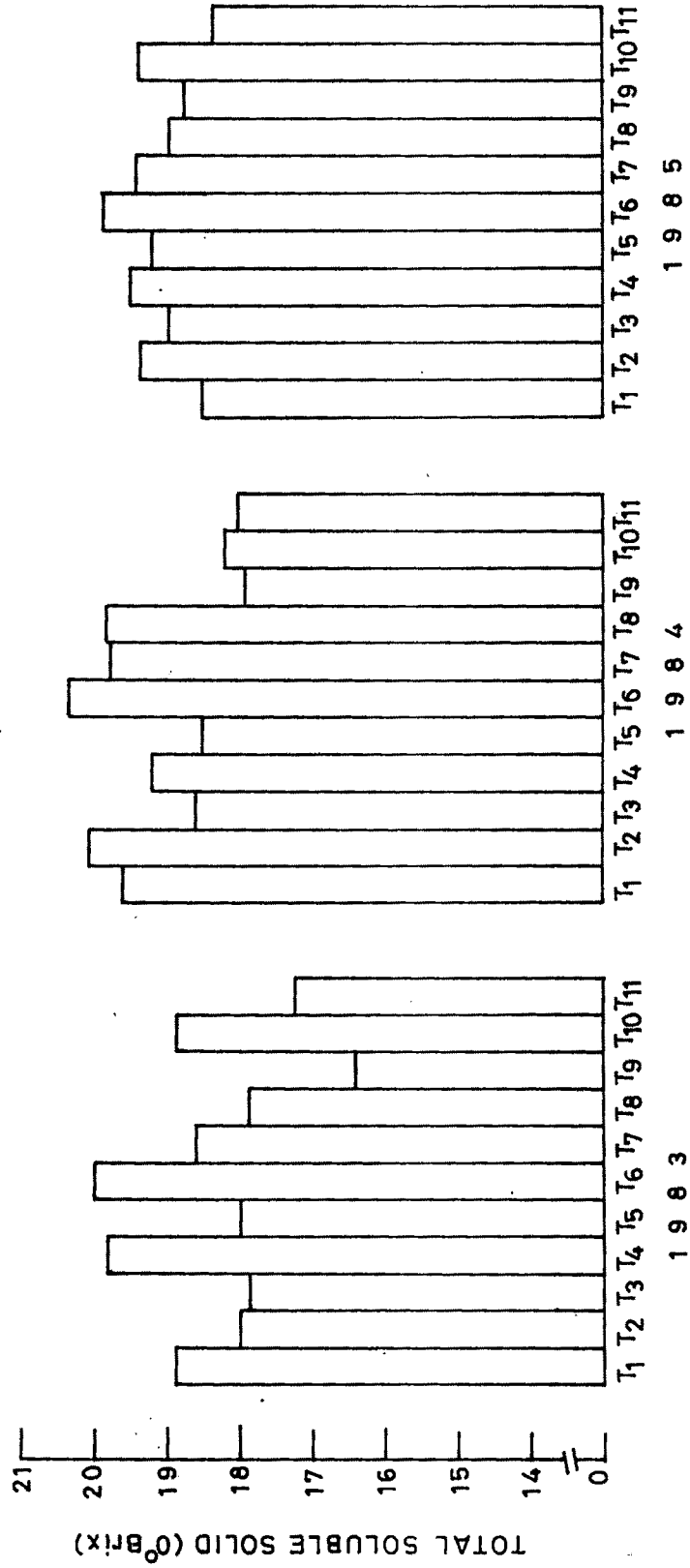


FIG.13. TOTAL SOLUBLE SOLID CONTENT OF FRUIT DUE TO TREATMENT WITH CHEMICALS.

Reducing sugar :

It is evident from the data presented in Table 51 that treatment with chemicals proved effective in increasing the reducing sugar content over control. Application of 40 ppm of NAA caused the maximum reducing sugar content of 4.44, 4.35 and 4.37 per cent in 1983, 1984 and 1985, respectively as compared to 3.19, 3.57 and 3.72 per cent in the respective years under control. In 1983 and 1984, GA₃ at both the concentrations, 2,4-D at 20 ppm and 2,4,5-T at 10 ppm increased the reducing sugar content significantly over control. In 1985, treatment with different chemicals except GA₃ 20 ppm, 2,4-D 10 ppm and Almon 500 ppm caused increase in reducing sugar of fruits.

Non-reducing sugar :

From the data presented in Table 51, it is observed that all the treatments except 10 ppm 2,4-D, 20 ppm NAA and Almon at both concentrations increased the non-reducing sugar significantly over control (8.24%) in 1983 and treatment with 40 ppm NAA caused the maximum non-reducing sugar content of 10.83 per cent. This treatment was followed by GA₃ at 40 ppm. In 1984, 10 ppm 2,4-D and both the concentrations of Almon were found less effective but the other treatments enhanced non-reducing sugar content of fruits over control (8.42%). The highest non-reducing sugar was obtained (11.18%) when the plants were treated with GA₃ at 40 ppm.

In 1985 all the treatments showed pronounced effect on increasing non-reducing sugar content over control (8.81%). The

Table 51. Total, reducing and non-reducing sugar content of fruit due to different chemicals.

Treatments	Total sugar (% fresh weight)			Reducing sugar (% fresh weight)			Non-reducing sugar (% fresh weight)		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
GA ₃ 20 ppm	15.26	15.55	15.36	4.37	3.94	3.82	10.34	11.02	11.12
GA ₃ 40 ppm	15.45	15.90	15.52	4.14	4.12	3.91	10.74	11.18	11.03
2,4-D 10 ppm	12.17	12.74	13.64	3.47	3.68	3.74	8.26	8.60	9.39
2,4-D 20 ppm	15.62	15.38	14.30	4.35	3.86	4.05	10.70	10.94	9.73
NAA 20 ppm	13.12	13.68	15.43	3.76	3.63	3.86	8.88	9.54	10.98
NAA 40 ppm	15.85	16.00	15.78	4.44	4.35	4.37	10.83	11.06	10.84
2,4,5-T 10ppm	15.14	15.65	15.44	3.94	4.04	4.22	10.63	11.02	10.66
2,4,5-T 20ppm	14.40	15.68	15.82	3.27	4.10	4.07	10.57	10.99	11.15
Almon 500 ppm	12.12	12.36	14.27	2.85	3.54	3.62	8.82	8.37	10.12
Almon 1000ppm	12.48	12.52	14.15	3.55	3.59	4.17	8.47	8.48	9.48
Control	11.88	12.44	12.99	3.19	3.57	3.72	8.24	8.42	8.81
S. Em \pm	0.215	0.086	0.114	0.233	0.044	0.049	0.307	0.095	0.141
C.D. at 5%	0.622	0.249	0.331	0.675	0.129	0.143	0.887	0.276	0.405

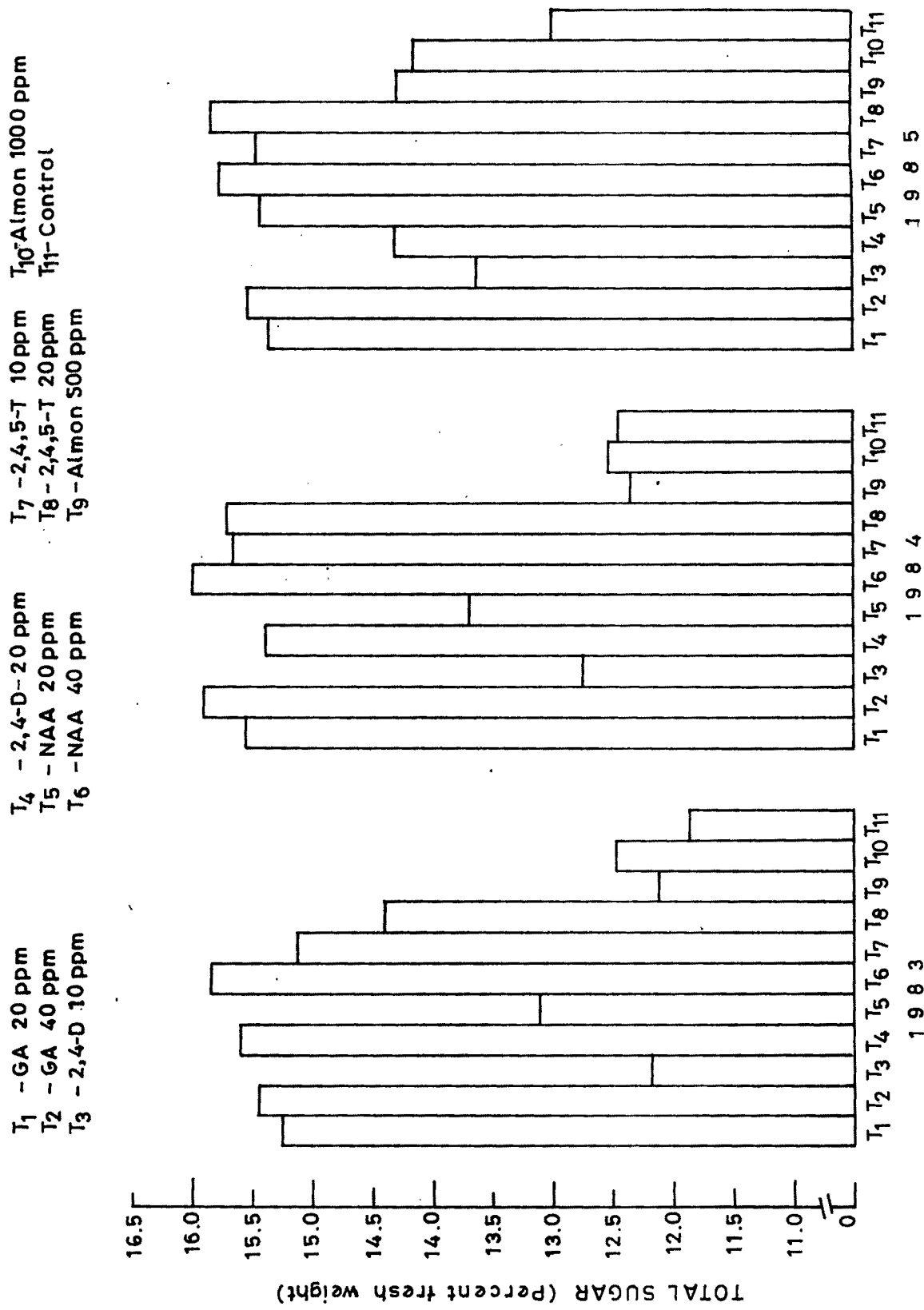


FIG.14: VARIATION IN TOTAL SUGAR CONTENT OF FRUIT DUE TO TREATMENT WITH CHEMICALS.

highest non-reducing sugar content of 11.15 per cent was obtained by the application of 20 ppm 2,4,5-T followed by GA₃, NAA, 2,4-D and Almon.

Fruit acidity :

The significant difference in acid content of fruits was recorded under the various treatments (Table 52). In 1983, all the treatments, except 20 ppm 2,4,5-T and 500 ppm Almon decreased the fruit acidity as compared to that under control (0.38%), 20 ppm GA₃ resulted in the lowest acidity (0.25%). Application of GA₃ at 40 ppm, NAA at 20 ppm and Almon at 1000 ppm caused reduction of fruit acidity over control (0.42%) and minimum value was recorded (0.25%) with 40 ppm GA₃ and 10 ppm 2,4,5-T (1984).

In 1985, treatments with GA₃, NAA at 20 ppm and 2,4,5-T at 10 ppm markedly reduced the acidity as compared to control (0.43%) and 2,4,5-T recorded the lowest acidity of 0.30 per cent.

Sugar/acid ratio :

It is clear from the data presented in Table 52 that treatments with different chemicals showed marked variation in sugar/acid ratio of fruits in all the years of the experiment. Application of GA₃ at 20 ppm resulted in maximum sugar/acid ratio of 61.04, while the least value of 20.89 was obtained under 500 ppm Almon in the year 1983 ('on' year). But in the 'off' year of 1984 the highest sugar/acid ratio of 63.6 was obtained with the application of GA₃ at 40 ppm and in control it was 29.61. 2,4,5-T at 10 ppm caused the highest sugar/acid ratio of 51.46 in 1985 ('on' year) as compared to 30.21 under control.

Table 52. Effect of different chemicals on acidity and sugar/acid ratio of fruit.

Treatments	Acidity (% fresh weight)			Sugar/acid ratio		
	1983	1984	1985	1983	1984	1985
GA ₃ 20 ppm	0.25	0.38	0.33	61.04	40.92	46.54
GA ₃ 40 ppm	0.26	0.25	0.32	59.42	63.60	48.50
2,4-D 10 ppm	0.26	0.32	0.42	46.80	39.81	32.48
2,4-D 20 ppm	0.29	0.38	0.43	53.86	40.47	33.25
NAA 20 ppm	0.29	0.29	0.33	45.24	47.17	46.75
NAA 40 ppm	0.26	0.44	0.46	60.96	47.05	34.30
2,4,5-T 10 ppm	0.26	0.25	0.30	58.23	62.60	51.46
2,4,5-T 20 ppm	0.51	0.38	0.41	28.33	41.26	38.59
Almon 500 ppm	0.58	0.44	0.40	20.89	28.09	35.67
Almon 1000 ppm	0.26	0.29	0.41	48.00	43.17	34.51
Control	0.38	0.42	0.43	31.26	29.61	30.21
S. Em \pm	0.014	0.040	0.019			
C.D. at 5%	0.042	0.116	0.057			

Discussion :

Results of the experiment stated in the foregoing pages clearly indicate that all the chemicals used in the experiment prevented premature and preharvest drop of fruits and as a consequence increased the number of harvestable fruits. Among the chemicals, the effects of 2,4-D, NAA and 2,4,5-T were promising regardless of 'on' and 'off' year. Further, it was observed that 20 ppm of 2,4-D gave the best result in all the years, followed by 40 ppm of NAA and 20 ppm of 2,4,5-T. Lower concentrations of these chemicals were also found to have beneficial effect. The effect of GA₃ and Almon were however, less pronounced and both the chemicals showed their effectiveness only at lower concentrations and at higher concentration retention percentage of fruits declined. Similar beneficial effect of 2,4-D NAA, 2,4,5-T and GA₃ on prevention of premature fruit drop in mango have been reported by several workers. It has been reported that, 2,4-D (Gill and Mukherjee, 1967, Roy et al., 1963), NAA (Prasad and Pathak, 1972, Srivastava, 1962), 2,4,5-T (Arora and Singh, 1964) and GA₃ (Teaotia et al., 1967) could be used to reduce the early fruit drop in mango. Reduction in fruit drop was also recorded with the application of 2,4-D in citrus (Chapman, 1983, Babu et al., 1984, Babu and Lavania, 1985) and NAA in litchi (Singh and Phogat, 1984).

It is also evident from the result that fruit drop was much higher at the earlier stage of development than at the later stages. Chadha and Singh (1964b) reported fruit drop in Langra, Dashehari and Fajri cultivars to the extent of about 98, 95 and 99 per cent

respectively of the fruits initially formed and majority of the fruits dropped in April. Perhaps this excessive drop during early stage was caused due to high competition for nutrient and moisture among the developing fruits. It is now well established that fruit drop in mango is accompanied by the formation of an abscission layer. The phenomenon of abscission is regulated by ethylene and inhibitor like ABA. Ram (1983) recorded that the level of ABA like inhibitor was high in the first 21 days following pollination which coincided with the period of slow fruit growth and heavy fruit drop. Gokhale and Kanitkar (1951), Chadha and Singh (1963) observed that growth regulators controlled fruit drop by strengthening the abscission region.

The pattern of fruit and seed growth in mango were sigmoid. Singh and Arora (1965) noted that in mango the auxin activity of seed increased with the increase in the size of the seed. The endogenous auxin level increased and decreased with the rate of fruit growth and GA_3 content in the seed increased rapidly during early seed growth and declined as growth decreased (Ram, 1983). During the period of rapid fruit growth the level of inhibitors decreased and promoters increased. Thus, decrease in fruit drop with the increase in fruit size suggests an inverse relationship between the auxin and gibberellin activity of the seed and fruit drop. It has also been established that auxin activity of the adhering fruit is always greater than the abscising one (Singh and Arora, 1965). From the above findings and the results obtained in the present study it would be logical to

suppose that fruit drop in mango is under the control of internal auxin and gibberellin production and by their exogenous application it can be regulated effectively. Singh and Ram (1983) also opined that the exogenous application of these hormones increased the fruit retention percentage either by increasing their internal levels or by antagonizing the adverse effects of endogenous growth hormones like ethylene, ABA etc.

Perusal of the results given earlier showed that besides increasing the fruit yield by reducing the premature drop, chemical treatments also increased the weight and size of individual fruits in all the years of the experiment. Treatments with 2,4-D, Almon and GA₃ were very striking in these regards. The beneficial effect of auxins and gibberellins can be illustrated in light of the fact that fruit growth is also influenced by hormones. Maurya et al. (1973) also noted enhanced growth with the help of growth regulators. Auxins promoted cell elongation by bringing about some modifications in the osmotic system of the cell (Devlin, 1975). The increased size and weight of fruits with the application of NAA (Prasad and Pathak, 1972), 2,4-D (Veera and Das, 1971) and GA (Singh et al., 1976b and Singh et al., 1977) have been reported. Improvement in size of litchi fruits was also observed by Sarkar et al. (1984). Gibberellins improved fruit size and weight by its effect on cell elongation and multiplication (Adalakha and Verma, 1964) in tomato. A significantly increased fruit weight with NAA treatment has also been reported by Singh and Phogat (1984) in litchi. The beneficial effects of NAA, 2,4-D, 2,4,5-T and GA

separately and in combination in increasing the fruit weight were also reported in mango by several workers (Kripal Singh et al., 1959b, Arora and Singh, 1964, Teatota et al., 1967, Prasad and Pathak, 1972, Singh et al., 1976b and Singh et al., 1977). The increased yield obtained under different treatments was due to the retention of larger number of fruits accompanied by increased weight of individual fruit.

Treatments with chemical improved the fruit quality appreciably by increasing the sugar contents and decreasing the acidity and consequently increased the sugar/acid ratio. Similar observations were also made by Prasad and Pathak (1972) and Singh et al. (1976b). In the present study NAA and 2,4-D proved most effective in enhancing the T.S.S. and sugar content of fruits. Singh et al. (1976b) and Prasad and Pathak (1972) obtained greater T.S.S. and sugar with the application of NAA. Chadha and Singh (1963) noted improved fruit quality by increasing the sugar and T.S.S. and decreasing acid content. According to Skoog and Robinson (1950) auxin increased sugar contents by acting as a catalyst in carbohydrate metabolism. In the present study GA_3 was found less effective in improving the fruit quality and this finding corroborates the earlier observations made by Veera and Das (1971). In an investigation with guava, however, Bagde and Kandalkar (1981-83) reported that fruit quality was best improved by GA_3 at 75 or 100 ppm. In the present study NAA and 2,4,5-T proved effective in reducing the fruit acidity markedly over control in all the years, which is in conformity with the earlier observations

made by Singh et al. (1976b). Besides these, GA₃ was also found very effective in reducing acidity whereas Singh et al. (1976b) reported that the effect of GA was at par with control in this regard.

Experiment IV : Physico-chemical changes during growth and development of mango fruits cvs. Fazli and Langra.

Fruit weight :

Data on fruit weight of two cultivars during the period of progressive development have been presented in Table 53 and Fig. 15. In this investigation, the data were collected from 30 days after fruit set and subsequent data were collected at an interval of 15 days. It was observed that the average weight of fruit increased during the entire period of development in both Fazli and Langra mangoes but the rate of increase was slower during the early part of growth and became rapid thereafter. The maximum increase in fruit weight was recorded between 45 to 90 days after fruit set (480.67 g in Fazli and 217.00 g in Langra). The maximum fruit weight of 768.33g was recorded in the cultivar Fazli, while in the cultivar Langra it was 301.66 g. Thus, a perusal of the data revealed that a gain in fruit weight amounting to 735.67 g per fruit during a period of 120 days occurred in cv. Fazli while in case of Langra 277.33 g increase in weight per fruit was noted over a period of 90 days.

Fruit size (length and breadth) :

It is revealed from the data in Table 53 and Fig.16 that the

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Fruit size (length and breadth) :

It is revealed from the data in Table 53 and Fig.16 that the

length and breadth of fruits increased consistently from the early stage to progressive developmental stage in both the cultivars. In Fazli mangoes, from 2.46 cm and 1.23 cm in length and breadth respectively at 30 days after fruit set, the size increased correspondingly to 16.16 and 10.40 cm at the ripening stage. In case of Langra, the length and breadth of the fruits at the initial stage were 2.26 and 1.96 cm, respectively which increased to 10.66 and 8.56 cm at the ripening stage.

Peel weight :

It is evident from the Table 53 that the peel weight increased significantly in two cultivars, namely Fazli and Langra during their development upto climacteric stage but in case of Langra it diminished after reaching the ripening stage. Maximum peel weight of 110.66 and 42.66 g were recorded in Fazli and Langra, respectively.

Stone weight :

It was also found that the weight of stone increased significantly during the progress of development in the fruits of both Fazli and Langra. The average weight of seed in Langra increased from 1.33 g at the initial stage of sampling to 97.33 g at the last date of observation. Similarly in Langra, the seed weight increased from 0.66 to 41.66 g during the period of fruit development (Table 53)

Pulp:fruit ratio :

It is conspicuous from the data in Table 53 that the change in pulp:fruit ratio was not consistent during the period of fruit

development in both the cultivars. After 30 days from fruit set, the pulp:fruit ratio was highest being 1:1.19 in Fazli and 1:1.14 in Langra and there after declined. In Langra, pulp:fruit ratio was widest (1:1.51) after 75 days of fruit set when stone was formed. After that, as the fruits were attaining maturity pulp contents increased gradually and at harvest the ratio was 1:1.38. However, no such distinct variation was noted in cv. Fazli.

Specific gravity :

The changing patterns in specific gravity of fruits during their period of development have been presented in Table 53 and Fig. 17. It was found that in the cultivars Fazli and Langra the specific gravity value increased steadily upto ripening stage. In case of Fazli the specific gravity varied between 0.933 and 1.066 while in Langra it ranged between 0.92 and 1.053 throughout the period of observation.

Total soluble solids (T.S.S.) :

In case of Fazli it was found that the T.S.S. contents increased gradually from the early stage (30 days after fruit set) to ripening stage (150 days after fruit set). At the climacteric peak T.S.S. contents rose suddenly from 10.4 to 16.2 per cent and it further increased by 4.5 per cent at the ripening stage. Similar trend was also recorded in case of Langra where it ranged from 5.9 to 11.7 per cent between the early growth stage and climacteric stage. The T.S.S. contents increased further by 7.2 per cent between climacteric

Table 53. Changes in physical parameters during growth and development of fruit in cvs. Fazli and Langra.

Days after fruit set	Cultivars	Fruit weight (g)	Length of fruit (cm)	Breadth of fruit (cm)	Peel weight (g)	Stone weight (g)	Pulp:fruit ratio	Specific gravity
30	Fazli	32.66	2.46	1.23	4.00	1.33	1:1.19	0.933
	Langra	24.33	2.26	1.96	2.33	0.66	1:1.14	0.920
45	Fazli	55.66	4.83	3.33	8.33	4.33	1:1.29	0.943
	Langra	37.66	3.43	2.60	4.33	0.96	1:1.16	0.966
60	Fazli	115.33	8.63	5.86	23.33	6.66	1:1.35	0.946
	Langra	80.00	6.66	5.83	16.66	3.33	1:1.33	0.973
75	Fazli	242.66	10.10	7.90	37.33	22.33	1:1.32	0.983
	Langra	156.33	8.66	6.53	40.00	13.33	1:1.51	1.016
90	Fazli	536.33	14.46	8.96	81.33	55.00	1:1.34	1.006
	Langra	254.66	10.06	8.30	43.33	40.66	1:1.49	1.023
105	Fazli	574.00	14.70	9.93	89.66	62.33	1:1.36	1.023
	Langra	293.33	10.26	8.13	46.33	41.33	1:1.42	1.036
120	Fazli	638.33	15.53	10.36	102.66	64.33	1:1.35	1.043
	Langra	301.66	10.66	8.56	42.66	41.66	1:1.38	1.053
135	Fazli	754.00	16.06	10.26	108.66	80.33	1:1.33	1.060
	Langra	-	-	-	-	-	-	-
150	Fazli	768.33	16.16	10.40	110.66	97.33	1:1.37	1.066
	Langra	-	-	-	-	-	-	-
S. Em ±	Fazli	10.047	0.267	0.245	2.367	1.570	-	0.016
	Langra	7.885	0.180	0.098	1.668	1.464	-	0.006
C. D. at 5%	Fazli	30.124	0.802	0.735	7.098	4.710	-	0.048
	Langra	24.30	0.555	0.302	5.141	4.512	-	0.021

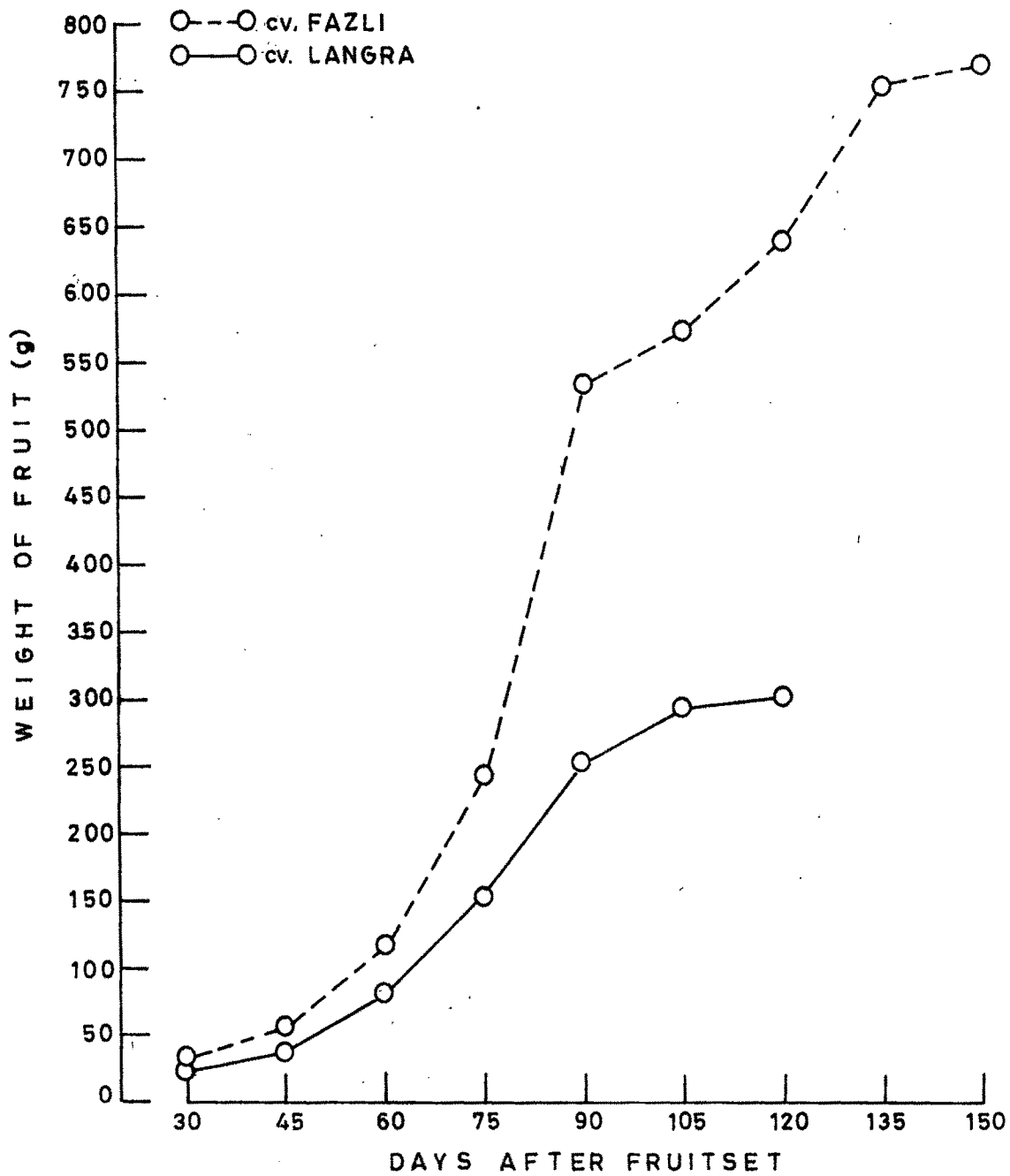


FIG.15. CHANGES IN WEIGHT OF FRUIT DURING DEVELOPMENT AND MATURATION.

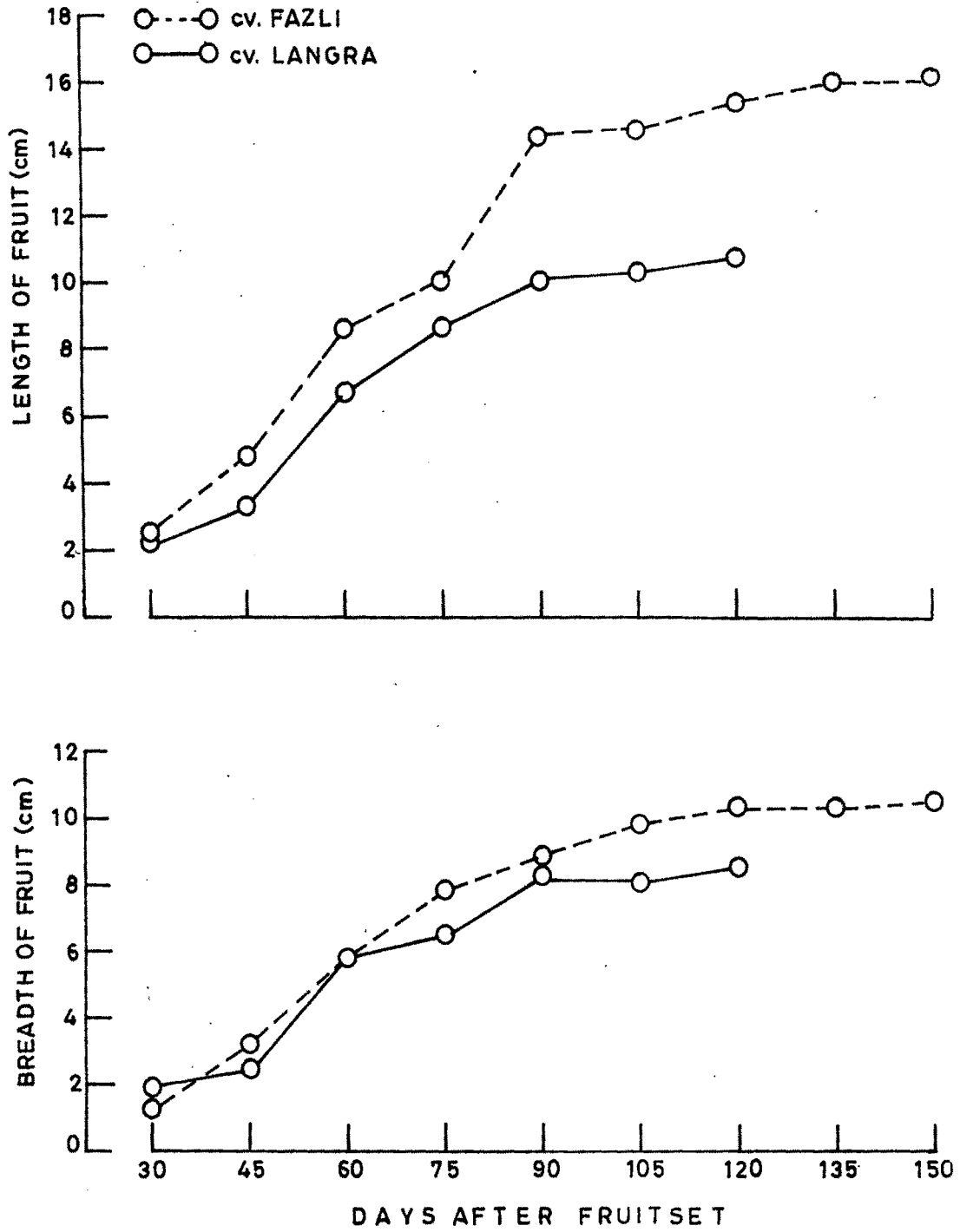


FIG.16. GROWTH (SIZE) OF MANGO FRUIT AFTER FRUITSET.

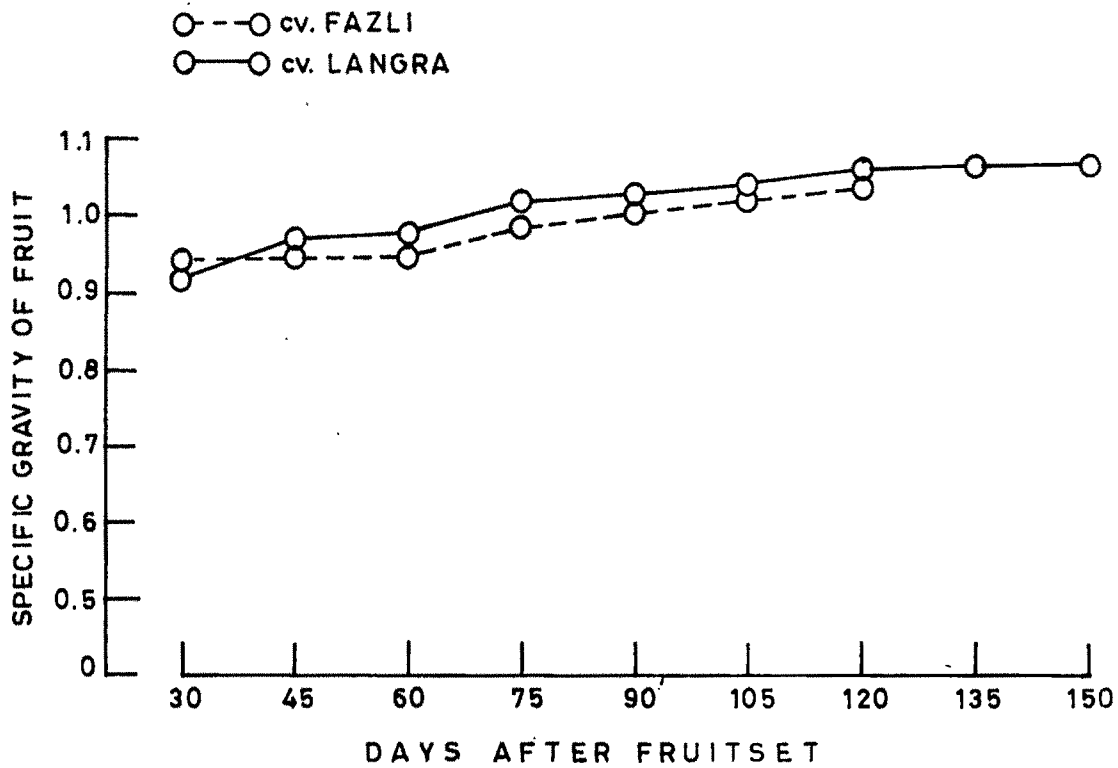


FIG.17: CHANGES IN SPECIFIC GRAVITY OF FRUIT DURING DEVELOPMENT AND MATURATION.

and ripening stage (Table 54 and Fig. 18).

Total sugar :

Data on total sugar contents of fruits during their development and maturation stages have been presented in Table 54 and Fig. 19. It is evident from table that in both the cultivars, the total sugar percentage increased during the entire period of fruit development. Starting from later part of March (i.e., 30 days after fruit set) up to the third week of June (i.e., 120 days after fruit set) increase in total sugar content was less pronounced and varied from 2.05 to 6.34 per cent. It showed a sharp rise at the maturation stage (10.84%) and further increased by 2.32 per cent at the ripening stage in Fazli mangoes while in Langra total sugar increased sharply at the end of climacteric stage to ripening stage (5.04 to 11.07%).

Reducing sugar :

The data presented in Table 54 indicate the changing pattern of reducing sugar content of fruits in both the cultivars during their development and maturation. It was found that in both the cultivars the rate of increase in reducing sugar from the early growth stage to climacteric stage was not conspicuous. But reducing sugar content increased suddenly between climacteric and ripening stage. Reducing sugar content of 2.54 to 3.70 per cent and 2.13 to 2.32 per cent were noted in cultivars Fazli and Langra, respectively.

Non-reducing sugar :

It is evident from the Table 54 that the non-reducing sugar

percentage was very low at the first stage of sampling (0.75%) and it increased gradually through the subsequent stage in the cultivar Fazli. But when the fruits reached the maturity stage, non-reducing sugar content suddenly increased from 2.9 to 7.88 per cent (i.e. from 120 to 135 days after fruit set) and attained 8.97 per cent in the ripening stage. Almost similar trend was observed in case of Langra. The non-reducing sugar percentage varied from 0.22 to 2.76 upto the maturity stage while at the ripening stage, the non-reducing sugar content increased by 5.54 per cent within a period of 15 days.

Acidity percentage :

Changing pattern of total titratable acidity has been presented in Table 54 and Fig. 20 and it is clear from the data that the percentage was low (0.93%) at the initial stage (i.e. 30 days after fruit set) and increased gradually as the fruits matured. In the climacteric stage fruit acidity attained the maximum level (3.62%) but at ripening stage acidity decreased to 0.38 per cent in Fazli. In case of Langra fruits, acidity varied between 2.71 in the early stage and 3.75 per cent in the pre-climacteric stage. But after reaching into the climacteric stage acidity decreased slightly. In the ripening stage fruit acidity abruptly decreased from 2.47 to 0.63 per cent.

Sugar/acid ratio :

A perusal of data reveals that sugar/acid ratio noted in different dates did not exhibit any consistent trend. This ratio was

Table 54. Chemical composition of fruit during growth and development in cvs. Fazli and Langra.

Days after fruit set	Cultivars	T.S.S. (°Brix)	Total sugar (% fresh weight)	Reducing sugar (% fresh weight)	Non-reducing sugar (% fresh weight)	Acidity (% fresh weight)	Sugar/acid ratio
30	Fazli	5.4	2.05	1.27	0.75	0.93	2.20
	Langra	5.9	1.30	1.06	0.22	1.06	1.22
45	Fazli	5.9	2.23	1.40	0.78	1.11	2.01
	Langra	6.7	2.11	1.25	0.82	2.08	1.01
60	Fazli	6.3	2.34	1.52	0.77	1.28	1.82
	Langra	7.6	2.20	1.18	0.97	2.71	0.81
75	Fazli	6.6	2.46	1.44	0.96	1.85	1.32
	Langra	8.1	3.24	1.81	1.35	3.75	0.86
90	Fazli	8.6	4.28	2.61	1.57	3.34	1.28
	Langra	8.6	3.47	1.92	1.46	3.45	1.01
105	Fazli	9.2	4.85	2.83	1.91	3.62	1.33
	Langra	11.7	5.04	2.13	2.76	2.47	2.04
120	Fazli	10.4	6.34	3.27	2.90	3.30	1.92
	Langra	18.9	11.07	2.32	8.30	0.63	17.57
135	Fazli	16.2	10.84	2.54	7.88	0.51	21.25
	Langra	-	-	-	-	-	-
150	Fazli	20.7	13.16	3.70	8.97	0.38	34.63
	Langra	-	-	-	-	-	-
S. Em ±	Fazli	0.114	0.083	0.041	0.349	0.047	-
	Langra	0.149	0.050	0.040	0.066	0.041	-
C.D. at 5%	Fazli	0.343	0.249	0.121	1.048	0.143	-
	Langra	0.461	0.155	0.123	0.204	0.125	-

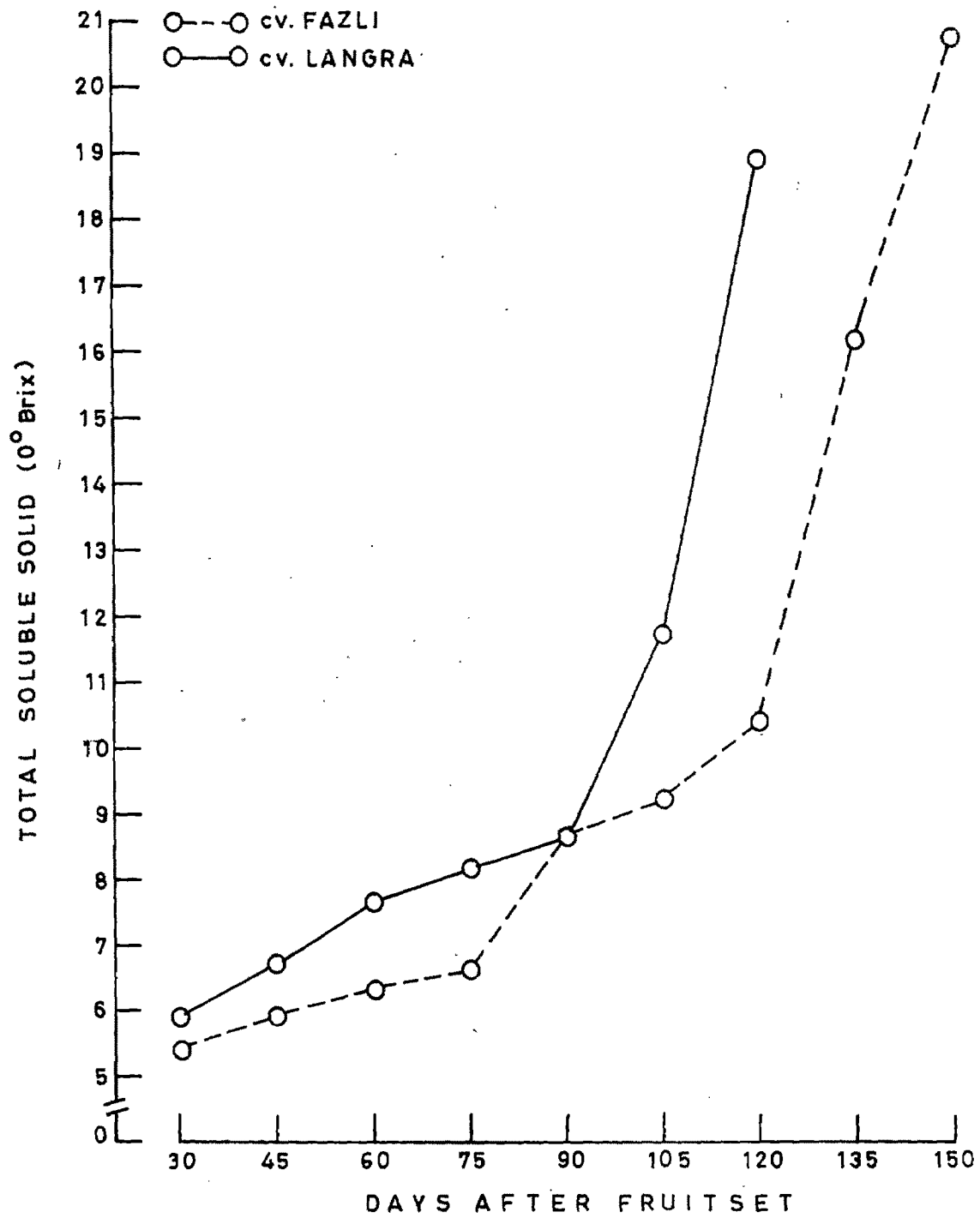


FIG.18. CHANGES IN TOTAL SOLUBLE SOLID CONTENT OF FRUIT DURING DEVELOPMENT

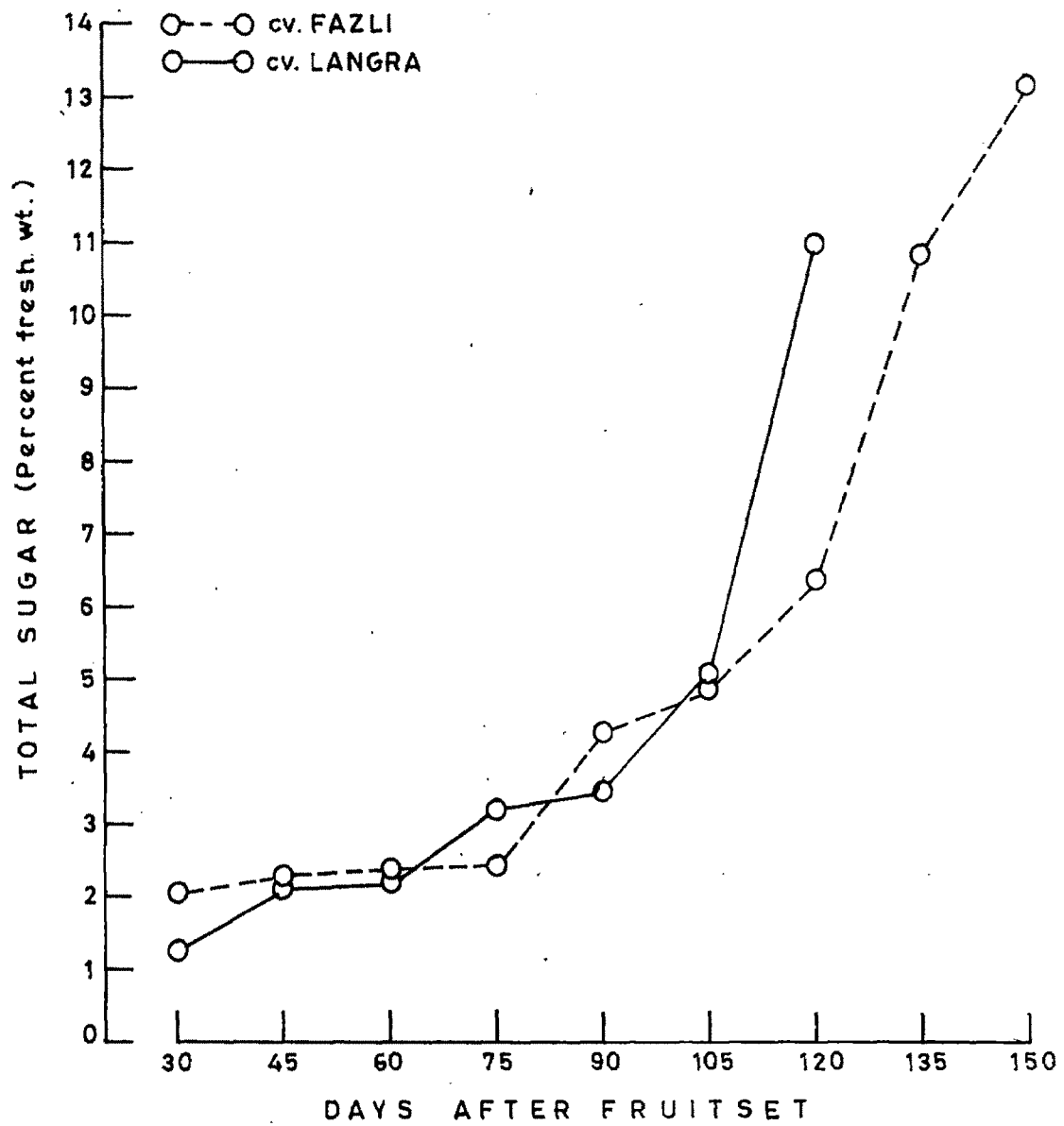


FIG.19. CHANGES IN TOTAL SUGARS CONTENT DURING DEVELOPMENT OF FRUIT.

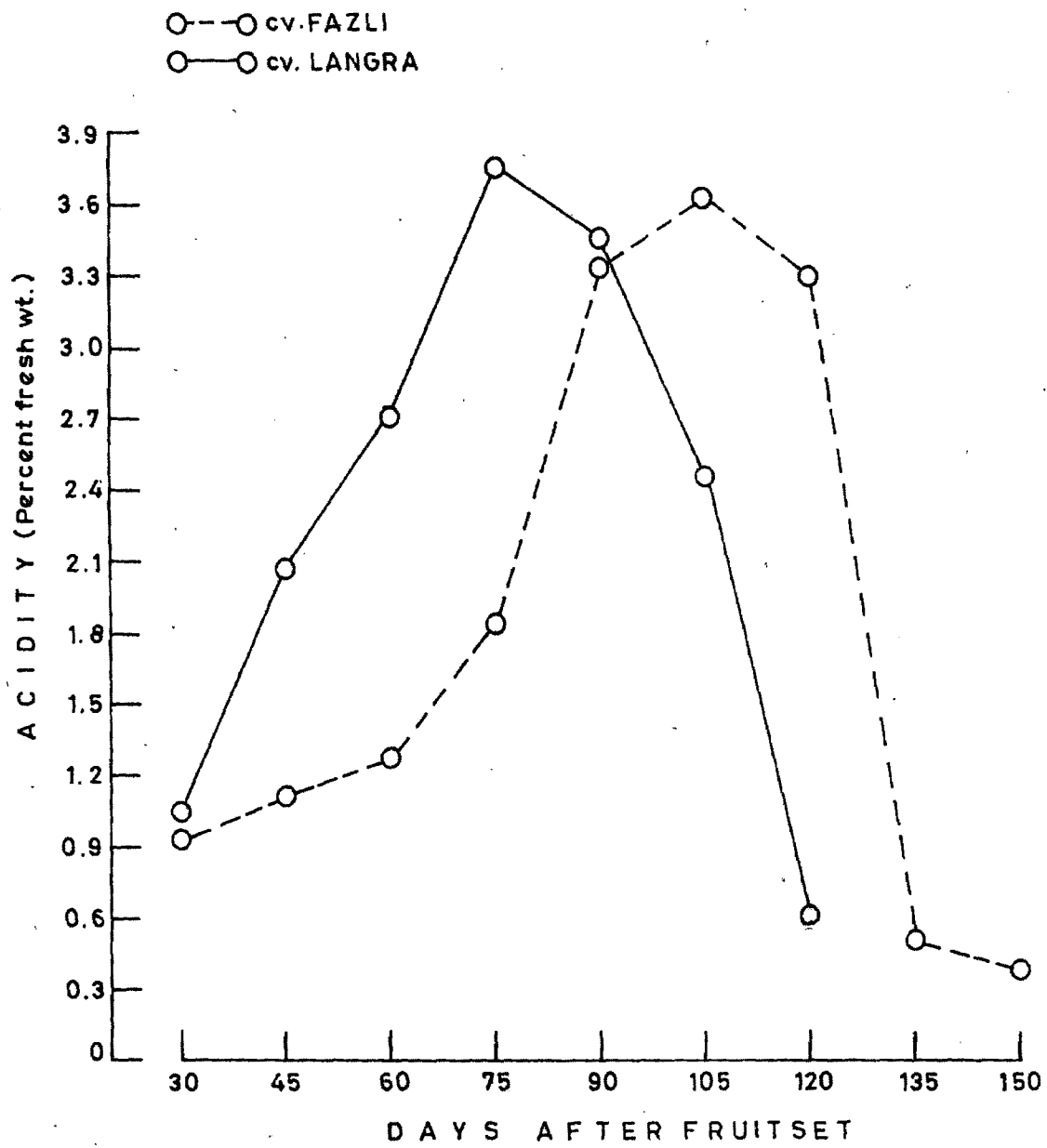


FIG. 20. CHANGES IN TITRATABLE ACIDITY OF FRUIT DURING DEVELOPMENT.

comparatively higher (2.20) at the initial stage of observation after which it reduced gradually upto 90 days after fruit set followed by a gradual enhancement in the next 15 days and reached the maximum values when the fruits were at ripening stage in case of Fazli. Likewise, in Langra sugar/acid ratio increased at the initial stage (1.22) i.e., 30 days after fruit set and decreased gradually upto 60 days after fruit set and the ratio was maximum during the later part of fruit development (Table 54).

Discussion :

Results on the physico-chemical changes during the developmental stage of mango presented in the previous pages revealed some interesting features which are discussed hereunder.

The growth of fruits with respect to length and breadth and weight continued to increase till harvest maturity in both the cultivars. The rate of increment was slow up to 45 days of anthesis for both the cultivars and thereafter the growth rate increased steadily up to 135 and 90 days in cultivars Fazli and Langra, respectively, thereafter it showed a decline at later stages. Such trends in growth of mango fruits have also been noted by Lakshinarayana et al. (1970) and Pandey et al. (1974). It was further observed that in the early stages the growth rate of seed was also poor. The poor growth of fruit was probably due to the poor growth of seed as reported by Chattopadhyaya et al. (1978). According to Ram (1983), the level of

ABA like inhibitor was high in the first 21 days which corresponded with the period of slow fruit growth. The period of maximum fruit growth was accompanied by the period of maximum seed growth. These findings are in line with the earlier observations made by Chattopadhyay et al. (1978) in cultivars Bombai and Himsagar. Seed is the primary and main source of auxins and gibberellins like substances and the maximum increase in growth rate is directly associated with the period of maximum activity of these growth substances (Chacko et al., 1972). Ram (1983) further observed that during the period of rapid fruit and seed growth, cytokinin concentration also increased rapidly.

In the cultivar Fazli, the peel weight increased suddenly after 90 days of fruit set, while in case of Langra abrupt increase in peel weight occurred after 75 days of fruit set, and thereafter the increase was meagre. Similar to peel weight, changes in the stone weight also occurred after 90 days of fruit set in both the cultivars. Changes in the values of pulp:fruit ratio were not much pronounced particularly in Fazli. In langra, pulp:fruit ratio decreased slightly after 90 days of fruit set. This was perhaps due to the increase in the peel and stone weight. Teotia et al. (1968) reported that the percentage of pulp and stone to whole fruit increased during the growth and development.

As regards the changes in the values of specific gravity during the developmental stages till maturity, it was observed that

specific gravity increased continuously till maturity in both the cultivars. Similar findings were also reported by Popenoe et al. (1958) and Mukherjee (1959). Gangwar and Tripathi (1973) observed that specific gravity of fruits increased continuously till one month prior to maturity. The increase in the values of specific gravity in the developmental period was perhaps due to the accumulation of starch during that period (Mukherjee, 1959). Varietal difference was not, however, conspicuous.

A sharp and significant rise in the values of total soluble solids content was noted in both the cultivars. Sharp rise in T.S.S. occurred after 135 days and 105 days in the cvs. Fazli and Langra, respectively. In this connection references can be made to the work of Askar et al. (1972), Rao et al. (1972) and Gangwar and Tripathi (1973), who also reported that increase in total soluble solids contents took place in the later part of development.

Total sugar, reducing sugar and non-reducing sugar contents of the fruits also increased as fruits developed and matured in both the cultivars. Total sugar and non-reducing sugar increased markedly after 135 and 120 days in Fazli and Langra, respectively. But no such variation was noted in the values of reducing sugar. Siddappa and Bhatia (1954) reported that total sugar and non-reducing sugar contents increased gradually in mango as the fruits tended to mature and reducing sugar remained constant. But in the present investigation increase in reducing sugar content continued steadily throughout the period of fruit growth and development. It was also evident that

up to 135 days in Fazli and 120 days in Langra, the percentages of reducing sugar were higher than non-reducing sugar and thereafter it was just reverse. Mukherjee (1959) also reported that throughout the period of fruit development, the reducing sugar content was much higher than the non-reducing sugar content.

Results mentioned earlier gave a clear indication that fruit acidity was low during the early development stage and as growth progressed, acid content increased steadily and then declined sharply when fruits attained harvest maturity. Decrease in the acidity level of mango fruits during later part of their development has been reported by Askar et al. (1972) and Rao et al. (1972). Mukherjee (1959) noted a rise in the acid content of fruits during the early period of their development followed by a decline with fruit maturity and ripening.

Sugar/acid ratio in both the cultivars decreased after 30 days of fruit set and again increased progressively as fruits developed and a sharp rise in value was observed when fruits were fully matured. The maximum value was recorded at ripe stage. The decline in the ratio was perhaps due to the fact that the rate of increase in acid content was more than that of total sugar, and at maturity sugar contents increased and acidity decreased markedly.

CHAPTER—V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

In order to elucidate the role of micronutrient like, zinc, iron and boron with or without urea on growth, yield and fruit quality in mature (30 years) and young plants (4 years) of mango cv. Fazli, experiments were carried out at the Mango Research Centre of the Bidhar Chandra Krishi Viswavidyalaya, located at Mathurapur and Ratua and in two private orchards at Ratua and Najirpur in the district of Malda in West Bengal.

Effect of zinc, iron and boron and their interactions were studied separately with and without urea application following randomized block design.

Both zinc and boron promoted vegetative growth as indicated by plant height, trunk girth and spread of the young Fazli plants. The effect of iron was less pronounced than boron and zinc. Treatments with these micronutrient, however, were not very effective in augmenting flowering percentage in young mango plants except zinc at 0.2 per cent. In mature plants however, zinc and boron enhanced flowering in the 'on' year (1985) whereas iron and boron caused significant increase in flowering in the 'off' year (1984). Spray application of both zinc and boron increased fruit number and fruit weight in the 'off' and 'on' years in mature mango trees. Maximum fruit weight was obtained with the highest level of zinc. It was also evident that application of zinc, iron and boron increased fruit yield in the mature

trees and among the three nutrients, zinc and boron, particularly at higher levels were more effective.) Fruit quality as evident by T.S.S. and sugar content was enhanced markedly by the application of zinc and boron in young as well as mature trees. The effect of iron was less prominent. The maximum total sugar content was obtained with the highest level of boron.) Application of micronutrients in combination with urea further promoted flowering, fruit number and yield in young mango trees, particularly at higher levels. The effect of zinc was most pronounced followed by boron and iron.) Treatment with micronutrients and urea also resulted in significant increase in T.S.S. and sugar contents of ripe edible fruits, the best result was obtained with boron.) The micronutrients caused greater accumulation of nitrogen in the leaf and shoot of mature mango trees, irrespective of stage of sampling and the maximum nitrogen content was observed with the highest level of boron. Phosphorus and potassium contents in leaf and shoot also increased in the treated plants at the vegetative stage but decreased later with the on set of flowering. (Micronutrients when used in combination with 1 per cent urea also enhanced nitrogen, phosphorus and potassium content in leaf and shoot of young mango plants.) (Boron at 0.4 per cent in combination with urea showed higher nitrogen contents in the leaf as compared to other treatments.) Nitrogen, phosphorus and potassium contents in leaf and shoot were always higher during the vegetative stage and declined during flowering.

In another experiment the effects of different chemicals like GA₃, 2,4-D, 2,4,5-T, NAA and Almon each at two concentration on

fruit drop, fruit growth and quality were studied. All the chemicals reduced premature and preharvest fruit drop and thereby increased the yield, and among the chemicals used 2,4-D, NAA and 2,4,5-T were effective regardless of 'on' and 'off' years. 2,4-D at 20 ppm proved to be most effective treatment in reducing the fruit drop in all the years of the experiment. GA₃ and Almon were less pronounced in this regard. Maximum fruit retention was observed with 20 ppm 2,4-D followed by 40 ppm NAA. Fruit drop was more in the initial stages of fruit growth and patterns of fruit and seed growth in mango were sigmoid. Besides increasing the fruit yield through reduction of fruit drop, chemical treatments also caused increase in weight and size of individual fruits 2,4-D, Almon and GA₃ proved more effective in this respect. Treatment with chemicals improved the fruit quality by increasing the sugar/acid ratio. NAA, 2,4-D and 2,4,5-T improved the fruit quality to a greater extent as compared to others.

Physico-chemical changes during the growth and development in mango cvs. Fazli and Langra were studied. Fruit growth with respect to length, breadth and weight continued at a slower rate upto 45 days from anthesis and thereafter the growth rate increased steadily upto 135 and 90 days in cvs. Fazli and Langra respectively, thereafter growth declined. During the early stages, seed growth was also slow. Peel weight showed pronounced increase after 90 days in Fazli and 75 days of fruit set in Langra, whereas stone weight showed marked increase after 90 days of fruit set in both the cultivars. Changes in the

values of pulp:fruit ratio were not much pronounced. The specific gravity of the fruits increased continuously till maturity in both the cultivars. Sharp rise in T.S.S. occurred after 135 and 105 days in cvs. Fazli and Langra respectively. Total, reducing and non-reducing sugar contents of the fruits also increased with fruit development and maturity and marked increases in total sugar and non-reducing sugar were noted after 135 and 120 days in Fazli and Langra respectively. The fruit acidity increased during early development but sharply declined with harvest maturity. Sugar/acid ratio showed marked increase at harvest maturity and continued upto ripening.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Adalakha, P.A. and Verma, S.K. (1964) Effect of Gibberellic acid on the quality of tomato fruits. Punjab Hort. J., 4 : 148.
- ✓Agerwala, S.C. and Sharma, C.P. (1978) Plant nutrients - their functions and uptake. Soil Fertility Theory and Practice, I.C.A.R., New Delhi, pp.26-32.
- Alvarrez-Rosario, E. (1965) Boron studies with apple in New Jersey, Diss. Abst., 26 : 12.
- Anantanarayanan, K.K. and Pillai, O. A.A. (1968) Fruit maturity studies in mango at Kanyakumari (Tamil Nadu). South Indian Hort., 16 : 56-7.
- ✓Anonymous (1979) Effect of growth regulators on fruit drop in mango. Paper presented at Mango Workers Meeting, Goa, pp.426-7.
- A.O.A.C. (1970) Official Methods of Analysis, Association of Agricultural Chemists, 9th edition, Washington, D.C.
- Aravindakshan, K., Ramachandran, C., Pynadath, J.H. (1979) Effect of planofix on fruit set in mango (var. Neelum). Agric. Res. J. Kerala, 17 : 105-7.
- Arora, J.S. and Singh, J.R. (1970) Some effects of iron spray on growth, yield and quality of guava fruits (Psidium guajava L.) J. Jap. Soc. Hort. Sci., 39 : 139-43.

- Arora, K.S. and Singh, R. (1964) Effect of plant regulators on fruit drop, fruit quality and seed germination in mango. Indian J. Agric. Sci., 34 : 46-55.
- Asana, R.D., Sarin, R.D. and Saxena, M.N. (1971) Hand book of Manures & Fertilizers, I.C.A.R., New Delhi, pp.160-94.
- Askar, A., El-Tamimi, A. and Raouf, M. (1972) The chemical constituents of mango and their behaviour during growth and ripening. Mitteilungen Rebe Und Wein, Obstbau Und Fruchtev., 22:120-5.
- Avilan, R.L. (1971) Variation in mango leaf N, P, K and Ca during a production cycle. Agron. trop., 21 : 3-10.
- Babu, G.H.V.R. and Lavania, M.L. (1985) Effect of plant growth regulators on fruit set and fruit drop of pant Lemon-I (Citrus limon Burm.). Indian J. Hort., 42 : 237-40.
- Babu, R.S.H., Rajput, C.B.S. and Rath, S. (1984) Effects of zinc, 2,4-D and GA₃ on fruiting of Kagzi lime (Citrus aurantifolia Swingle). Indian J. Hort., 41 : 216-20.
- Bagde, T.R. and Kandalkar, D.S. (1981-1983) Effect of growth regulators on quality of guava (Psidium guajava L.) var. Sardar. Magazine, College of Agriculture, Nagpur, 54/55 : 19-22.
- Baqui, S.M., Mattoo, A.K. and Modi, V.V. (1977) Glyoxylate metabolism and fatty acid oxidation in mango fruit during development and ripening. Phytochem., 16 : 51-4.

- Bopaiiah, M.G., Thakur, R.S. and Srivastava, K.C. (1985) Study on some aspects of soil and leaf nutrients in Dashehari mango. Paper presented at the second international symposium on mango, Bangalore, p.39.
- Bultovic, S. and Jovanovic, M. (1970) The effect of foliar applied boron on some fruit characters in apple variety Golden Delicious. *JugoslovVocarstre*, 4 : 1-10.
- Burstrom, H. (1948) The rate of nutrient transport to swelling buds of trees. *Physiol. Plant.*, 1 : 124-35.
- Chacko, E.K., Singh, R.N. and Kachru, R.B. (1972) Studies on the Physiology of flowering and fruit growth in mango. VI. Hormonal control of fruit development and its possible significance to biennial bearing. *Acta Hort.*, No.24, pp.155-63.
- Chadha, K.L. (1985) Mango Industry of India. Paper presented at the second international symposium on mango, Bangalore, p.3.
- Chadha, K.L. and Singh, K.K. (1963) Effect of NAA, 2,4-D and 2,4,5-TP on fruit drop, size and quality of Langra mango. *Indian J. Hort.*, 20 : 30-3.
- Chadha, K.L. and Singh, K.K. (1964a) Fruit drop in mango. II. Intensity periodicity and nature of shedding of immature fruits. *Indian J. Hort.*, 21 : 1-14.

- Chadha, K.L. and Singh, K.K. (1964b) Fruit drop in mango. Fruit drop and its relation to fruit growth. Indian J. Hort., 21:197-200.
- Chapman, J.C. (1983) Effect of 2,4-dichlorophenoxyacetic acid and gibberellic acid in delaying preharvest drop and rind senescence on Ellendale mandarin fruit. Qd. J. Agric. Anim. Sci., 40 : 129-31.
- Chattopadhyaya, P.K., Sadhukhan, S.K., Sadhu, M.K. and Bose, T.K. (1978) Studies on the physiology of fruit growth in mango. Indian Agric., 22 : 199-206.
- Dabhade, R.S. and Khedkar, D.M. (1980) Studies on dry and dehydration of raw mangoes for preparation of mango powder (amchur). Part I. Physico-chemical composition of raw mangoes during growth and development. Indian Fd. Pack., 34 : 3-17.
- ✓ Daulta, B.S., Singh, H.K. and Chauhan, K.S. (1981) Effect of zinc and CCC sprays on flowering, fruiting and physico-chemical composition of fruit in mango (Mangifera indica L.) cv. Dashehari. Haryana J. Hort. Sci., 10 : 161-5.
- De, H.N. and Debnath, J.C. (1966) Biochemical and nutritional studies on East-Pakistan fruits. Part II. Differential mechanism of ripening of ordinary variety and Kanchamitha (unripe green sweet) variety of mangoes (Mangifera indica L.). Pakist. J. Sci. Ind. Res., 9 : 57-60.
- Devlin, R.M. (1975) Plant Physiology. Affiliated East-West Press Pvt. Ltd., New Delhi.

- Gangwar, B.M., and Tripathi, R.S. (1973) A study on physico-chemical changes during growth, maturity and ripening in mango. Punjab Hort. J., 13 : 230-6.
- Gangwar B.M. and Moti (1974) A study on flowering, fruiting behaviour, maturity, yield and quality of some late mango varieties. Progressive Hort., 5 : 61-8.
- ✓ Gill, A.P.S. (1960) Control of fruit drop in mango. M.Sc.(Agric.) Thesis submitted to Punjab University, Ludhiana.
- ✓ Gill A.P.S and Mukherjee, S.K. (1967) Control of fruit drop in mango. Proc. Int. Symp. Trop. Sub-trop. Hort., New Delhi, pp.454-67.
- ✓ Gokhale, A.V. and Kanitkar, U.K. (1951) Fruit drop in Alphonso mango and its control Proc. Indian Sci. Cong., 38 : 151.
- Hatcher, J.T. and Wilcox, L.V. (1950) Colorimetric determination of boron using carmine. Anal. Chem., 22 : 567-9.
- Jackson, N.L. (1967) Soil Chemical Analysis. Prentice Hall of India, pp. 326-8.
- Jacobs, C.J. (1970) Marketing mangoes. Fmg. S. Afr., 46 : 37-40.
- ✓ Jagirdar, S.A.P. and Choudry, M.R. (1967) Fruit drop control in mangoes by hormonal spray. W.Pakist. J. Agric. Res., 5:33-42.
- Kalra, S.K. and Tandon, D.K. (1983) Ripening behaviour of "Dashehari" mango in relation to harvest period. Scientia Hort., 19:263-9.
- ✓ Kelyansundaram, P. (1974) Studies on fruit drop in Mulgoa mango (Mangifera indica L.). Indian J. Hort., 31 : 47-51.

- Kapur, K.L. (1974) Studies on biochemical changes in mango during growth and ripening. *Indian Fd. Pack.*, 28 : 10-6.
- Kennard, W.C. and Winters, H.W. (1956) The effect of 2,4,5-TP application on the size, maturation and quality of Amini mangoes. *Proc. Amer. Soc. Hort. Sci.*, 67 : 290-7.
- Krishnamurthy, S. and Subramanyam, H. (1970) Respiratory climacteric and chemical changes in the mango fruit (*Mangifera indica* L.). *J. Amer. Soc. Hort. Sci.*, 25 : 333-7.
- Kunte, Y.N. and Yawalkar, K.S. (1970) Introduction to principles of fruit growing. Agri-Horticultural Publishing House, Nagpur, pp.47-8.
- Lakshminarayana, S., Subhadra, N.V. and Subramanyam, H. (1970) Some aspects of developmental physiology of the mango fruit. *J. Hort. Sci.*, 45 : 133-42.
- Lelyveld, L.Van, and Oostrum, A.Van (1978) Mango fruit abscission. *Inf. Bull. Citrus and Subtrop. Fruit Res. Inst. No. 65*, pp.2-3.
- Lindsay, W.L. and Norvell, W.A. (1978) Development of a DTPA test for zinc, iron, manganese and copper. *Amer. J. Soil Sci. Soc.*, 42 : 421-8.
- Luckwill, L.C. (1948) Hormone content of seed in relation to endosperm development and fruit drop in the apples. *J. Hort. Sci.*, 24 : 32-44.

- Lynch, S.J. and Ruehle, G.D. (1940) Little leaf of mangoes - a zinc deficiency. Proc. Fla. St. Hort. Soc., 53 : 167.
- Majumder, P.K. and Sharma, D.K. (1985) Fruits of India - Tropical and Subtropical, Ed. by T.K. Bose, Naya Prokash, Calcutta, p.80.
- Malevski, Y., Gomez Brito, L., Peleg, M. and Silberg, M. (1977) External colour as maturity index of mango. J. Fd. Sci., 42 : 1316-8.
- ✓ Mallik, P.C. and Singh, D.L. (1959) Deficiency symptoms in mango due to the absence of trace elements. Indian J. Hort., 16 : 228-32.
- Mann, S.S., Singh, R.N. and Pandey, R.M. (1975) Studies on mango exudate in relation to fruit maturity. Progressive Hort., 7 : 51-5.
- Mann, S.S. and Singh, R.N. (1976) Lenticels as an aid for judging the maturity of mango fruit. Sci. and Cult., 42 : 529-31.
- ✓ Martin-Prevel, P., Marchal, J. and Furon, V. (1975) A case of zinc deficiency in mango fruits IFAC, Dakar Senegal, 30 : 201-6.
- ✓ Maurya, A.N., Singh, S.M. and Singh, A.R. (1973) Effect of plant regulators on the fruit retention and quality of Dashehari mango. Punjab Hort. J., 13 : 117-21.
- Mazumder, B.C. (1976) Comparative fruit development of three mango (Mangifera indica L.) varieties in West Bengal. Indian Agric., 20 : 163-8.

- Menchu, J.F. (1973) The development of mango fruit on the tree.
Proc. Trop. Reg., Amer. Soc. Hort. Sci., 17 : 125-43.
- Minessy, F.A., Biely, M.P. and El-Fahl, A. (1971) Effect of iron chelates in correcting malformations of terminal bud growth in mango. Sudan Agric. J., 6 : 71-74.
- Minessy, F.A., Biely, M.P. and El-Fahl, A. (1974) Effect of iron chelates in correcting malformation of terminal bud growth of mango in the Sudan. Egyptian J. Hort., 1 : 121.
- Modi, V.V. and Reddy, V.V.R. (1967) Carotenogenesis in ripening mangoes. Indian J. Exp. Biol., 5 : 233-5.
- Mukherjee, P.K. (1959) Biochemical and physiological studies during development of mango fruit. Hort. Advance, 3 : 95-101.
- Mukherjee, P.K. and Tiwari, J.P. (1979) Ascorbic acid concentration in mango (Mangifera indica L.) during pre and post-harvest period. Progressive Hort., 11 : 17-25.
- Mukherjee, S.K. (1949) The mango and its relatives. Sci. and Cult., 15 : 5.
- Mukherjee, S.K. (1953) The mango, its botany, cultivation, uses and future improvement especially as observed in India. Econ. Bot., 7 : 130-62.
- Nijjar, G.S., Arora, J.S., Gurcharan Singh and Dwivedi, R.S. (1976) Symptoms of Zn deficiency in mango. Punjab Hort. J., 16 : 113-4.

- Njoku, E. (1957) The effect of mineral nutrition and temperature of leaf shape in Ipomoea caerulea. New Phytologist, 56:154.
- Oppenheimer, C. and Gazit, S. (1961) Zinc deficiency in mango grove in Israel and its correction. Hort. Advance, 5 : 1-12.
- Pandey, R.M., Rao, M.M. and Singh, R.N. (1974) Biochemical changes in the developing mango fruit (Mangifera indica L.) cv. Dashehari. Progressive Hort., 5 : 47-59.
- Panse, V.G. and Sukhatme, P.V. (1978) Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.
- Popenoe, J. and Long, W.G. (1957) Evaluation of starch content and specific gravity as measures of maturity of Florida mangoes. Proc. Fla. St. Hort. Soc., 70 : 272-4.
- Popenoe, J., Hatton, T.T.Jr. and Harding, P.L. (1958) Determination of maturity of hard green Haden and Zill mangoes. Proc. Amer. Soc. Hort. Sci., 71 : 326-9.
- Prasad, A. and Pathak, R.A. (1972) Effect of methyl ester of naphthylacetic acid on fruit retention, size, ripening and quality of mangoes (Mangifera indica L.) variety Dashehari. Allahabad Farmer, 46 : 125-8.
- Rajput, C.B.S. and Tiwari, J.P. (1975) Effect of foliar spray of urea on flowering and fruiting characters of three cultivars of mango. Bangladesh Hort., 3 : 1-5.

- Rajput, C.B.S. and Chand, S. (1975) Significance of boron and zinc in guava (Psidium guajava L.). Bangladesh Hort., 3 : 22-7.
- Rajput, C.B.S. and Chand, S. (1976) Effect of boron and zinc on the physico-chemical composition of guava fruits (Psidium guajava L.). J. Nat. Agric. Soc. Ceylon, 13 : 49-54.
- ✓ Rajput, C.B.S., Singh, B.P. and Mishra, H.P. (1976) Effects of foliar application of boron on mango. Scientia Hort., 5 : 311-3.
- ✓ Rajput, C.B.S., Singh, B.P. and Singh, S.B. (1976) Effect of foliar application of zinc sulphate on vegetative growth of mango (Mangifera indica L.). Bangladesh Hort., 4 : 23-4.
- Rajput, C.B.S. and Ram, M. (1979) Effect of NAA, GA₃ and 2,4-D on fruit set, fruit retention and fruit quality of mango cultivars Langra, Dashehari and Fazari. Paper presented at the Mango Workers Meeting, Goa, p.434.
- ✓ Ram, S. (1983) Hormonal control of fruit growth and fruit drop in mango cv. Dashehari. Acta Hort., No.134, pp.169-78.
- Ram, S. and Sirohi, S.C. (1979) Studies on fruit drop in mango. Paper presented at the Mango Workers Meeting, Goa, pp.432-3.
- ✓ Remeshwar, A. and Rao, M.N. (1979) Fruit drop control. Paper presented at the Mango Workers Meeting, Goa, p.423.
- ✓ Rao, D.P. and Mukherjee, S.K. (1985) Soil and leaf nutrient status in relation to yield of some cultivars of Mangifera indica L. Paper presented at the second international symposium on mango, Bangalore, pp.31-2.

- ✓ Rao, M.N., Rameshwar, A. and Rao, S.N. (1979) Studies on the effect of different growth regulators, irrigation and urea sprays on fruit drop in mango. Paper presented at the Mango Workers Meeting, Goa, pp.421-2.
- ✓ Rao, M.R.K., Pal, R.N. and Chadha, K.L. (1976) Control of fruit drop in mango. Paper presented at the fruit research workshop, Hyderabad, p.218.
- Rao, P.V.S., Giridhar, N., Prasad, P.S.R.K. and Rao, G.N. (1970) Optimum maturity and harvesting time of mangoes, var. Baneshan (Syn. Banganapalle). I. Physico-morphological features of fruit vs maturity. Indian J. Hort., 27 : 117-22.
- Rao, P.V.S., Giridhar, N., Prasad, P.S.R.K. and Rao, G.N. (1972) Optimum maturity and harvesting time of mangoes var. Baneshan, Par II. Physico-chemical components of fruits vs maturity. Indian J. Hort., 29 : 126-34.
- Rao, S.N. (1961) Studies on the effect of GA₃ and other plant growth regulators on fruit set, fruit drop and total yield of citrus, guava, mango and other fruit crops. Paper presented at the Fourth Hort. Res. Worker Conf. Poona.
- ✓ Rao, S.N. and Rao, C.S. (1963) Effect of some plant growth regulators on fruit drop in Neelum mango. Punjab Hort. J., 3 : 205-8.
- ✓ Rath, S., Singh, R.L., Singh, B and Singh, D.B. (1980) Effect of boron and zinc sprays on the physico-chemical composition of mango fruits. Punjab Hort. J., 20 : 33-5.

- ✓ Roy, R.S., Chhonkar, V.S. and Prasad, S.N. (1963) Effect of plant growth regulators on fruit drop in mango. Punjab Hort. J., 3 : 209-13.
- Ruehle, G.D. (1951) Fertilizer practices for the mango; mango studies. Florida Mango Forum, 1 : 34-9.
- Sarker, G.K., Sinha, M.M. and Misra, R.S. (1984) Effect of NAA on fruit set, fruit drop, cracking, fruit size and quality in litchi cv. Rose Scented. Progressive Hort., 16 : 301-4.
- Sarker, S.C., Muhsi, A.A.A. and Choudhury, S.H. (1979) Acid sugar balance in mango (Mangifera indica L.). Bangladesh Hort., 7 : 30-35.
- Schollenberger, C.J. and Simon, R.H. (1945). Determination of exchange capacity and exchangeable bases in soil-ammonium acetate method. Soil Sci., 59 : 13-24.
- Sen, P.K. (1939) Annual report of the Fruit Research Station, Sabour, Bihar, Suptd. Govt. Printing, Patna.
- Sharma, D.D. and Biswas, P. (1981) Physico-chemical composition of some local cultivars of mango grown in West Bengal. Indian Agric., 25 : 7-12.
- Shukla, H.S., and Bajpai, P.N. (1978) Maturity assessment in mango cv. Dashehari, I. A physico-morphological approach. Plant Sci., 10 : 119-24.

- Siddappa, G.S. and Bhatia, B.S. (1954) Tender green mangoes as a source of vitamin C. *Indian J. Hort.*, 11 : 104-11.
- Singh, A. (1980) Fruit Physiology and Production, Kalyani Publishers, New Delhi, Ludhiana, p.199.
- Singh, B.P., Singh, S.B., Singh, D.C. and Singh, T.B. (1977) Effect of soil and foliar application of urea on the physico-chemical composition of mango fruit (Mangifera indica L.) cv. Langra. *Bangladesh Hort.*, 5 : 29-33.
- Singh, D.B. and Pathak, S.P. (1979) Control of fruit drop on mango cv. Langra. Paper presented at Mango Workers Meeting, Goa, pp. 428-9.
- Singh, K.K., Singh, S. and Chadha, K.L. (1959a) Effect of some plant regulators on fruit drop in mango. *Indian J. Hort.*, 16 :86-91.
- Singh, K.K., Singh, S. and Chadha, K.L. (1959b) Control of fruit drop in mango. *Curr. Sci.*, 28 : 346.
- Singh, K.K. and Chadha, K.L. (1961) Factors affecting the vitamin C content of mango. *Punjab Hort. J.*, 1 : 171-9.
- Singh, O.P. and Phogat, K.P.S. (1984) Effect of growth regulators on fruit drop, size and quality of litchi cv. Calcuttia. *Punjab Hort. J.*, 24 : 83-88.
- Singh, R. and Arora, K.S. (1965) Some factors affecting fruit drop in mango (Mangifera indica L.). *Indian J. agric. Sci.*, 35 : 196-205.

Singh, R.N. (1978) Mango, I.C.A.R., New Delhi, p.72.

✓ Singh, R.R. (1977) Effect of various concentration of boron on growth characters and chemical composition of leaves of mango (Mangifera indica L.) cv. Langra. Bangladesh Hort., 5 : 30-4.

✓ Singh, R.R. and Rajput, C.B.S. (1977) Effect of various concentration of zinc on vegetative growth characters, flowering, fruiting and physico-chemical composition of fruits in mango cv. Chousa. Haryana J. Hort. Sci., 6 : 10-4.

✓ Singh, R.S. and Ram, S. (1983) Studies on the use of plant growth substances for fruit retention in mango cv. Dashehari. Indian J. Hort., 40 : 188-94.

Singh, S., Singh, K.K. and Gill, A.S. (1961) Further studies on the control of fruit drop in mango with plant regulators. Paper presented at the Fourth Hort. Res. Worker. Conf. Poona.

Singh, S., Krishnamurthi, S. and Katyal, S.L. (1963) Fruit Culture in India. I.C.A.R., pp.2-3.

Singh, U.R. (1957) Effect of 2,4,5-T and 2,4,5-TP on the fruit drop in mango (Mangifera indica L.) var. Karela Bhagalpur. A.R. Fr. Res. Sta. Saharanpur, U.P., pp.65-8.

✓ Singh, U.R. and Singh, A.P. (1976) Control of fruit drop in mango. Paper presented at the fruit Research Workshop, Hyderabad, pp.213-6.

- Singh, U.R., Pandey, I.C., Upadhyay, N.P. and Tripathi, B.M. (1976a) Physiological and biochemical changes during maturity of mango (Mangifera indica L.) variety Neelum. Progressive Hort. 8 : 13-8.
- Singh, U.R., Pandey, I.C., Upadhyay, N.P. and Tripathi, B.M. (1976b) Effect of plant regulators on ripening and quality of mango (Mangifera indica L.) cv. Gourjeet. Progressive Hort., 8 : 83-8.
- Singh, U.R., Tripathi, J.S. and Tripathi, B.M. (1977) Effect of gibberellic acid on size and quality of mango fruit. Punjab Hort. J., 17 : 120-1.
- Singh, U.R., Singh, D.V. and Shukla, B. (1978) Determination of maturity indices for Taimuria and Sukul cultivars of mango (Mangifera indica L.). Haryana J. Hort. Sci., 7 : 47-9.
- Skoog, F. and Robinson, B.J. (1950) A direct relationship between indole acetic acid effects on growth and reducing sugar in tobacco tissues. Proc. Soc. Exp. Biol. Med., 74:565-8.
- Smith, P.F. and Scudder, G.K. (1951) Some studies of mineral deficiency symptoms in mango. Proc. Fla. St. Hort. Soc., 64:243.
- Snedecar, G.W. (1959) Statistical Methods. Iowa State College Press. Ames, Iowa.
- Spencer, J.L., Morris, M.P. and Kennarel, W.C. (1956) Vitamin C concentration in developing and mature fruits of mango (Mangifer indica L.). Plant Physiol., 31 : 79-80.

- ✓ Srivastava, R.P. (1962) Studies in the flowering season, sex distribution, fruit development and the influence of α Naphthalene acetic acid spray on fruit drop of Dashehari mango. B.H.U. J. Sci. Res., 12 : 104-15.
- Stewart, I. and Leonard, C.D. (1957) Use of chelates in citrus production in Florida. Soil. Sci., 84 : 87-97.
- Sturrok, T.T. (1961) A study of the effect of growth substances on fruit setting of the mango. Diss. Abstr., 22 : 19.
- Tandon, D.K. and Kalra, S.K. (1983) Changes in sugars, starch and amylase activity during development of mango fruit cv. Dashehari. J. Hort. Sci., 58 : 449-53.
- ✓ Teotia, S.S., Singh, R.N., Upadhyay, S.K. and Srivastava, V.S. (1967) Effect of growth substances on fruit retention in mango (Mangifera indica L.) variety Langra and Dashehari. Proc.Int. Sym.Trop. Subtrop. Hort., New Delhi, pp. 225-9.
- Teotia, S.S., Singh, R.D. and Maurya, V.N. (1968) Studies on maturity standards for Mangifera indica L. cv. Langra. Indian J. Hort., 25 : 24-30.
- Thomas, P. and Oke, M.S. (1980) Technical note : Vitamin C content and distribution in mangoes during ripening. J. Fd. Tech., 15 : 669-72.
- Tiwari, J.P. and Rajput, C.B.S. (1975) Effect of urea sprays on vegetative growth and fruit weight of different mango cvs. Bangladesh Hort., 3 : 31-6.

- ✓ Veera, S. and Das, R.C. (1971) Effect of growth regulators on development and quality of fruits in mango (Mangifera indica L.) South Indian Hort., 19 : 29-35.
- Wadleigh, C.H. (1957) Growth and plants in soils. Year book of Agriculture, U.S.D.A., Washington, D.C.
- Wallihan, E.F., Garber, M.J., Hammond, J.R., Wilma, L. Printy, Rayner, D.S. and Sharpless, R.G. (1967) Iron requirements of Navel orange trees in solution cultures. Hilgardia, 37 : 247-64.
- Webb, R.A. and Hallas, D.G. (1966) The effect of iron supply on strawberry, var. 'Royal Sovereign'. J. Hort. Sci., 41 : 179-88.